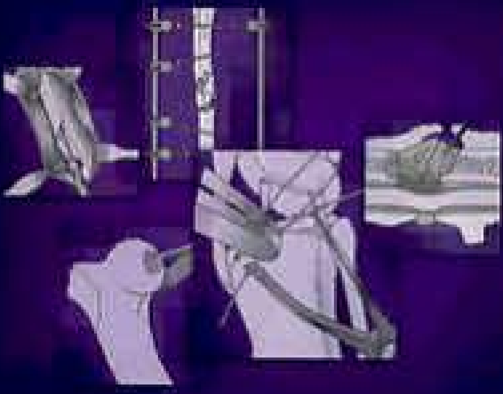
Ann L. Johnson and Dianne Dunning

# Atlas of ORTHOPEDIC SURGICAL PROCEDURES OF THE DOG AND CAT



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11830 Westline Industrial Drive
St. Louis, Missouri 63146

ATLAS OF ORTHOPEDIC SURGICAL PROCEDURES OF THE DOG AND CAT

ISBN 0-7216-9381-4



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**International Standard Book Number 0-7216-9381-4**

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Printed in the United States of America

Last digit is the print number: 9 8 7 6 5 4 3 2 1

*This book is dedicated to my family,*
*mentors, colleagues, residents, and students,*
*all of whom have provided input in my*
*development as a surgeon and consequently in*
*the development of this book.*
***Ann Johnson***

*I thank Ann Johnson for her generosity and*
*friendship. This book is dedicated to my*
*amazing children, George Henry and Sydney,*
*who generate an abundance of love, happiness,*
*and true joy in my life.*
***Dianne Dunning***

# Preface

Our goal in writing this atlas of orthopedic surgical procedures was to create a uniquely portable, easy-to-use reference resource for surgeons in the operating room—an atlas that demonstrates a wide range of procedures commonly performed in veterinary surgery. We thank Laura Duprey for helping us reach this goal by providing superb illustrations of the procedures.

In our surgical practice at the University of Illinois, we strongly encourage our residents and students to use textbooks in the surgery suite to guide them in each surgical technique and to maximize their proficiency. With the constant explosion of surgical techniques and procedures, this guidance is essential for those who do not have the opportunity to master each technique by performing the procedures on a daily basis.

The techniques selected and described are based on our years of experience in training surgical residents, interns, and students and in offering continuing education to practicing veterinarians. Also included are tips that we have found helpful as we have performed these procedures in our own practice.

It was a joy to compile this atlas; we hope that it is as illuminating to read as it was instructive to write.

*Ann Johnson*
*Dianne Dunning*

# SHOULDER

# Chapter 1 Osteochondrosis of the Shoulder via Caudolateral or Caudal Approach

## INDICATIONS

Candidates include dogs with persistent lameness of the shoulder caused by osteochondrosis that is not responsive to conservative management.

## OBJECTIVES

- To improve limb function by removal of the entire osteochondrosis flap, curettage of the adjacent diseased cartilage, and forage to provide blood supply to the exposed subchondral bone

## ANATOMIC CONSIDERATIONS

The shoulder joint is easily located by palpating the acromial process of the scapula and the greater tubercle of the humerus. The acromial head of the deltoideus is bordered cranially by the omobrachial vein and caudally by the axillobrachial vein. Muscular branches of the axillary nerve and caudal circumflex vessels are located deep in the caudal aspect of the acromial head of the deltoideus muscle, superficial to the triceps muscle.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), blunt Hohmann retractor, bone curettes, pin chuck or high-speed wire driver, Kirschner wires or small Steinmann pin for forage

## PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to the carpus. Use a hanging leg preparation with the dog in lateral recumbency to allow for maximal manipulation of the shoulder joint during surgery.

## PROCEDURE

**Craniolateral Approach:**[1] Incise the skin and subcutaneous tissues in a curvilinear fashion from mid-scapula to mid-humerus. Incise the deep fascia between the acromial and spinous portions of the deltoideus muscle (Plate 1A). Further delineate this separation by blunt dissection with Mayo scissors, allowing for cranial retraction of the acromial head and caudal retraction of the spinous portion of the deltoideus muscle. The muscle branch of the axillary nerve is visualized at this point and preserved. Place the Gelpi retractors at 90 degrees to each other to facilitate visualization. Incise the joint capsule parallel to the rim of the glenoid cavity and replace the Gelpi retractors within the joint space to facilitate visualization. Internally rotate and adduct the humerus to maximize exposure to the caudal aspect of the femoral head. Place a blunt Hohmann retractor caudomedial to the femoral head to exteriorize the femoral head and further facilitate lesion visualization (Plate 1C).

**Caudal Approach:**[2] Incise the skin and subcutaneous tissues in a curvilinear fashion from mid-scapula to mid-humerus. Incise between the caudal border of the spinous head of the deltoideus and the long and lateral heads of the triceps muscle (Plate 1B). Bluntly dissect under the deltoideus muscle to visualize the axillary nerve and caudal circumflex humeral artery and vein. Use Gelpi retractors to craniodorsally retract the teres minor muscle located deep to the spinous head of the deltoideus muscle. Elevate and gently retract the axillary nerve off of the joint capsule. Incise the joint capsule parallel to the rim of the glenoid cavity, and replace the Gelpi retractors within the joint space to facilitate visualization. Internally rotate and adduct the humerus to maximize exposure to the caudal aspect of the femoral head (Plate 1D).

**Curettage:** Remove the cartilage flap with thumb or Halstead forceps. Probe the remaining cartilage surrounding the defect with a curette, and remove any abnormal cartilage not adherent to the subchondral bone (Plate 1E).

**Forage:** Using a small Kirschner wire or small Steinmann pin, penetrate the sclerotic subchondral bone in multiple sites until it bleeds (Plate 1F). Explore the caudal cul-de-sac of the joint for loose or free fragments of cartilage. Lavage the joint, and close the joint capsule and wound in a routine fashion.

## CAUTIONS

Osteochondrosis is often bilateral (42% to 65%)[3]; both shoulders should be evaluated, even if the animal exhibits a unilateral lameness. Accurate hemostasis should be used when approaching the shoulder, as hemorrhage will greatly impede joint visualization.

## POSTOPERATIVE EVALUATION

No specific postoperative evaluation is required.

## POSTOPERATIVE CARE

Exercise should be restricted for 3 to 4 weeks to allow soft tissue healing and cartilage resurfacing, and then normal activity should be reintroduced slowly.

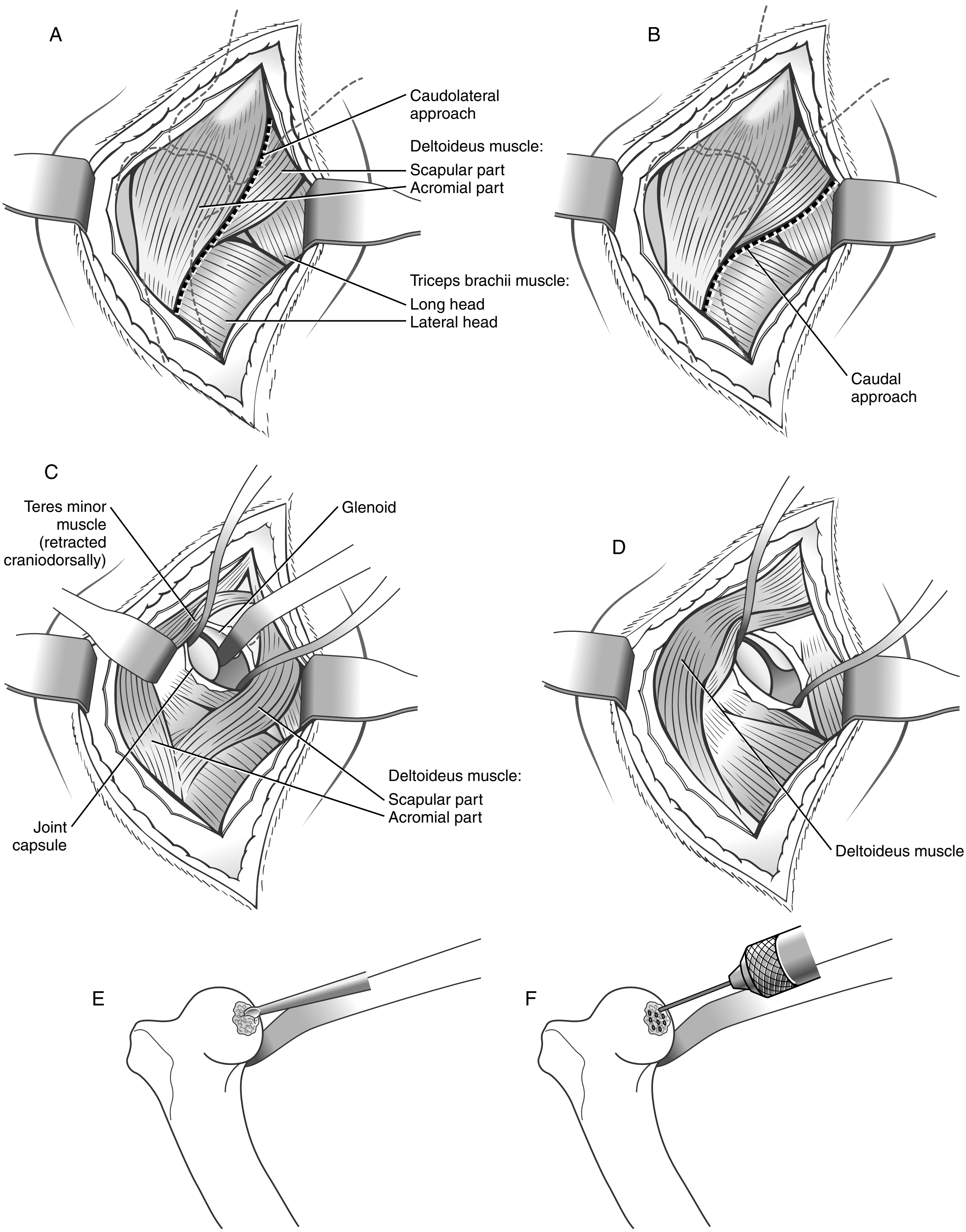
## EXPECTED OUTCOME

Outcome is good to excellent in most cases.[4] Note that degenerative joint disease may develop despite the surgical removal of an osteochondrosis flap.

### References

1. Piermattei DL, Johnson KA: Approach to the caudolateral region of the shoulder joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Piermattei DL, Johnson KA: Approach to the caudal region of the shoulder joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Whitehair J, Rudd R: Osteochondritis dissecans of the humeral head in dogs. Compend Cont Ed 12:195–203, 1990.
4. Rudd R, Whitehair J, Marogolis J: Results of management of osteochondritis dissecans of the humeral head in dogs: 44 cases (1982–1987). J Am Anim Hosp Assoc 26:173–178, 1990.

# PLATE 1


A
B
Caudolateral
approach
Deltoideus muscle:
Scapular part
Acromial part
Triceps brachii muscle:
Long head
Lateral head
Caudal
approach
C
D
Teres minor
muscle
(retracted
craniodorsally)
Glenoid
Deltoideus muscle:
Scapular part
Acromial part
Joint
capsule
Deltoideus muscle
E
F

# SHOULDER

# CHAPTER 2 Infraspinatus Contracture

## INDICATIONS

Candidates are animals with infraspinatus contracture that is not responsive to rest and management with nonsteroidal anti-inflammatory drugs. These dogs display a characteristic gait abnormality of external rotation of the shoulder, elbow abduction, and outward rotation of the pes.

## OBJECTIVES

- To restore normal shoulder joint range of motion and forelimb function by releasing the fibrotic infraspinatus muscle

## ANATOMIC CONSIDERATIONS

The infraspinatus muscle is one of the cuff muscles of the shoulder joint,[1] lying just caudal to the scapular spine. Its tendon lies beneath the acromial head of the deltoideus muscle and crosses the joint craniolaterally, inserting on the lateral aspect of the greater tubercle of the humerus. The teres minor tendon inserts just distally to the infraspinatus along the lateral aspect of the greater tubercle of the humerus.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, and formalin jar for histopathology

## PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to the carpus. Use a hanging leg preparation, with the dog in lateral recumbency to allow for maximal manipulation of the shoulder joint during surgery.

## PROCEDURE[2]

Incise the skin and subcutaneous tissue in a curvilinear fashion from the mid-scapular spine to the proximal portion of the humerus. Incise the deep fascia along the cranial border of the acromial head of the deltoideus muscle. Elevate and caudally retract the muscle with Gelpi retractors (Plate 2A). The infraspinous tendon should be visible as it inserts on the greater tubercle of the proximal humerus. Affected tendons will appear grossly thickened and fibrotic and will become visibly taut and inhibit the range of motion of the shoulder when it is placed in extension or flexion. Isolate the tendon by sharp and blunt dissection with a scalpel blade and periosteal elevator. Transect the tendon and any associated fibrotic bands until the shoulder moves freely. Resect a portion of the tendon (approximately 1 cm) to prevent recurrence and submit for histopathology (Plate 2B). Closure is routine.

## CAUTIONS

There are no specific cautions.

## POSTOPERATIVE EVALUATION

Once released, the shoulder should resume full range of motion. A portion of the affected tendon should be biopsied and submitted for histopathology for disease verification.

## POSTOPERATIVE CARE

Excessive activity should be restricted for 10 to 14 days to prevent seroma formation.

## EXPECTED OUTCOME

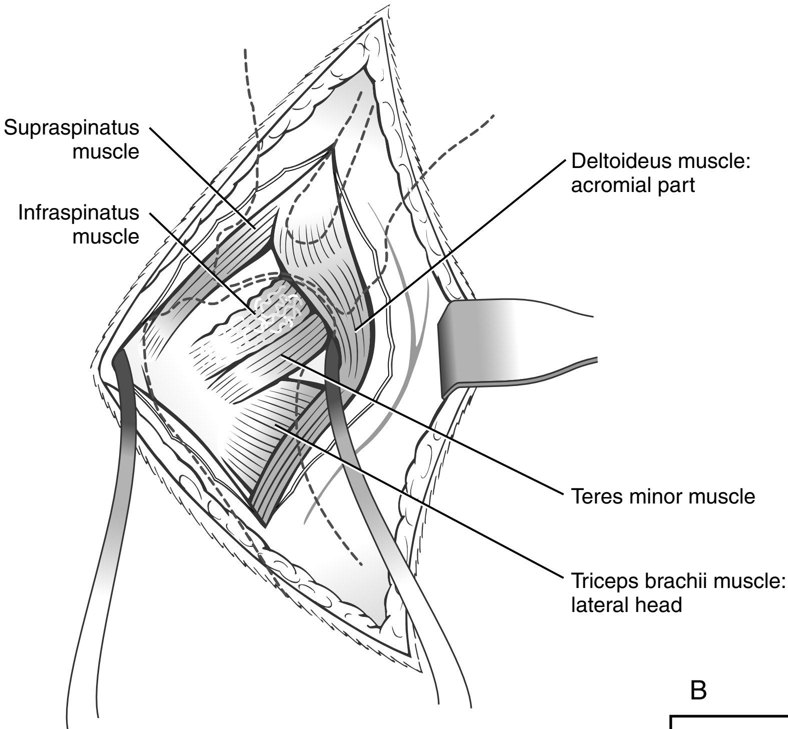
Outcome is usually excellent, with a full return to function expected.[3]

### References

1. Vasseur P, Moore D, Brown S: Stability of the canine shoulder joint: An in vitro analysis. Am J Vet Res 43:352–355, 1982.
2. Piermattei DL, Johnson KA: Approach to the craniolateral region of the shoulder joint by tenotomy of the infraspinatus muscle. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Bennet R: Contracture of the infraspinatus muscle in dogs: A review of 12 cases. J Am Anim Hosp Assoc 22:481–487, 1986.

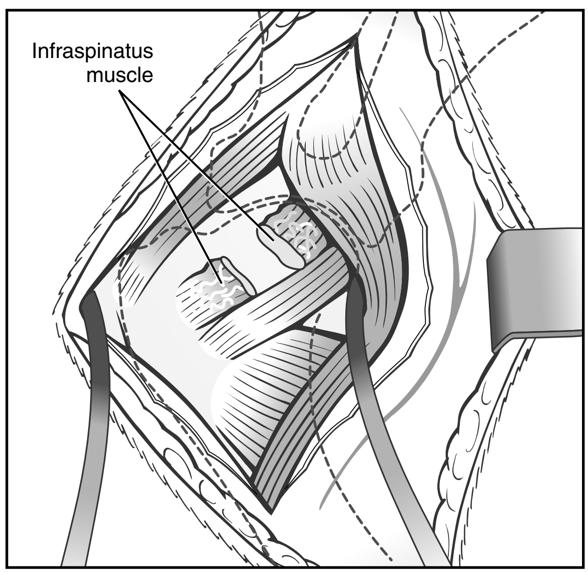
# PLATE 2

A



Supraspinatus muscle
Infraspinatus muscle
Deltoideus muscle: acromial part
Teres minor muscle
Triceps brachii muscle: lateral head


B



Infraspinatus muscle

## SHOULDER

# CHAPTER 3 Stabilization of Medial Shoulder Luxation

### INDICATIONS

This procedure is indicated in animals with medial shoulder luxation and instability. Open reduction and stabilization is indicated if a traumatic luxation is unstable enough after closed reduction that reluxation occurs, or if the luxation is chronic. Surgery is warranted in animals with congenital luxation or instability that causes severe or persistent lameness.

### OBJECTIVES

- To restore normal stability, congruency, mobility, and function to the shoulder joint without altering regional anatomy[1]

### ANATOMIC CONSIDERATIONS

Anatomic landmarks for the scapulohumeral joint are the acromion process of the scapular spine, the greater tubercle, and the acromial head of the deltoid muscle. Anatomic landmarks for positioning the skin incision include the acromion of the scapula, the greater tubercle of the humerus, and the pectoral muscles. The suprascapular nerve is present over the cranial lateral surface of the scapula. The caudal circumflex humeral artery and axillary nerve are present on the caudolateral aspect of the shoulder, and these should be avoided.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, two small Hohmann retractors, wire driver, intramedullary pins or Kirschner wires, mallet, 20-pound nylon* or the appropriate-size nonabsorbable suture material, and a suture anchor system†

Alternatively, if a suture anchor system is not available or if the animal is not large enough to accommodate the suture anchor system, a screw and washer combination may be used. Additional instrumentation needed for this technique includes a high-speed drill, bone screw and washer, drill bit, tap, depth gauge, and screwdriver.

### PREPARATION AND POSITIONING

Prepare the leg circumferentially, from the dorsal midline to the carpus. Use a hanging leg preparation with the dog in dorsal recumbency to allow for maximal manipulation of the shoulder joint during surgery.

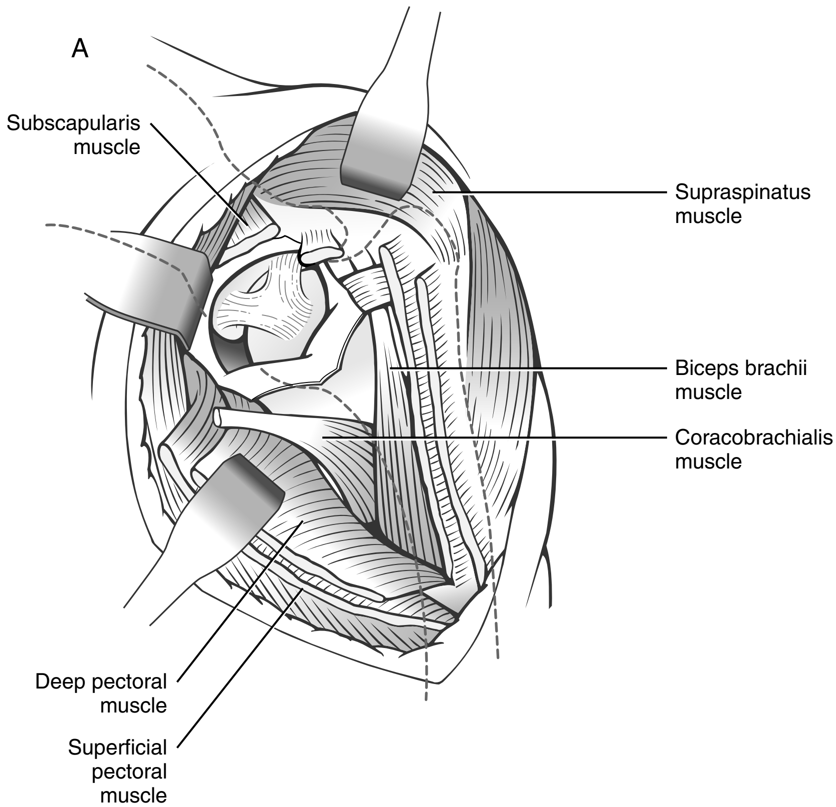
### PROCEDURE

**Approach:**[2] Use an approach to the craniomedial shoulder joint to expose the luxated joint. If possible, reduce the luxation before the approach to reestablish normal anatomic relationships. Incise the skin and subcutaneous tissue from the medial aspect of the acromion over the greater tubercle to the medial aspect of the midhumeral diaphysis. Ligate the omobrachial vein if it interferes with the intended approach. Incise the fascial border of the brachiocephalicus muscle and retract the muscle medially. Incise the insertions of the superficial and deep pectoral muscles from the humerus and retract them medially. Retract the supraspinatus muscle laterally. Transect the tendon of the coracobrachialis muscle near its origin to expose the subscapularis muscular tendon. Incise and elevate the subscapularis muscle tendon at its origin, exposing 0.5 to 1.0 cm of the distal scapula. Place one small Hohmann retractor cranial and underneath the supraspinatus muscle and another caudally against the caudal scapula for good visualization of the medial glenohumeral joint (Plate 3A). Inspect the joint, and assess the condition of the humeral head and medial labrum of the glenoid.

*Continued*

*Mason Nylon Leader Line, Mason Tackle Company, Otisville, Michigan.
†Bone Biter Suture Anchor System, Warsaw, Indiana.

# PLATE 3


A
Subscapularis muscle
Supraspinatus muscle
Biceps brachii muscle
Coracobrachialis muscle
Deep pectoral muscle
Superficial pectoral muscle

**Stabilization with the Suture Anchor System:**[1,3] Reduce the joint and identify the insertion and origins of the medial glenohumeral ligament in the distal scapula and proximal humerus. Drill three holes, one each at the cranial and caudal components of the ligament origin on the distal scapula and another at the ligament insertion on the proximal humerus (Plate 3B). Insert suture anchors threaded with fish leader line or nonabsorbable suture into each of these holes. There should be two independent suture loops for the cranial and caudal components of the medial glenohumeral ligament. Tie the sutures with the limb held at a normal standing angle (approximately 135 degrees of extension) such that the sutures are taut, but not overly tight, avoiding plication of the joint capsule (Plate 3C). Imbricate the capsule and subscapularis tendon with nonabsorbable mattress sutures. Place the scapulohumeral joint through a range of motion and evaluate joint stability and mobility. Closure is routine.

**Stabilization with a Screw and Washer Combination:**[1] Reduce the joint and identify the origins and insertion of the medial glenohumeral ligament in the distal scapula and proximal humerus. Drill, measure, and tap three holes, one each at the cranial and caudal components of the ligament origin on the distal scapula and another at the ligament insertion on the proximal humerus. Use a screw and washer combination to prevent subsidence into the soft metaphyseal bone and slippage of the ligature. There should be two independent suture loops for the cranial and caudal components of the medial glenohumeral ligament. Tie the sutures with the limb held at a normal standing angle (approximately 135 degrees of extension) such that the sutures are taut, but not overly tight, avoiding plication of the joint capsule (Plate 3D). Imbricate the capsule and subscapularis tendon with nonabsorbable mattress sutures. Place the scapulohumeral joint through a range of motion and evaluate joint stability and mobility. Closure is routine.

## CAUTIONS

Because the suprascapular nerve lies in close proximity to the fascial attachment between the deep pectoral and supraspinatus muscles, care must be taken during the approach in order to avoid trauma.

## POSTOPERATIVE EVALUATION

Joint stability and range of motion should be evaluated at 2 and 4 weeks to assess continued need for external coaptation.

## POSTOPERATIVE CARE

A Velpeau sling is indicated to protect the repair for 2 to 4 weeks.

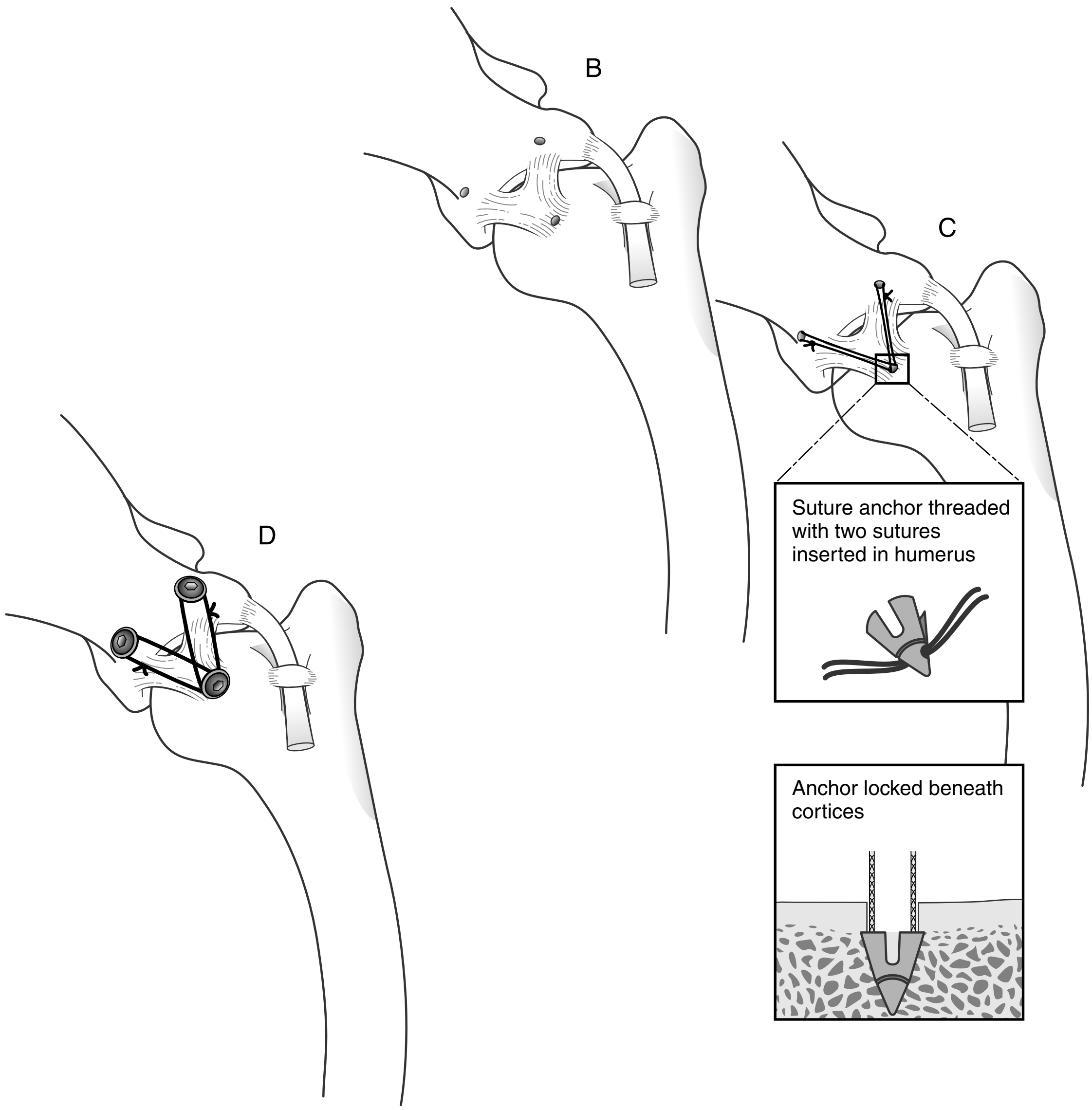
## EXPECTED OUTCOME

Outcome is good to excellent in most cases. A published case series noted minimal gait abnormalities following surgery and rehabilitation, even in the face of degenerative joint disease and joint malformation stemming from congenital shoulder luxation.[1]

### References

1. Fitch R, Breshears L, Staatz A, et al: Clinical evaluation of prosthetic medial glenohumeral ligament repair in the dog (10 cases). Vet Comp Orthop Traumatol 14:222–228, 2001.
2. Piermattei DL, Johnson KA: Approach to the craniomedial region of the shoulder joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Ringwood P, Kerwin S, Hosgood G, et al: Medial glenohumeral ligament reconstruction for ex-vivo medial glenohumeral luxation in the dog. Vet Comp Orthop Traumatol 14:196–200, 2001.

# PLATE 3


B
C
D
Suture anchor threaded with two sutures inserted in humerus
Anchor locked beneath cortices

SHOULDER

# Chapter 4 Stabilization of Lateral Shoulder Luxation

## INDICATIONS

Lateral shoulder luxations are usually traumatic in origin and occur after glenohumeral ligament and infraspinatus tendon rupture. Open reduction and stabilization is indicated if the luxation is unstable enough after closed reduction that reluxation occurs, or if the luxation is chronic.

## OBJECTIVES

- To restore normal stability, congruency, mobility, and function to the shoulder joint without altering regional anatomy

## ANATOMIC CONSIDERATIONS

Anatomic landmarks for the scapulohumeral joint are the acromion process of the scapular spine, the greater tubercle, and the acromial head of the deltoideus muscle. Anatomic landmarks for positioning the skin incision include the acromion of the scapula, the greater tubercle of the humerus, and the acromial head of the deltoideus muscle.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, wire driver, intramedullary pins or Kirschner wires, mallet, 20- to 60-pound nylon,* and a suture anchor system*

Alternatively a bone tunnel, screw, and washer combination may be used, if a suture anchor system is not available or if the animal is not large enough to accommodate the suture anchor system. Additional instrumentation needed for this technique includes a high-speed drill, bone screw and washer, drill bit, tap, depth gauge, and screwdriver.

## PREPARATION AND POSITIONING

Prepare the leg circumferentially from the dorsal midline to the carpus. Use a hanging leg preparation, with the dog in lateral recumbency, to allow for maximal manipulation of the shoulder joint during surgery. The animal is positioned in lateral recumbency with the affected leg draped.

## PROCEDURE

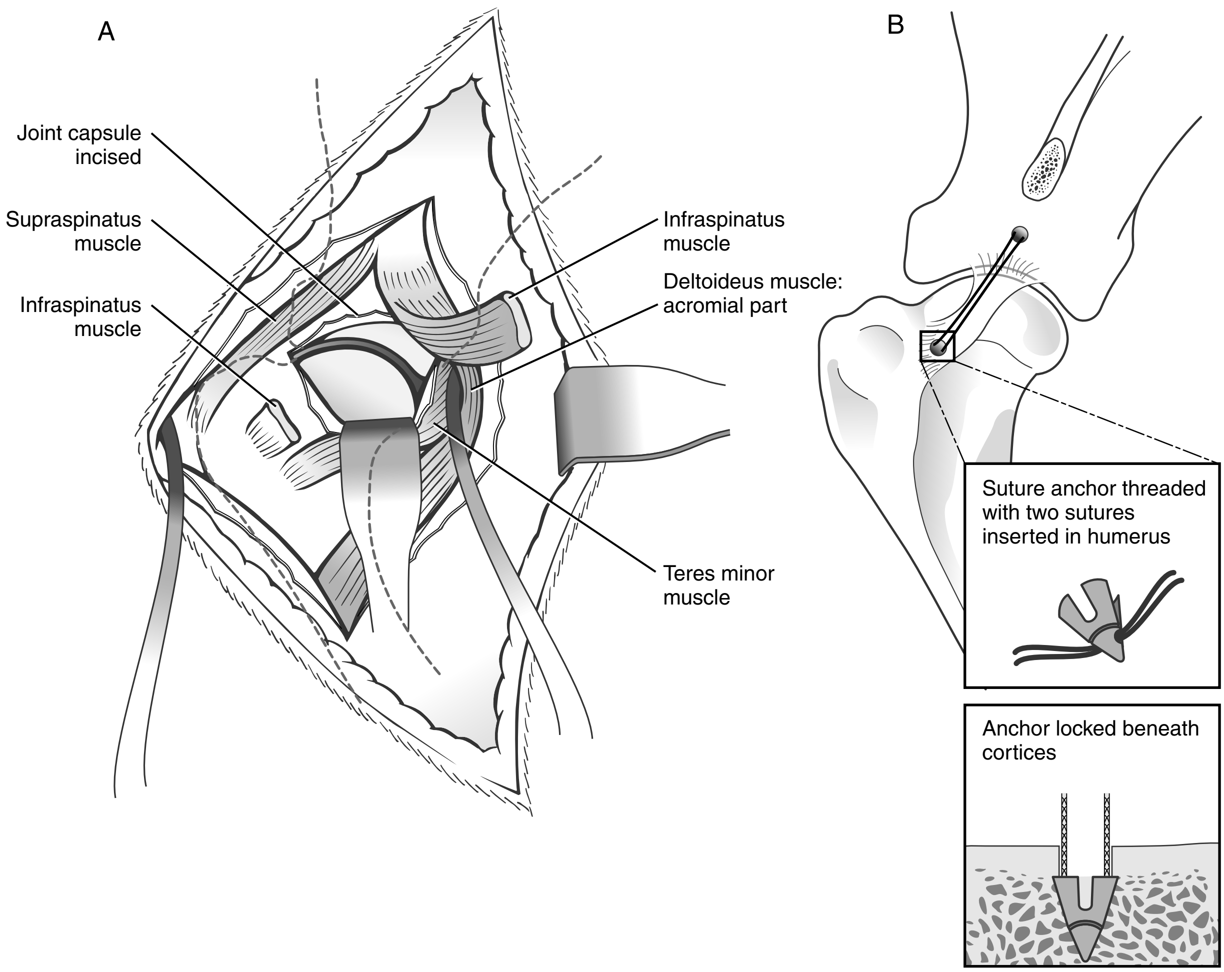
**Approach:**[1,2] Use an approach to the craniolateral region of the shoulder joint to expose the luxated joint. It may be helpful to reestablish normal anatomic relationships by reducing the joint before the approach is made. Incise the skin and subcutaneous tissue in a curvilinear fashion from the mid-scapular spine to the proximal portion of the humerus. Incise the deep fascia along the cranial border of the acromial head of the deltoideus muscle. Elevate and caudally retract the muscle with Gelpi retractors. If the infraspinatus tendon is not torn, either incise it 5 mm from its origin or perform an osteotomy of the acromial process to facilitate reattachment. Incise the joint capsule, inspect the joint, and assess the condition of the humeral head and lateral labrum of the glenoid (Plate 4A). If the labrum is worn, the prognosis for successful stabilization of the shoulder is poor and arthrodesis should be considered (see Chapter 5). Reduce the joint and identify the origin and insertion of the lateral glenohumeral ligament. Primary apposition of the torn ligament, if possible, is the method of choice for repair. If greater stability is desired, reinforcement of the repaired ligament with prosthetics may be necessary.

**Stabilization with the Suture Anchor System:**[3] Drill one hole in the distal scapula at the lateral glenohumeral ligament origin and a second hole at the ligament insertion on the proximal humerus. Insert suture anchors threaded with fishing leader line into each of these holes (Plate 4B). Tie the sutures with the limb held at a normal standing angle (approximately 135 degrees of extension) such that the sutures are taut, but not overly tight, avoiding plication of the joint capsule. Imbricate the capsule with nonabsorbable mattress sutures. Reattach the infraspinatus tendon with a three-loop pulley or locking loop suture pattern. Place the scapulohumeral joint through a range of motion and evaluate joint stability and mobility. Closure is routine.

*Continued*

*Bone Biter Suture Anchor System, Warsaw, Indiana.

# PLATE 4


A
Joint capsule incised
Supraspinatus muscle
Infraspinatus muscle
Infraspinatus muscle
Deltoideus muscle: acromial part
Teres minor muscle
B
Suture anchor threaded with two sutures inserted in humerus
Anchor locked beneath cortices

**Stabilization with a Bone Tunnel and Screw and Washer Combination:**[4] Reduce the joint, and identify the origin and insertion of the lateral glenohumeral ligament. Drill an oblique bone tunnel through the distal scapula at the origin of ligament (Plate 4C). Thread the fishing leader line through the bone tunnel. Drill, measure, and tap a bicortical screw hole in the ligament insertion on the proximal humerus. Use a screw and washer to prevent subsidence into the soft metaphyseal bone and ligature slippage. Tie the sutures in a figure-eight pattern, with the limb held at a normal standing angle (approximately 135 degrees of extension) such that the sutures are taut, but not overly tight, avoiding plication of the joint capsule (Plate 4D). Imbricate the capsule with nonabsorbable mattress sutures. Reattach the infraspinatus tendon with a three-loop pulley or locking loop suture pattern (Plate 4E). Place the scapulohumeral joint through a range of motion and evaluate joint stability and mobility. Closure is routine.

## CAUTIONS

There is a high potential for concurrent chest trauma with these injuries. Patients should be thoroughly evaluated (e.g., with electrocardiogram, thoracic radiographs, and blood work) and stabilized before initiating surgical repair.

## POSTOPERATIVE EVALUATION

The joint should be radiographed to assess implant positioning and joint congruency. Joint stability and range of motion should be evaluated at 2 and 4 weeks to assess continued need for external coaptation.

## POSTOPERATIVE CARE

The limb should be supported in a spica splint for 10 to 14 days. Passive range of motion exercises should be implemented after splint removal for the next 2 weeks, with concurrent exercise restriction. Over the following 2 weeks, the animal should slowly be returned to normal activity.

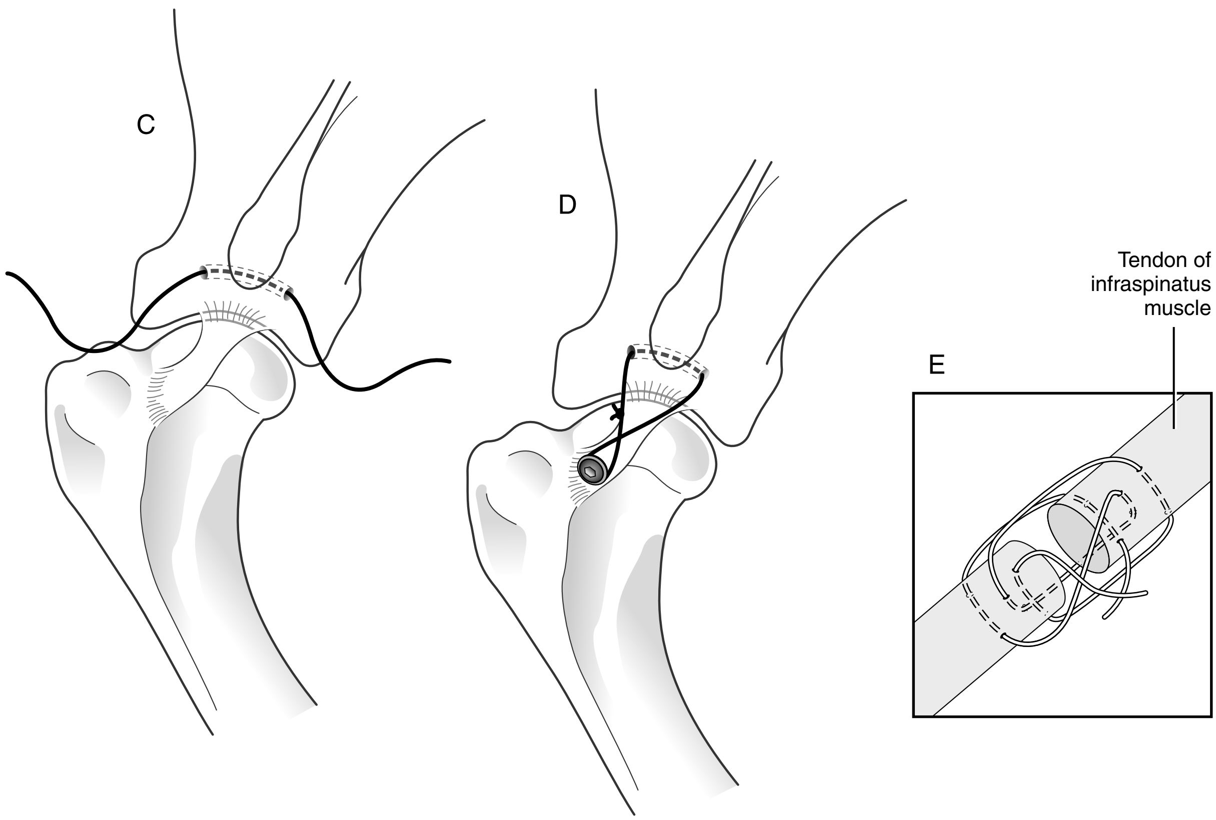
## EXPECTED OUTCOME

Outcome is usually fair to excellent, depending on the degree of trauma to the joint.

### References

1. Piermattei DL, Johnson KA: Approach to the craniolateral region of the shoulder joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Piermattei DL, Johnson KA: Approach to the lateral aspect of the humeral condyle and epicondyle. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Slocum B, Slocum TD: Suture stabilization for luxations of the shoulder. In Bojrab MJ (ed): Current Techniques in Small Animal Surgery, 4th ed. Baltimore, Williams & Wilkins, 1998.
4. Engen MH: Surgical treatment of shoulder luxations. In Bojrab MJ (ed): Current Techniques in Small Animal Surgery, 4th ed. Baltimore, Williams & Wilkins, 1998.

# PLATE 4



## SHOULDER

# CHAPTER 5 Shoulder Arthrodesis

### INDICATIONS

This procedure is used for animals with unreconstructable joint fractures, chronic shoulder luxation, or severe osteoarthritis that is refractory to medical treatment.[1]

### OBJECTIVES

- To fuse the bones of the scapulohumeral joint in a functional position

### ANATOMIC CONSIDERATIONS

The greater tubercle of the humerus and the acromion of the scapula are palpable landmarks. Osteotomy of the acromion allows reflection of a portion of the deltoideus muscle and visualization of the joint. Osteotomy of the greater tubercle also aids joint exposure and provides a flat surface for the plate. The suprascapular nerve and artery course over the scapular notch and under the acromion. The axillary artery and nerve are located immediately caudal to the joint, but these are not usually visualized with this approach.

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, oscillating saw, self-centering plate-holding forceps, high-speed drill and wire driver, Kirschner wires, wire cutter, orthopedic wire, wire twister, plating equipment, and rongeurs

### PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from dorsal midline to mid-radius. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft can be harvested from the ostectomized humeral head.

### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue over the cranial lateral aspect of the shoulder from the distal one third of the scapula to the proximal one third of the humerus. Osteotomize the acromion and retract the deltoideus muscle distally and caudally. Osteotomize the greater tubercle and elevate the supraspinatus muscle proximally. Incise the infraspinatus, teres minor, and biceps brachii tendons and the joint capsule to expose the articular surfaces (Plate 5A).[2]

**Alignment:** Predetermine the cranial caudal angle for the shoulder arthrodesis by observing the normal standing angle of the shoulder in the individual patient. This angle is commonly 110 degrees (Plate 5B).[1,2]

**Stabilization:** Remove the articular surface of the scapula with an oscillating saw directed perpendicular to the spine of the scapula. Flex the shoulder to the predetermined angle and perform an ostectomy of the humeral head. The humeral ostectomy should parallel the ostectomy surface of scapula when the shoulder is flexed to the appropriate angle (see Plate 5B). Appose the distal scapular and the proximal humeral ostectomy surfaces, and temporarily fix them with Kirschner wires (Plate 5C). Use an aluminum template to determine the cranial contour of the junction of the spine and body of the scapula and the cranial aspect of the proximal humerus. Use the bending pliers and the torque irons to contour an appropriately sized bone plate (allowing at least three screws proximally and distally to the shoulder) to match the aluminum template. Apply the plate by first placing screws through the proximal and distal plate holes. Place a lag screw through the plate and across the ostectomy surfaces (see Plate 5C). Fill the remaining plate holes, directing the proximal screws into the thick bone at the junction of the spine and body of the scapula (Plate 5D). Remove the Kirschner wires. Collect cancellous bone from the ostectomized humeral head with rongeurs and place it around the ostectomy surfaces. Reattach the biceps brachii tendon to the fascia of the supraspinatus muscle. Attach the greater tubercle to the humerus lateral to the plate with a lag screw (see Plate 5D). Wire the acromion.[1,2] Close the wound routinely.

### CAUTIONS

The suprascapular nerve and artery must be protected during the procedure, and care must be taken not to trap the nerve under the plate. Medial and lateral angulation of the saw blade should be avoided when performing the scapular and humeral articular ostectomies. Angular and rotational alignment of the limb should be checked carefully before the plate is secured.

### POSTOPERATIVE EVALUATION

The axial alignment of the limb and the angle of the arthrodesis should be observed critically. Radiographs for limb alignment and implant placement should be evaluated.

### POSTOPERATIVE CARE

A soft padded bandage should be placed around the forelimb and over the scapula to control bleeding and swelling. The arthrodesis site should be protected with a spica splint for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Barring complications, the plate should not be removed.

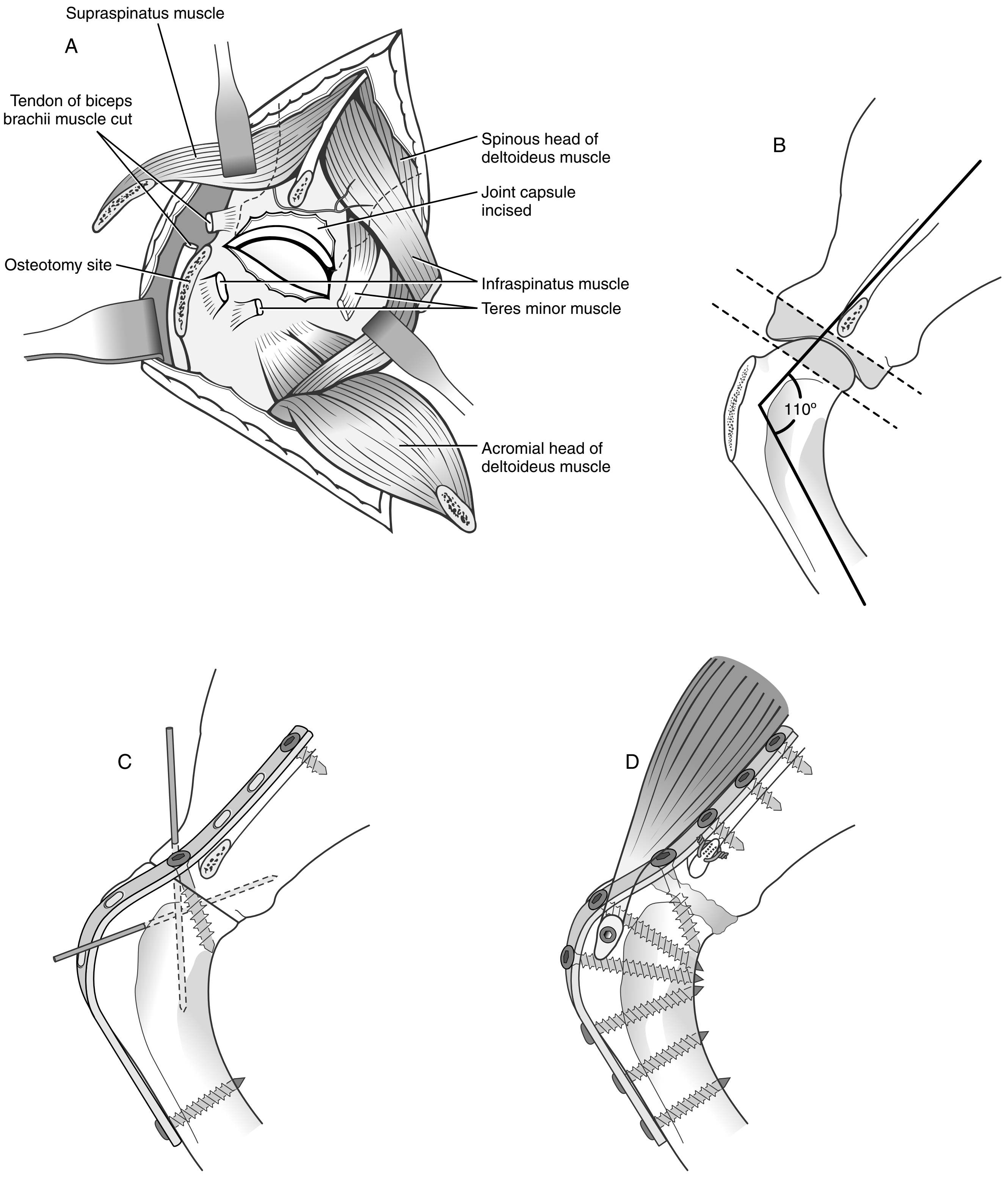
### EXPECTED OUTCOME

The bone should heal in 12 to 18 weeks. Satisfactory function of the treated limb can be expected as long as the elbow and carpus are free of disease.

#### References

1. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.
2. Piermattei DL, Flo GL: The shoulder joint. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 5


A
Supraspinatus muscle
Tendon of biceps brachii muscle cut
Osteotomy site
Spinous head of deltoideus muscle
Joint capsule incised
Infraspinatus muscle
Teres minor muscle
Acromial head of deltoideus muscle
B
110°
C
D

## ELBOW

# Chapter 6 Fragmented Medial Coronoid Process and Osteochondrosis of the Elbow

### INDICATIONS[1]

The ideal candidates for this surgery are dogs with persistent lameness that exhibit minimal degenerative changes to the joint on radiographs. Dogs with severe degenerative joint disease and persistent lameness that are not responsive to conservative management and nonsteroidal anti-inflammatory drugs may also benefit from joint exploration, loose fragment excision, and osteophyte curettage.

### OBJECTIVES

- To improve function and limit pain stemming from osteoarthritis and elbow incongruity

### ANATOMIC CONSIDERATIONS[2]

The elbow joint is exposed through a medial approach. The medial epicondyle and the pronator teres and flexor carpi radialis muscles are key anatomic landmarks for this approach. The median nerve, brachial artery, and ulnar nerve are located just proximal to the epicondyle. The median nerve and brachial artery and vein course cranially to the medial epicondyle. The ulnar nerve courses caudally to the medial epicondyle, over the anconeus muscle.

### EQUIPMENT

- Standard surgical pack, a small Frazier suction tip (size 8 or 10), two baby Gelpi retractors, bone curettes, osteotome and mallet, periosteal elevator, Lempert rongeur, pin chuck or high-speed wire driver, Kirschner wires or small Steinmann pin for forage, and an Ochsner forceps

### PREPARATION AND POSITIONING

Prepare the limb from shoulder to carpus. Position the dog in dorsal recumbency, with the affected limb suspended for draping. Then release the limb to allow access to the medial surface of the elbow.

### PROCEDURE

**Approach:**[2] Incise the skin from just proximal to the medial epicondyle to the proximal radius. Incise the subcutaneous fat and fascia along the same lines. Identify the separation between the flexor carpi radialis and the superficial digital flexor tendon by counting the muscle bellies from cranial to caudal, starting with the pronator teres. Separate the muscles via blunt dissection, paying close attention to the muscular branch of the ulnar artery and vein. Expose the joint capsule and incise it parallel to the muscle-splitting incision to expose the coronoid process. Insert the baby Gelpi retractors into the joint to facilitate visualization (Plate 6A).

**Joint Exploration:** Identify the fragmented coronoid process and any osteochondrotic or kissing lesions on the medial humeral condyle. Remove the coronoid fragment with rongeurs or osteotome and mallet so that the base of the medial coronoid process is level with that of the radial head (Plate 6B). This eliminates excessive forces on the medial coronoid process that are present when incongruities in radial and ulnar length exist.[3,4]

**Osteochondrosis Curettage:** Remove the cartilage flap with thumb or Ochsner forceps. Probe the remaining cartilage surrounding the defect with a curette, and remove any abnormal cartilage not adherent to the subchondral bone (Plate 6C).

**Forage:** Using a small Kirschner wire or small Steinmann pin, penetrate the sclerotic subchondral bone in multiple sites until it bleeds. Lavage the joint copiously, and close the joint capsule and wound in a routine fashion.

### CAUTIONS

A muscular branch of the recurrent ulnar artery and vein is present in the intermuscular septum between the flexor carpi radialis and deep digital flexor muscles. Strict hemostasis of these intermuscular vessels is imperative for adequate visualization within the joint.

### POSTOPERATIVE EVALUATION

No specific postoperative evaluation is required.

### POSTOPERATIVE CARE

The limb should be bandaged after surgery for 2 to 3 days to prevent swelling and to provide soft-tissue support. Exercise should be restricted for 4 weeks (e.g., kennel confinement when not under direct observation; walks outside on leash only to urinate/defecate; no running, jumping, or playing). Over the following 4 weeks, the animal should slowly return to normal activity.

### EXPECTED OUTCOME[1,5]

The outcome is usually guarded to good. Multiple clinical studies have found that surgical treatment does not halt the progression of degenerative joint disease. Continued nonsteroidal anti-inflammatory therapy may be required in some patients, especially those with advanced degenerative joint disease.

#### References

1. Read R, Armstrong S, Black A, et al: Relationship between physical signs of elbow dysplasia and radiographic score in growing rottweilers. J Am Vet Med Assoc 209:1427–1430, 1996.
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4. Wind AP, Packard ME: Elbow incongruity and developmental elbow diseases in the dog: Part II. J Am Anim Hosp Assoc 22:725–731, 1986.
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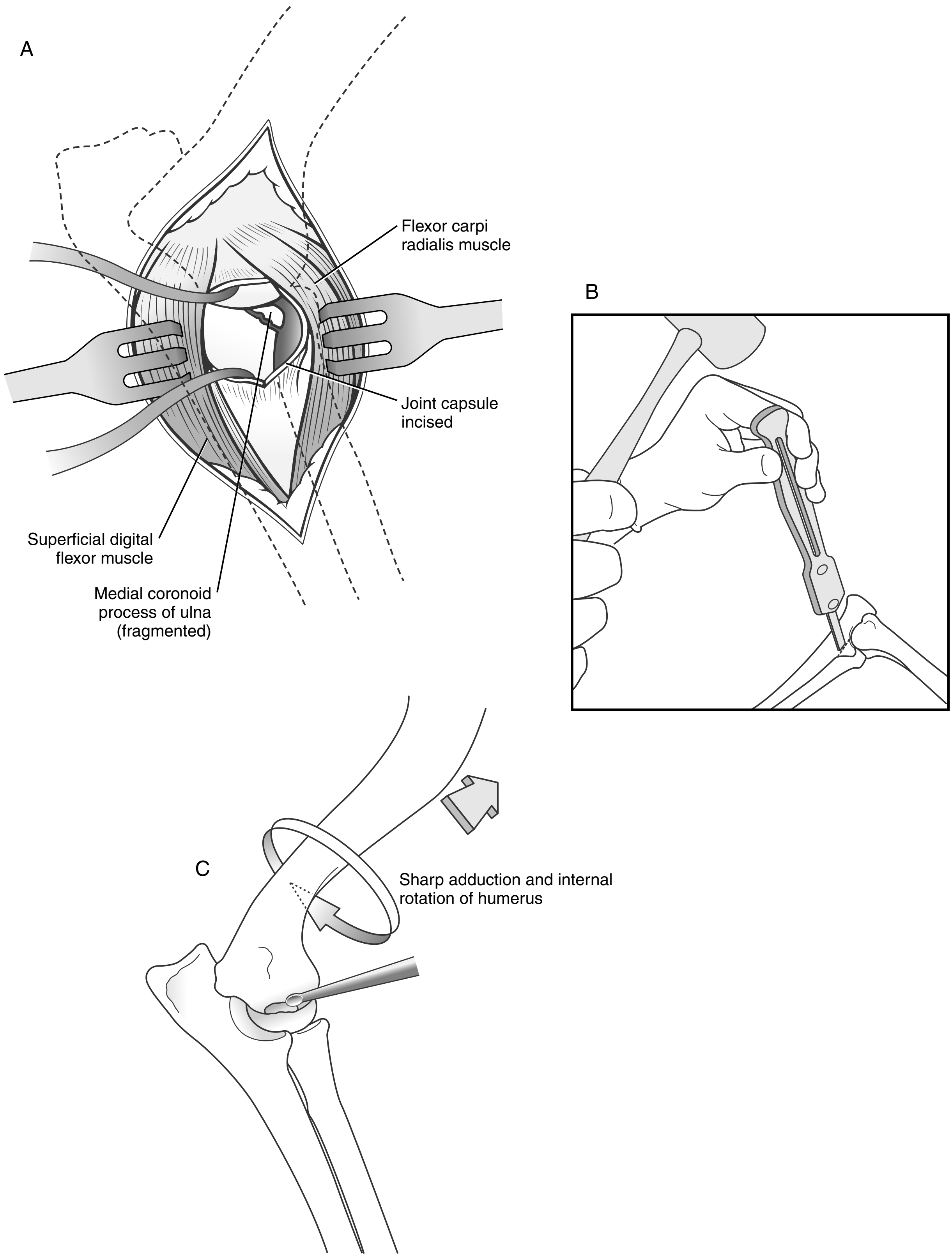
# PLATE 6


A
Flexor carpi radialis muscle
Joint capsule incised
Superficial digital flexor muscle
Medial coronoid process of ulna (fragmented)
B
C
Sharp adduction and internal rotation of humerus

## ELBOW

# CHAPTER 7 Stabilization of Lateral Elbow Luxation

### INDICATIONS[1]

The indications for open reduction of luxated elbows include Monteggia fractures; acute luxations that cannot be reduced by closed manipulation because of instability, bony fragments, or hematomas; failed closed reductions; and chronic luxations with muscle contracture and capsule fibrosis.

### OBJECTIVES

- To reestablish normal joint orientation and stability while preserving functional pain-free range of motion of the elbow joint

### ANATOMIC CONSIDERATIONS[2]

More than 90% of traumatic elbow luxations are lateral because of the large medial epicondylar ridge of the humerus and the distal slope of the medial epicondyle. A limited lateral approach to the elbow is used. Anatomic landmarks for open reduction are the lateral humeral condyle, the olecranon and anconeal processes, and the radial head. A deep branch of the radial nerve courses proximally to the cranial border of the extensor carpi radialis muscle. A superficial branch of the radial nerve is located between the lateral head of the triceps and the brachialis muscle, and this must be protected in the proximal portion of the incision.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, two small Hohmann retractors, wire driver, intramedullary pins or Kirschner wires, mallet, and a suture anchor system*

If a suture anchor system is not available or if the animal is not large enough to accommodate the suture anchor system, a screw and washer combination may be used. Additional instrumentation needed for this technique includes high-speed drill, bone screw and washer, drill bit, tap, depth gauge, and screwdriver.

### PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to the carpus. Use a hanging leg preparation with the dog in lateral recumbency to allow for maximal manipulation of the shoulder joint during surgery. The animal is positioned in lateral recumbency with the affected leg draped.

### PROCEDURE

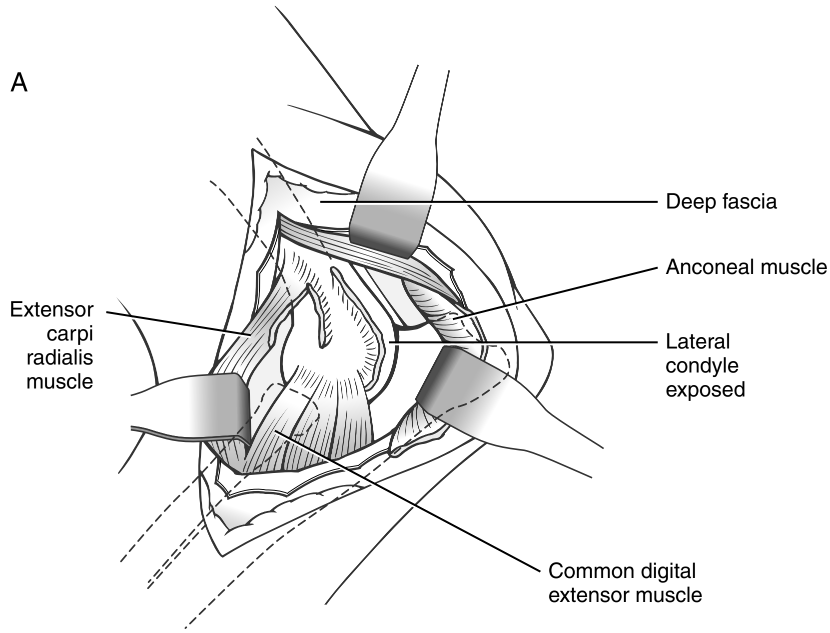
**Approach:**[2,3] Incise the skin and subcutaneous tissue over the lateral condyle, from the distal humerus to the proximal radius. Incise the deep brachial and antebrachial fascia to expose the lateral head of the triceps. Continue the incision though the deep fascia on the cranial border of the triceps and extend it distally over the extensor muscles of the antebrachium. Retract the muscles to expose the lateral condyle. Incise the periosteal origin of the anconeal muscle to expose the caudolateral compartment of the elbow. If additional exposure to the joint is necessary to visualize the radial head, a craniolateral compartment can be made. Incise the periosteal origin of the extensor carpi radialis, and extend this incision distally along the intermuscular septum between the extensor carpi radialis and the common digital extensor muscle. Elevate the extensor carpi radialis muscle from the bone and enter the joint (Plate 7A).

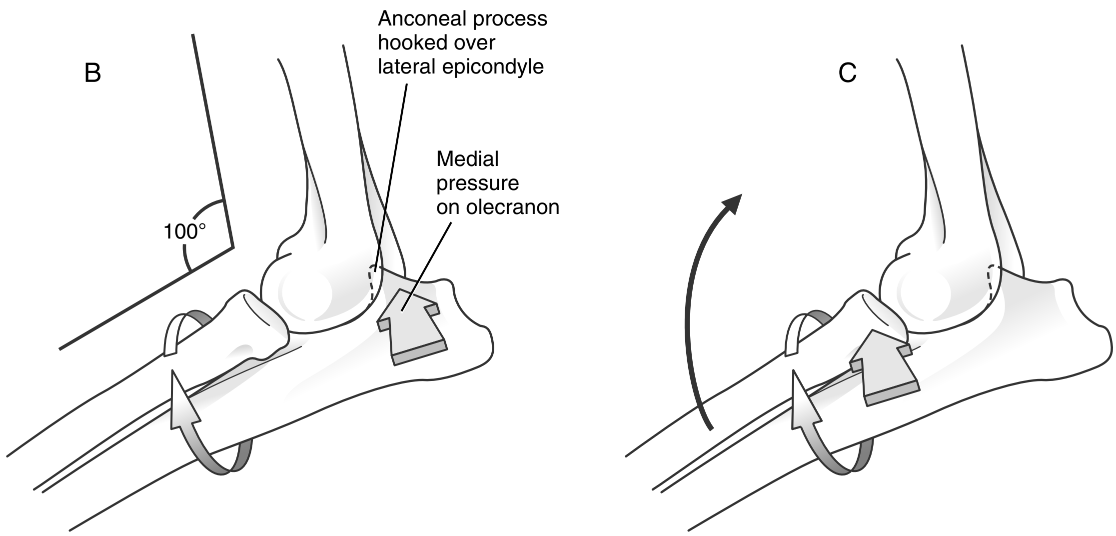
**Reduction:**[4,5] Reduce the elbow by hooking the anconeal process into the lateral condyle and restoring radiohumeral joint orientation (Plate 7B). First, flex the elbow about 100 degrees and inwardly rotate the antebrachium. Next, hook the anconeal process over the lateral condyle and slightly extend the elbow. While placing lateral to medial pressure over the head of the radius, reduce the radial head under the humeral capitulum. Abduct and inwardly rotate the antebrachium and into the fully reduced position (Plate 7C). Try to protect the cartilage during reduction. If the muscle contraction and subsequent overriding are severe, a blunt periosteal elevator can be used to gently lever the radial head into position. If reduction is not achieved, perform an olecranon osteotomy to eliminate the pull of the triceps muscle. After reduction, flush the joint and assess stability.

*Continued*

*Bone Biter Suture Anchor System, Warsaw, Indiana.

# PLATE 7


A
Deep fascia
Anconeal muscle
Extensor carpi radialis muscle
Lateral condyle exposed
Common digital extensor muscle


B
Anconeal process hooked over lateral epicondyle
Medial pressure on olecranon
100°
C

**Collateral Ligament Repair:** Identify the torn lateral collateral ligament. If possible, primary repair of the torn ligament should be attempted. Appose the torn ends of the ligament with a locking loop or three-loop pulley suture pattern. Reattach avulsed ligaments with a bone screw and spiked Teflon washer (Plate 7D). If needed, ligamentous repair may be supplemented with suture anchors with either heavy (No. 1 or No. 2) nonabsorbable suture or two screws and a figure-eight wire (Plate 7E). Check the joint for stability and range of motion. If additional stability is necessary, consider medial collateral ligament repair.

## CAUTIONS

There is a high potential for concurrent chest trauma with these injuries. Patients should be thoroughly evaluated (e.g., with electrocardiogram, thoracic radiographs, and blood work) and stabilized before initiating surgical repair. As soon as the patient is stabilized, reduction, repair, or both should be attempted.

## POSTOPERATIVE EVALUATION

The joint should be radiographed to assess implant positioning and joint congruency. Joint stability and range of motion should be evaluated at 2 and 4 weeks to assess continued need for external coaptation.

## POSTOPERATIVE CARE

The limb should be supported in a spica splint for 10 to 14 days. Passive range of motion exercises should be implemented after splint removal for the next two weeks with concurrent exercise restriction. Over the following 2 weeks, the animal should slowly return to normal activity.

## EXPECTED OUTCOME[1]

The usual outcome is fair to excellent. Most dogs have good limb function after surgical reduction. Smaller, less active dogs have a better prognosis than do larger, more active dogs. Common complications following surgery included degenerative joint disease and decreased range of joint motion.

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1. Schaeffer IGF, Wolvekamp P, Meij BP, et al: Traumatic luxation of the elbow in 31 dogs. Vet Comp Orthop Traumatol 12:33–39, 1999.
2. Piermattei DL, Johnson KA: Approach to the lateral aspect of the humeral condyle and epicondyle. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Piermattei DL, Johnson KA: Approach to the lateral humeroulnar part of the elbow joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
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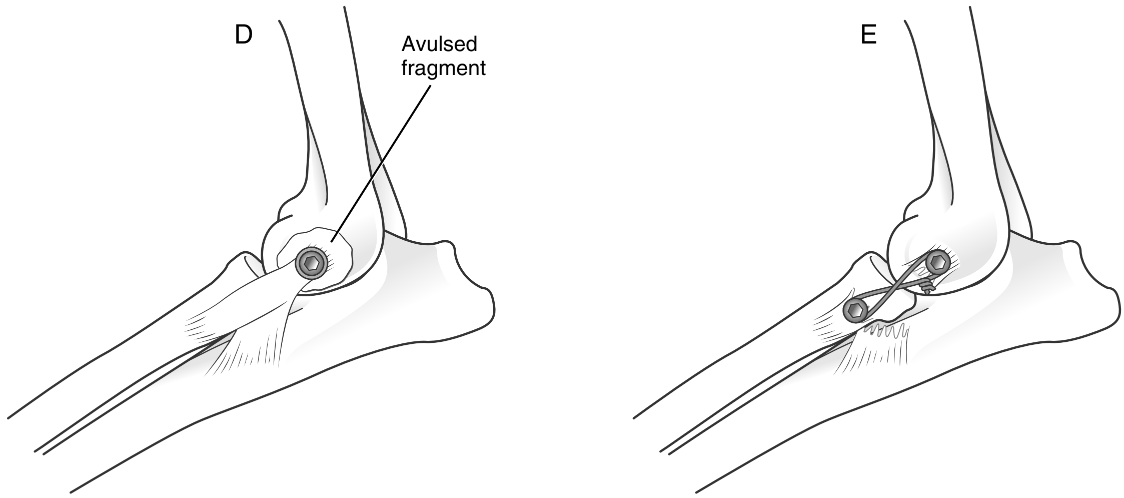
5. Piermattei DL, Flo GL: Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 7



## ELBOW

# CHAPTER 8 Treatment of Ununited Anconeal Process via Removal, Lag-Screw Fixation, and Dynamic Proximal Ulnar Osteotomy

## INDICATIONS[1–4]

Surgery is the treatment of choice for dogs older than 5 months with failure to form an osseous union between the anconeal process and the ulna. Medical therapy alone has been associated with a rapid progression of severe degenerative joint disease (DJD) and lameness. Three surgical treatment options have been reported: surgical excision, lag-screw fixation, and dynamic proximal ulnar osteotomy (DPUO). Considerable controversy exists regarding the best course of therapy. DPUO is recommended in dogs with minimal DJD and ununited anconeal process (UAP) that is tightly adhered to the ulna. Lag-screw fixation of the UAP, followed by concurrent DPUO, is recommended in dogs with minimal DJD and a loose anconeal process and an incongruent joint as found by evaluation of the joint via arthrotomy or arthroscopy. Surgical excision is generally reserved as a salvage procedure for dogs with severe DJD and UAP.

## OBJECTIVES[1,2]

- To improve joint congruity, encourage fusion of the anconeal process, and prevent DJD by DPUO and lag-screw fixation. Surgical excision is considered a salvage procedure aimed at eliminating the irritation caused by the UAP

## ANATOMIC CONSIDERATIONS[5,6]

Exposure of the anconeal process for either lag-screw fixation or excision is made via a caudolateral approach. Anatomic landmarks for the elbow are the lateral humeral condyle, the olecranon and anconeal processes, and the radial head. A deep branch of the radial nerve courses proximally to the cranial border of the extensor carpi radialis muscle. A superficial branch of the radial nerve is located between the lateral head of the triceps and the brachialis muscle, and this must be protected in the proximal portion of the incision. For a DPUO, a caudal approach to the proximal ulnar diaphysis is used. The landmark for ulnar osteotomy is the caudal border of the proximal ulna.

## EQUIPMENT

- Standard surgical pack, a Frazier suction tip, two medium Gelpi retractors, pointed reduction forceps, periosteal elevator, high-speed wire driver/drill/oscillating saw, aiming device, Kirschner wires or small Steinmann pins, plating equipment, bone curettes, osteotome and mallet, Lempert rongeur, and two Hohmann retractors

## PREPARATION AND POSITIONING

Prepare the limb from shoulder to carpus. Position the dog in dorsal recumbency with the affected limb suspended for draping. Then release the limb to allow access to the lateral and caudal surfaces of the elbow.

## PROCEDURE

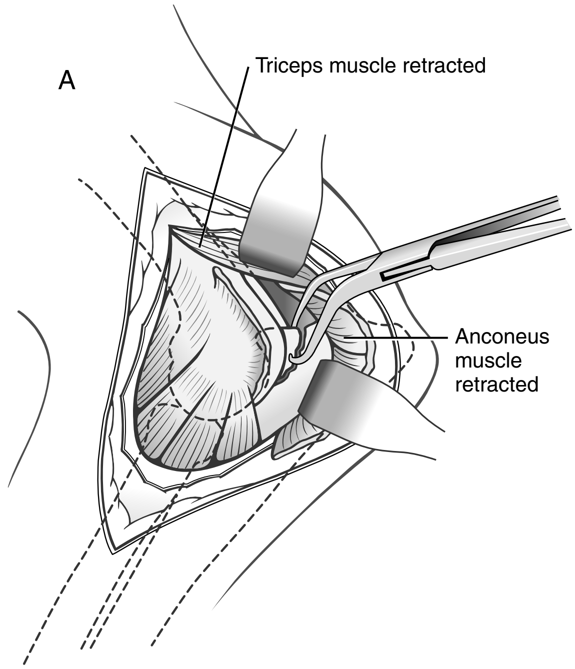
**Caudolateral Approach:[6]** Incise the skin and subcutaneous tissue over the lateral condyle, from the distal humerus to the proximal radius. Incise the deep brachial and antebrachial fascia to expose the lateral head of the triceps. Continue the incision though the deep fascia on the cranial border of the triceps and extend it distally over the extensor muscles of the antebrachium. Retract the muscles to expose the lateral condyle. Incise the periosteal origin of the anconeal muscle to expose the caudolateral compartment of the elbow and enter the joint through a capsular incision.

**Caudal Approach to the Proximal Ulna:[5]** Incise the skin and subcutaneous tissue along the shaft of the ulna from the tuber olecrani to the proximal midshaft region. Incise the periosteum of the flexor carpi ulnaris and the anconeus, continuing distally along the ulnaris lateralis muscle. Place the Hohmann retractors between the radius and ulna just distal to the medial and lateral coronoids to retract the tissues and visualize the ulna.

**Ununited Anconeal Process Excision:[4]** Flex the elbow joint fully to expose the anconeal process. Grasp the floating process with pointed reduction or tissue forceps and remove (Plate 8A). If the process is adherent to the ulna, sever the fibrous attachments with a periosteal elevator or osteotome and mallet.

*Continued*

# PLATE 8



**Ununited Anconeal Process Lag-Screw Stabilization:**[2,3,7] Reduce and maintain the UAP with the ulna using pointed reduction forceps (Plate 8B). Insert a Kirschner wire into the proximal quadrant of the anconeal process, passing perpendicular to the cleavage line and exiting 1 mm to 2 mm beyond the articular margin. Use this pin as a reference point to guide lag-screw positioning; it will be removed once the anconeal process is secured. Drill the screw hole from the caudal cortex of the ulna, parallel to the K-wire, and exiting at the point of the anconeal process (Plate 8C). Alternatively, an aiming device can be used to ensure accurate screw placement (Plate 8D). Secure the anconeal process with either a 2.7-mm or 3.5-mm cortical screw placed in lag fashion or a partially threaded 4.0 cancellous screw. Insert an additional Kirschner wire parallel to the screw to ensure rotational stability. Remove the first Kirschner wire that is penetrating the joint. Closure is routine.

**Dynamic Proximal Ulnar Osteotomy:**[1–3,8] Using an oscillating saw or Gigli wire, cut the bone distal to proximal at a 20- to 30-degree angle to the long axis of the ulna shaft. When the osteotomy is complete, the ulna should separate 2 mm to 4 mm spontaneously. Stabilize the ulna with a small intramedullary pin (Plate 8E). If not separated, lever the bone ends with a periosteal elevator to release the interosseus ligament. Closure is routine.

## CAUTIONS

Lag-screw fixation for UAP is technically difficult. Correct positioning of the lag screw is imperative. Incorrect drillings can result in failure because of penetration of the joint as a result of the small size of the anconeal process.

## POSTOPERATIVE EVALUATION

The joint should be placed through a thorough range of motion before closure. Postoperative radiographs are indicated to verify complete UAP excision, joint congruency, and/or implant and osteotomy position. Radiographs should be repeated every 4 to 6 weeks until the UAP is healed.

## POSTOPERATIVE CARE

All patients should be placed in a soft padded bandage for 2 to 3 days to prevent seroma formation. Exercise should be restricted until healing of the UAP is confirmed by radiograph. Exercise should be restricted for 2 to 4 weeks in dogs with surgical excision of the UAP.

## EXPECTED OUTCOME[2,3,8]

Surgical excision of the UAP is associated with a variable prognosis, with 70% of the patients improving in the immediate postoperative period. However, only 50% of the dogs were free of lameness on long-term follow-up examination, and moderate to severe DJD can be expected because of the inherent instability of the elbow following removal of the anconeal process and because of the preexisting joint pathology. The expected outcome is better in dogs with DPUO and/or lag-screw fixation. The reported clinical outcome is good to excellent for these animals, with fusion of the anconeal process and minimal to no progression of DJD expected.

### References

1. Turner BM, Abercromby RH, Innes J, et al: Dynamic proximal ulnar osteotomy for the treatment of ununited anconeal process in 17 dogs. Vet Comp Orthop Traumatol 11:76–79, 1998.
2. Meyer-Lindenberg A, Fehr M, Nolte I: Short- and long-term results after surgical treatment of an ununited anconeal process in the dog. Vet Comp Orthop Traumatol 4:101–110, 2001.
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5. Piermattei DL, Johnson KA: Approach to the proximal shaft and trochlear notch of the ulna. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
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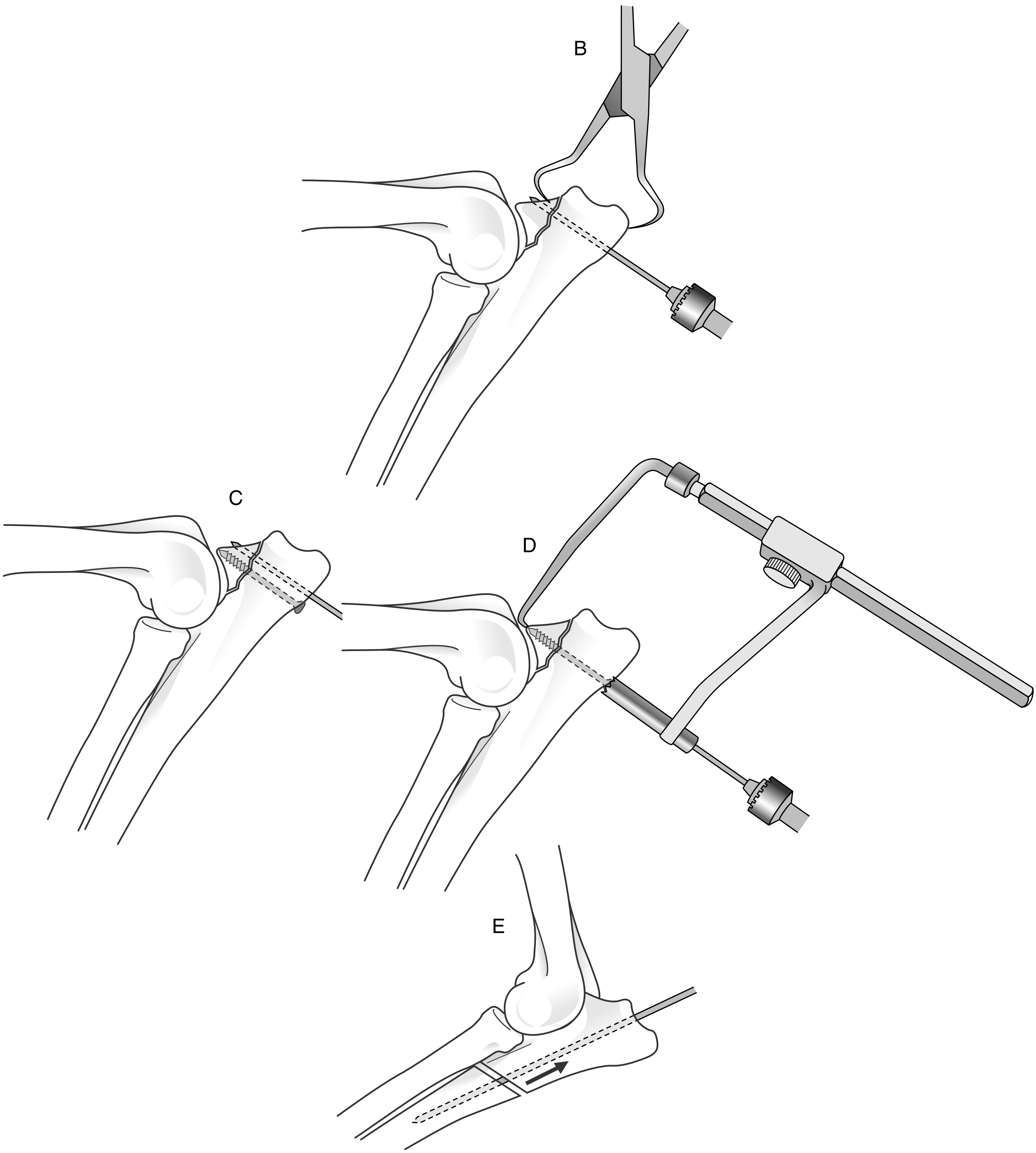
## PLATE 8



## ELBOW

# Chapter 9 Distal Ulnar Ostectomy with Fat Graft

### INDICATIONS[1–3]
Distal ulnar ostectomy is indicated as an early corrective surgery for premature closure of the distal ulnar physis, before the appearance of severe angular limb deformities. This procedure is most effective in young dogs (median age, 5 months) with less than 25 degrees of carpal valgus or in older animals (medial age, 6.5 months) with less than 13 degrees of valgus.

### OBJECTIVES
- To prevent or correct angular limb deformity, limb shortening, abnormal load transmission, and joint subluxation

### ANATOMIC CONSIDERATIONS
A caudal approach to the distal ulnar diaphysis is used. Landmarks for the ostectomy are the caudolateral border of the distal third ulna, the tendons of the lateral digital extensor, the ulnaris lateralis, the deep digital flexor muscles, and the abductor pollicis longus muscle.

### EQUIPMENT
- Standard surgical pack, a Frazier suction tip, one Gelpi retractor or two Senn retractors, two Hohmann retractors, periosteal elevator, high-speed oscillating saw or Gigli wire, and Lempert rongeur

### PREPARATION AND POSITIONING
Prepare the limb from shoulder to just distal to the carpus. Position the dog in dorsal or lateral recumbency, with the affected limb suspended for draping. Then release the limb to allow access to the caudolateral aspect of the antebrachium. Prepare the caudal abdominal/inguinal region for fat graft harvest.

### PROCEDURE
**Approach:**[4] Incise the skin and subcutaneous tissue along the shaft of the ulna, from the midshaft of the diaphysis to the styloid process. Incise the antebrachial fascia between the ulnaris lateralis and the lateral digital extensor tendons, exposing the periosteal surface of the ulna. Use a periosteal elevator to elevate the surround musculature, and place the Hohmann retractors between the radius and ulna at the proposed osteotomy site.

**Distal Ulnar Ostectomy:**[1,3] Using an oscillating saw or Gigli wire, cut the bone perpendicular to the longitudinal axis of the ulna (Plate 9A). Remove a 1-cm to 2-cm section of the ulna, and add a fat graft. Close the subcutaneous tissue and skin over the ostectomy site (Plates 9B and 9C).

**Fat Graft Harvest:**[2,5] Incise the skin and subcutaneous tissue in the cranial inguinal/caudal abdominal region. Harvest a fat graft of sufficient size to fill the defect, and place in the gap created by the ostectomy (Plate 9D). Closure is routine.

### CAUTIONS[2,5]
The periosteum must be completely removed with the ostectomized bone, because it will form a premature bony union if left in situ. Hemostasis is imperative to ensure that large blood clots do not fill the defect and promote connective tissue replacement. The fat graft should be harvested atraumatically in one piece, and should be of a size that is adequate to fill the ostectomy site. This will minimize the amount of graft necrosis and shrinkage.

### POSTOPERATIVE EVALUATION
Postoperative radiographs are indicated to verify ostectomy position and the complete removal of periosteum. To monitor ostectomy healing, joint congruity, and angular limb deformity, radiographs should be repeated every 4 to 6 weeks until radial bone growth is complete. Once bone growth is complete, corrective osteotomies can be performed if necessary.

### POSTOPERATIVE CARE[2]
All patients should be placed in a soft padded bandage for 2 to 3 days to prevent seroma formation. Exercise should be restricted for at least 6 to 8 weeks, until the full effect of the distal ulnar ostectomy is achieved. Excessive movement of the ostectomy site inhibits graft vascularization and may result in displacement and subsequent premature union of the ulna.

### EXPECTED OUTCOME[6]
The outcome is usually good to excellent. Younger dogs with less severe angular limb deformities have better functional results after distal ulnar ostectomy than do older dogs with severe angulation and joint subluxation. The mean age at surgery of dogs with good to excellent results is 6.5 months, contrasted to the mean age at surgery of 9.75 months in dogs with fair to poor results.

#### References
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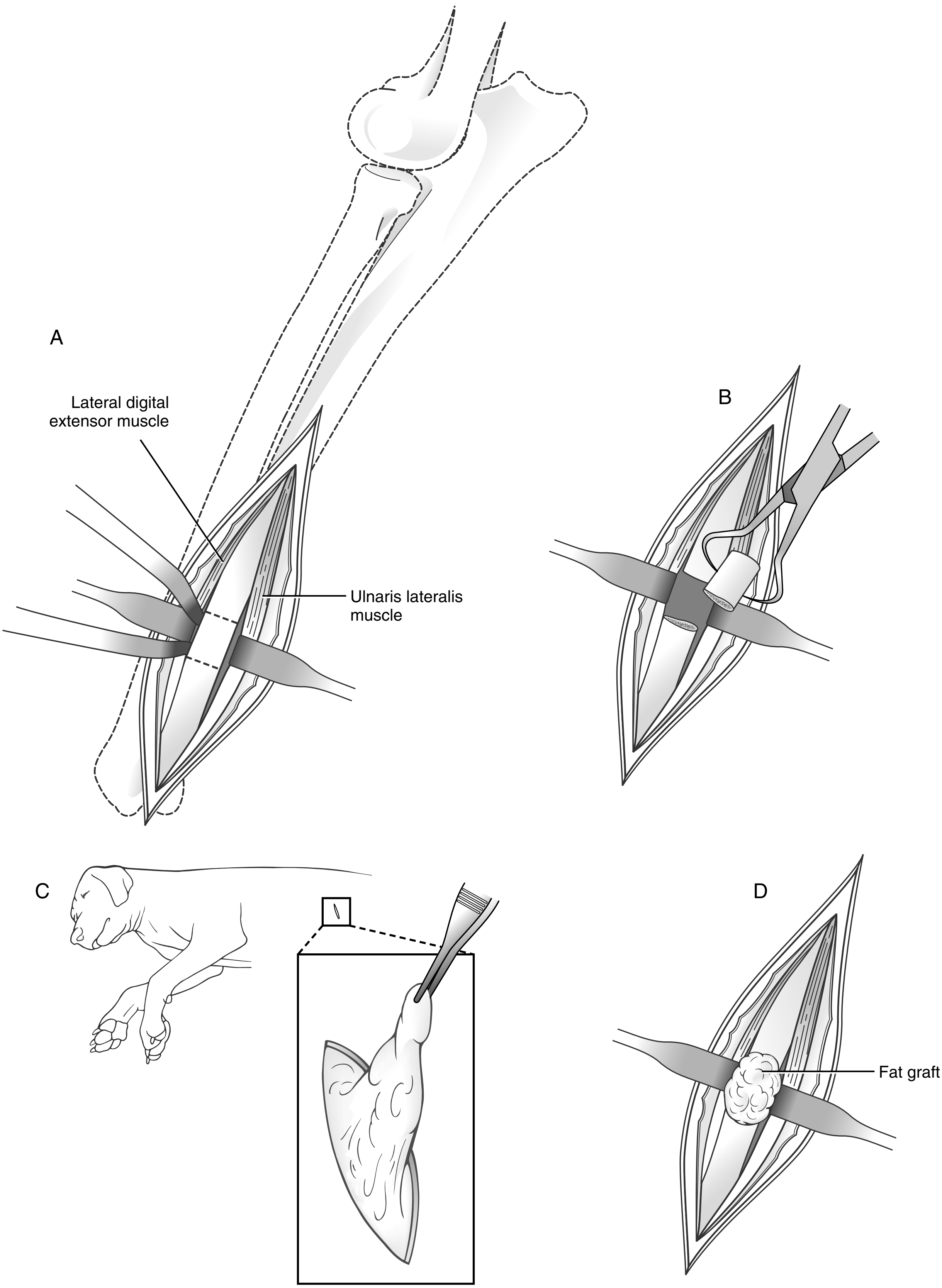
# PLATE 9


A
Lateral digital
extensor muscle
Ulnaris lateralis
muscle
B
C
D
Fat graft

# ELBOW

# CHAPTER 10 Elbow Arthrodesis

## INDICATIONS

This procedure is indicated in animals with unreconstructable joint fractures, chronic elbow luxation or subluxation, or severe degenerative joint disease that is not responsive to medical treatment.

## OBJECTIVES

- To fuse the bones of the humeroradial and humeroulnar joints in a functional position

## ANATOMIC CONSIDERATIONS

The triceps muscle courses in a cranial proximal direction from its insertion on the olecranon, and crosses the humerus rather than running parallel to it. The radial nerve lies beneath the lateral head of the triceps near the distal third of the humerus. The ulnar nerve courses over the medial aspect of the elbow, caudal to the medial epicondyle, and an olecranon osteotomy aids joint exposure. A proximal ulnar ostectomy provides a flat surface for the plate.

## EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, oscillating saw, bone curette, self-centering plate-holding forceps, high-speed drill, burrs and wire driver, Kirschner wires, wire cutters, plating equipment

## PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb elevated. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft can be harvested from the ipsilateral proximal humerus.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue on the caudal lateral aspect of the elbow from the distal one third of the humerus to the proximal one third of the ulna. Elevate the anconeus muscle from the olecranon. Osteotomize the olecranon process, and retract the triceps muscle proximally to expose the caudal surface of the distal humerus. Elevate the flexor carpi ulnaris and deep digital flexor muscles medially and the ulnaris lateralis muscle laterally to expose the proximal ulna. Reflect the origin of the flexor carpi ulnaris muscle to expose the trochlear notch. Incise the ulnaris lateralis, lateral collateral ligament, and joint capsule to expose the articular surfaces (Plate 10A).

**Alignment:** Predetermine the cranial caudal angle for the elbow arthrodesis by observing the normal standing angle of the elbow in the individual patient (commonly 110 degrees) (Plate 10B).[1,2]

**Stabilization:** Remove the articular cartilage of the humeral condyle, radial head, and trochlear notch with a bone curette or high-speed burr, following the contours of the bone ends. Perform an ostectomy of the proximal ulna to create a smooth surface for the plate (see Plate 10B). Temporarily fix the distal humeral condyle to the trochlear notch with a Kirschner wire (Plate 10C). Use an aluminum template to determine the contour of the caudal surfaces of the distal humerus and proximal ulna. Use the bending pliers and the torque irons to contour an appropriate-size bone plate (allowing at least four screws proximally and distally to the elbow) to match the aluminum template. Apply the plate by first placing screws through the proximal and distal plate holes. Place a lag screw through the plate and across the lateral portion of the humeral condyle into the radial head. Place a second lag screw through the plate across the ulna and into the medial portion of the humeral condyle (see Plate 10C). Fill the remaining plate holes. Screws placed through the ulna should penetrate the radius, if possible. Remove the temporary Kirschner wire. Reattach the osteotomized portion of the olecranon to the medial epicondyle with a lag screw (Plate 10D).[1,2] Collect cancellous bone from the proximal humerus and place it around the ostectomy surfaces. Close the wound routinely.

## CAUTIONS

The radial and ulnar nerves must be protected. All articular cartilage must be removed. Angular and rotational alignment of the limb must be checked carefully before the plate is secured.

## POSTOPERATIVE EVALUATION

The axial alignment of the limb and the angle of the arthrodesis should be observed critically. Radiographs should be evaluated for limb alignment and implant placement.

## POSTOPERATIVE CARE

A soft padded bandage should be placed to control bleeding and swelling. A lateral splint should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined and activity should be limited to leash walks until bone healing is complete. The plate may be removed 6 to 9 months after bone healing if it causes soft tissue irritation.

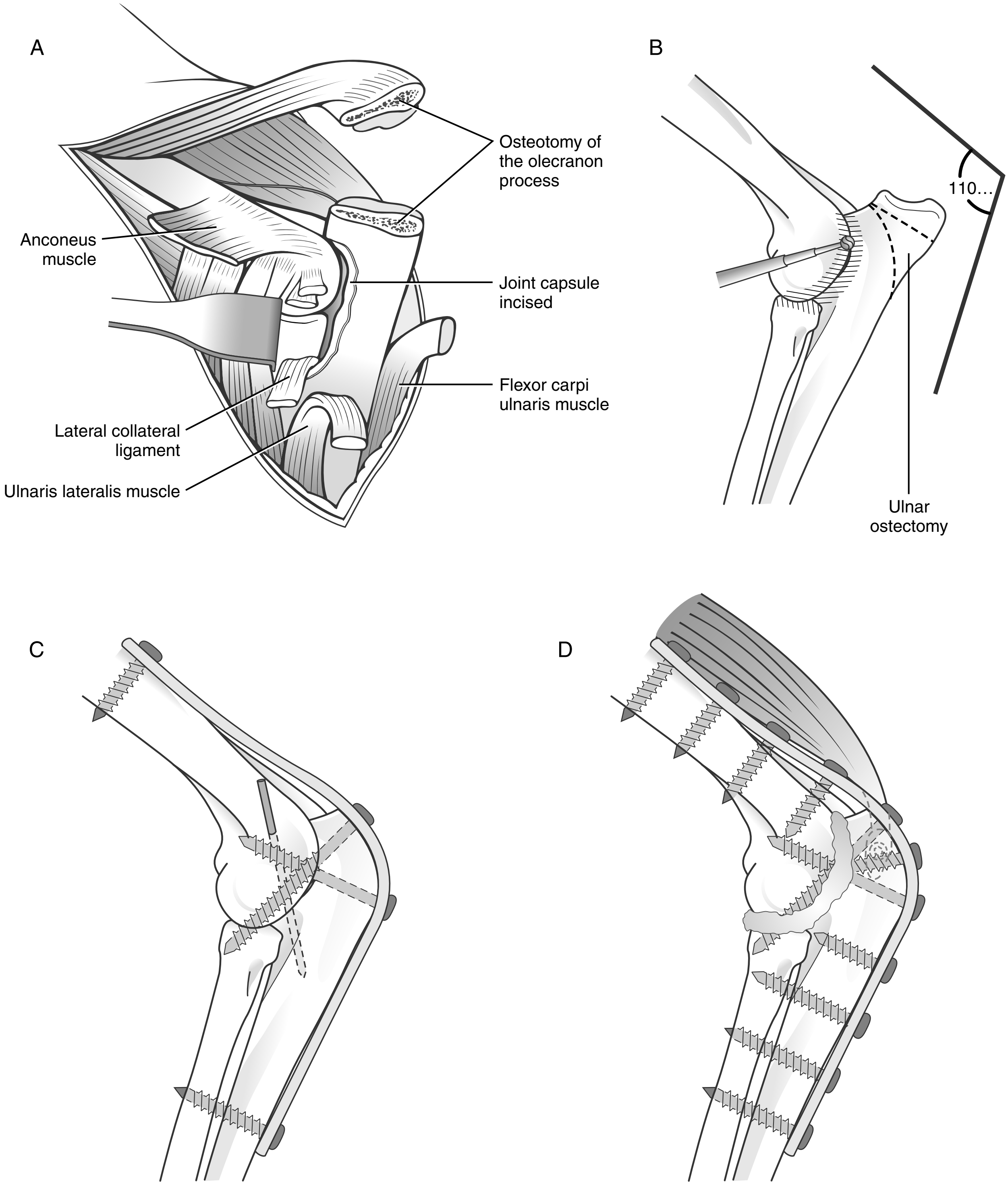
## EXPECTED OUTCOME

The bone usually heals in 12 to 18 weeks. Function of the treated limb can be awkward, and the animal may have trouble with stairs or with rough terrain.[1] Amputation may offer better function.[2]

### References

1. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.
2. Piermattei DL, Flo GL: The elbow joint. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 10


A
Osteotomy of the olecranon process
Anconeus muscle
Joint capsule incised
Flexor carpi ulnaris muscle
Lateral collateral ligament
Ulnaris lateralis muscle
B
110…
Ulnar ostectomy
C
D

## CARPUS

# CHAPTER 11 Radial and Ulnar Styloid Fractures

### INDICATIONS

Candidates include dogs with avulsion fractures of one or both styloid processes.

### OBJECTIVES

- To restore normal joint orientation and stability to the antebrachial carpal joint

### ANATOMIC CONSIDERATIONS[1–4]

The antebrachial carpal joint is formed by the radius and the styloid process of the ulna, articulating with the radial and ulnar carpal bones. This joint contributes to nearly 90% of the movement in the carpus and is important to carpal function. The radial and ulnar styloid processes serve as the origin of the collateral ligaments and also extend down into the joint, serving as a physical buttress against medial lateral instability. Internal fixation is required to restore stability to the antebrachial carpal joint.

### EQUIPMENT

- Surgical pack, pointed reduction forceps, Kirschner wires or small Steinmann pins (for large dogs), pin chuck or high-speed wire driver; plating equipment is required for lag-screw fixation

### PREPARATION AND POSITIONING

Prepare the limb circumferentially from the shoulder to the digits. Position the animal in dorsal recumbency for greater flexibility, with the affected limb suspended for draping. Then release the limb to allow access to the distal antebrachium.

### PROCEDURE

**Approach:** Expose the styloid processes by incising directly over the processes through the skin and subcutaneous tissue. Continue the incision into the retinacular and antebrachial fascia. Elevate the surrounding tissue as necessary to visualize the fracture and collateral ligament (Plate 11A [lateral view]).

**Reduction:**[3] Reduce the fractured process by tenting the bone ends, and lever the bone back into position. Maintain reduction with pointed reduction forceps.

**Stabilization:**[1,2,4] Accomplish fixation of the styloid process with the pin and tension band wire or lag-screw technique. If the fragments are too small to permit pin insertion, the collateral ligament may be reattached to the bone with a screw and spiked plastic washer.

**Pin and Tension Band Wire Technique:**[1–4] Depending on the avulsed fragment size, drive one or two wires into the styloid process, directing the wires obliquely across the fracture into the far cortex of the radius or ulna. For ulnar avulsions, insert a single K-wire into either the ulna or into the far cortex of the distal radius (Plate 11B). For radial styloid avulsions, two pins may be inserted into the far cortex of the radius (Plate 11C). Drill a transverse hole 1 to 2 cm proximal to the fracture site and pass a figure-eight wire through the hole and around the Kirschner wires. Tighten the wire, bend the pins over, and cut. Closure is routine.

**Lag-Screw Technique:** For the radial styloid process, drill a gliding hole (equal to the diameter of the threads on the screw) in the styloid fragment. Place an insert drill sleeve into the gliding hole and drill a smaller hole (equal to the core diameter of the screw) across the radius. Measure, tap, and select and place the appropriate-length screw (Plate 11D). Compression of the fracture should occur. When stabilizing the ulnar styloid process, treat the styloid process as the fragment by drilling the gliding hole through the ulna and the tapped hole in the radius (Plate 11E). Closure is routine.

### CAUTIONS[1]

It may not be possible to place two pins into the distal ulna in small dogs; therefore, the ulnar styloid fracture may not be completely rotationally stable. External coaptation is strongly recommended.

### POSTOPERATIVE EVALUATION

Radiographs should be evaluated for articular surface reduction and implant placement. Radiographs should be repeated every 6 to 8 weeks until the fracture has healed.

### POSTOPERATIVE CARE[2,4]

A Mason Meta splint or fiberglass half-cast is necessary to protect the repair for the first 6 to 8 weeks. Exercise should be restricted until the fracture heals. Implant removal is indicated if the implants become loose or if they irritate the soft tissues after the fracture heals.

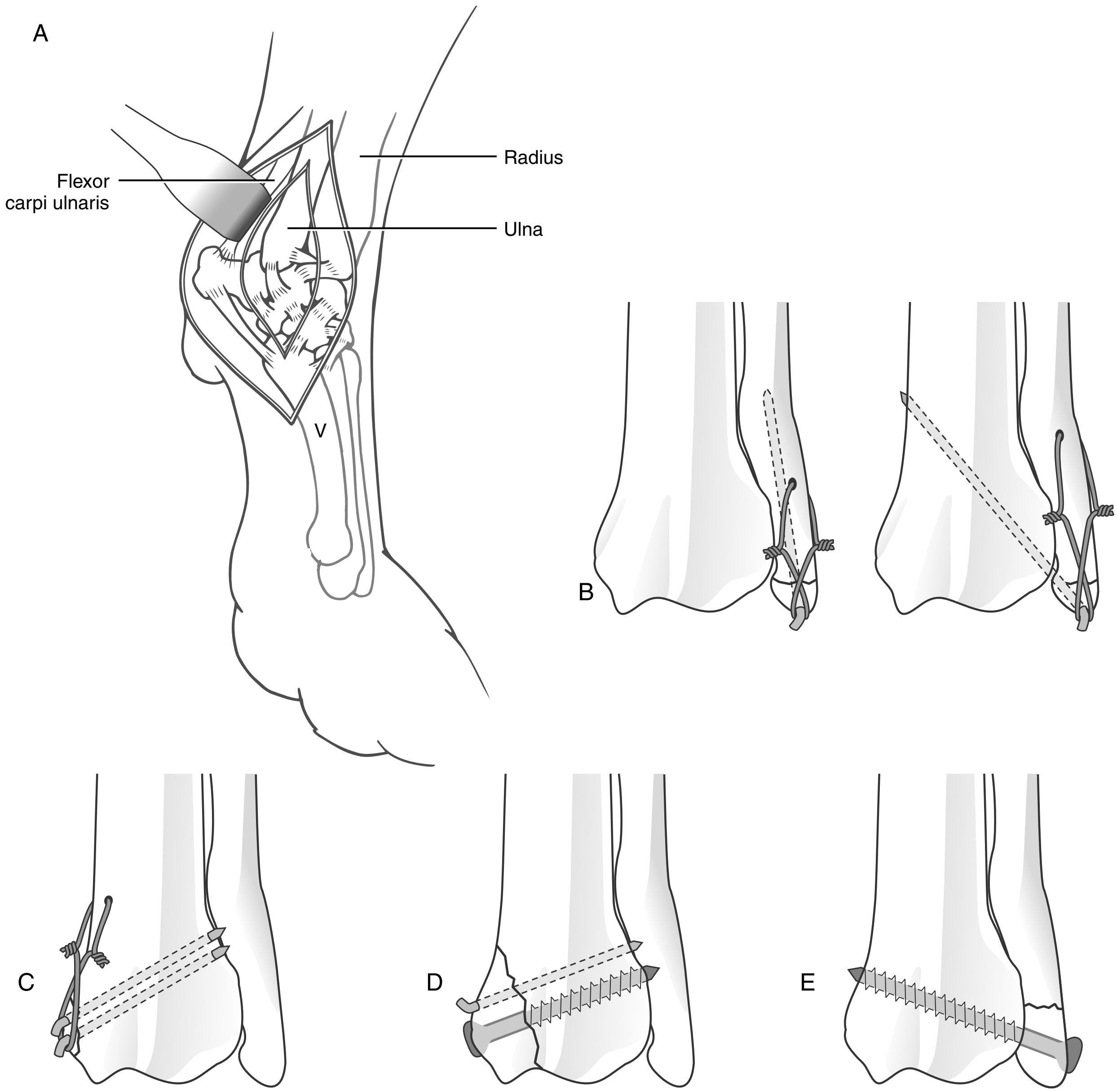
### EXPECTED OUTCOME[3,4]

Outcome is fair to excellent in most cases. Carpal stability and alignment depend on adequate reduction and stability of the styloid process. Mild to moderate degenerative joint disease may be expected because of the articular nature of this fracture.

#### References


1. Bruce WJ: Radius and ulna. In Coughlan AR, Miller A (eds): BSAVA Manual of Small Animal Fracture Repair and Management. Cheltenham, British Small Animal Veterinary Association, 1998.
2. Egger EL: Fractures of the radius and ulna. In Vasseur P, Slatter D (eds): Textbook of Small Animal Surgery, vol. 2, 2nd ed. Philadelphia, WB Saunders, 1993.
3. Miller AS: What is your diagnosis? (Radial carpal dislocation in a dog). J Small Anim Pract 34:11, 576, 582–583; 3 ref. 1993.
4. Probst CW: Stabilization of fractures of the radius and ulna. In Bojrab MJ (ed): Current Techniques in Small Animal Surgery, 4th ed. Baltimore, Williams & Wilkins, 1998.

# PLATE 11



CARPUS

# CHAPTER 12 Pancarpal Arthrodesis

## INDICATIONS

Candidates include dogs with hyperextension of the antebrachial carpal joint; dogs with severe injury (e.g., fracture, luxation, or shearing injury) of the antebrachial carpal joint that precludes maintaining a long-term, pain-free articulation; or dogs with painful degenerative joint disease that is not responsive to conservative measures.[1,2]

## OBJECTIVES

- To fuse the bones of the antebrachial, middle carpal, and carpometacarpal joints in a functional position

## ANATOMIC CONSIDERATIONS

The carpus consists of the radius, ulna, proximal (radial, ulnar, and accessory) carpal bones, distal row (II, III, and IV) carpal bones, and the metacarpal bones, forming the antebrachiocarpal, middle carpal, and carpometacarpal joints.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, self-centering plate-holding forceps, bone curette, high-speed drill and burrs, plating equipment

## PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from shoulder to digits. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal shoulder or ilial wing for cancellous bone graft harvest. Consider using a tourniquet to control bleeding.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue over the dorsal surface of the joint from the distal third of the radius to the distal third of the metacarpal bones. Elevate and resect the attachment of the carpal extensor tendons from the metacarpal bones. Elevate and retract the digital extensor tendons laterally to expose the distal radius, the carpus, and the proximal two thirds of the third metatarsal bone. Incise the joint capsule to enter each joint space and expose the articular surfaces (Plate 12A).

**Alignment:** The cranial caudal angle for the pancarpal arthrodesis is commonly 10 to 12 degrees[1,2] (see Plate 12E).

**Stabilization:** Flex the carpus and remove the articular cartilage from the antebrachial carpal joint surfaces, the middle joint surfaces, and the carpometacarpal joint surfaces with a bone curette or high-speed burr, following the contours of the bone ends (Plate 12B). Harvest cancellous bone and place the graft within the prepared joints (Plate 12C). Place an appropriate-size bone plate (limited by the size of the metacarpal bone), precontoured to 10 to 12 degrees of carpal extension, on the dorsal surface of the distal radius and third metacarpal bone. (Alternatively, use a hybrid plate that accommodates larger screws over the radius and smaller screws over the metacarpal bones.[3]) Position the plate so that one screw will penetrate the radial carpal bone. Ensure adequate plate holes for a minimum of three screws in the radius and three screws in the metacarpal bone. Mark the level of the distal metacarpal plate screw. Remove the plate and center the drill on the metacarpal bone. Secure the plate with three screws in the metacarpal bone, and then reduce the plate to the radius with self-centering forceps. Check plate and joint alignment and attach the plate to the radius, using the loaded drill guide in one or two holes to compress the antebrachial carpal joint (see Plate 12C). Fill the remaining plate holes (Plate 12D). One plate screw should secure the radial carpal bone (Plate 12E).[1]

## CAUTIONS

All of the articular cartilage should be removed. Angular and rotational alignment of the limb should be checked carefully before securing the plate to the radius. Tourniquet use should be limited to 60 minutes.

## POSTOPERATIVE EVALUATION

The axial alignment of the limb and the angle of the arthrodesis should be observed critically. Radiographs for limb alignment and implant placement should be evaluated.

## POSTOPERATIVE CARE

A soft, padded bandage should be placed to control bleeding and swelling. Casting should be delayed for 48 to 72 hours if a tourniquet has been used. A bivalve cast should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Implants are generally removed after 6 to 12 months to avoid soft tissue irritation.[3]

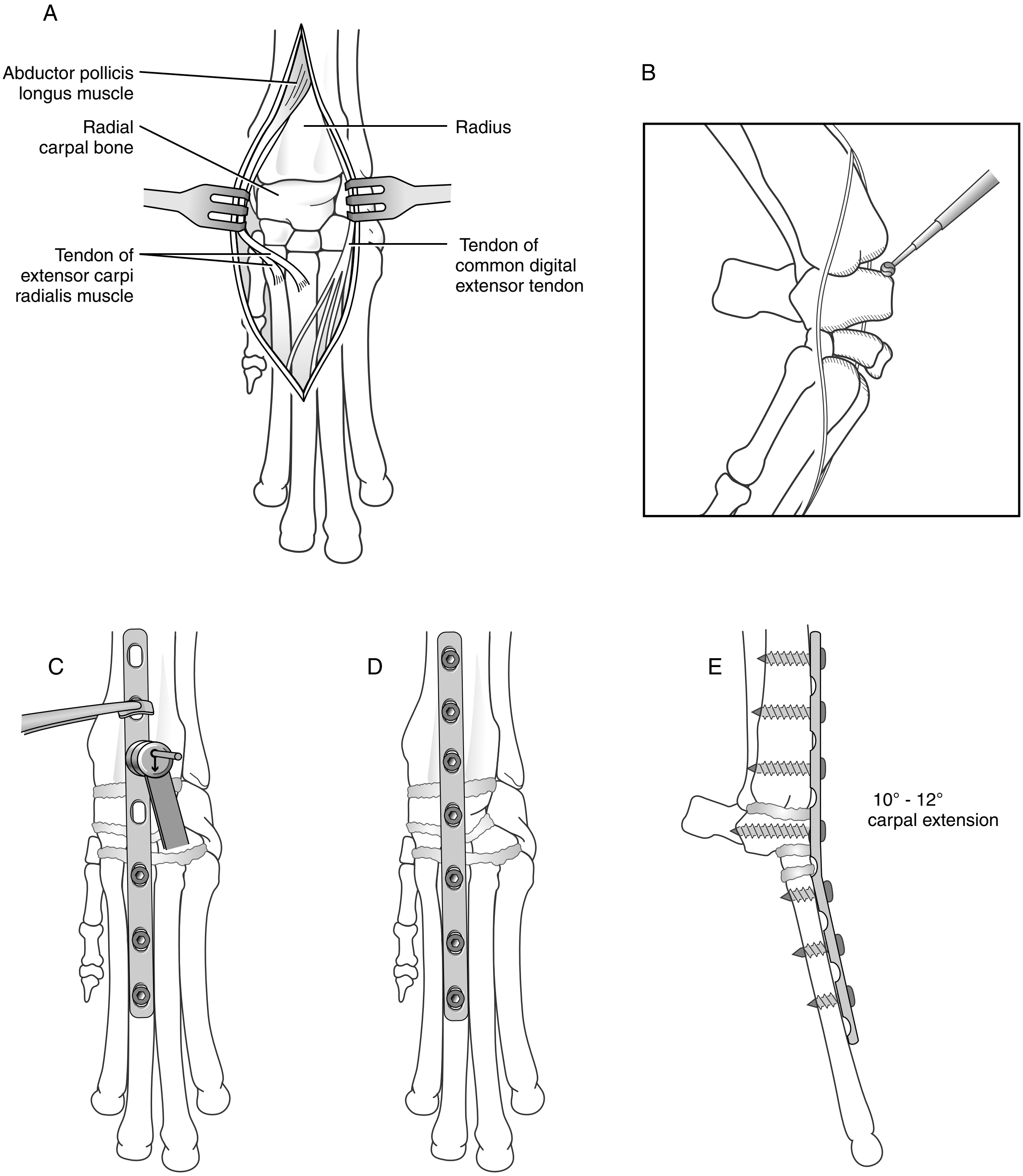
## EXPECTED OUTCOME

Bone healing is expected in 12 to 18 weeks, and good function in the treated limb is anticipated. Fatigue fractures of the distal metacarpal bone may occur; covering more than 50% of the metacarpal bone with the plate may reduce this problem.[4]

### References

1. McLaughlin RM: Arthrodesis. In Brinker WO, Olmstead ML, Sumner-Smith G, et al (eds): Manual of Internal Fixation in Small Animals. New York, Springer-Verlag, 1998.
2. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.
3. Li A, Gibson N, Carmichael S, et al: Thirteen pancarpal arthrodeses using 2.7/3.5 mm hybrid dynamic compression plates. Vet Comp Orthop Traumatol 12:102, 1999.
4. Whitelock RG, Dyce J, Houlton JEF: Metacarpal fractures associated with pancarpal arthrodesis in dogs. Vet Surg 28:25, 1999.

# PLATE 12


A
Abductor pollicis longus muscle
Radial carpal bone
Tendon of extensor carpi radialis muscle
Radius
Tendon of common digital extensor tendon
B
C
D
E
10° - 12° carpal extension

## CARPUS

# CHAPTER 13 Partial Carpal Arthrodesis with a Plate

### INDICATIONS
Candidates include dogs with hyperextension of the middle carpal and carpometacarpal joints.[1]

### OBJECTIVES
- To fuse the bones of the middle carpal and carpometacarpal joints in a functional position

### ANATOMIC CONSIDERATIONS
The carpus consists of the radius, ulna, proximal (radial, ulnar and accessory) carpal bones, distal row (II, III, and IV) carpal bones, and the metacarpal bones, forming the antebrachiocarpal, middle carpal, intercarpal, and carpometacarpal joints.

### EQUIPMENT
- Surgical pack, Senn retractors, small Hohmann retractors, Gelpi retractors, periosteal elevator, plate-holding forceps, bone curette, high-speed drill and burrs, plating equipment

### PREPARATION AND POSITIONING
Prepare the forelimb circumferentially from shoulder to digits. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal shoulder or ilial wing for cancellous bone graft harvest. Consider using a tourniquet to control bleeding.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue over the dorsal surface of the joint from the distal metaphysis of the radius to the distal third of the metacarpal bones. Elevate and retract the carpal extensor tendons medially and the digital extensor tendons laterally to expose the distal radius, the carpus, and the proximal two thirds of the third metatarsal bone. Incise the joint capsule to enter each middle and distal joint space and expose the articular surfaces (Plate 13A).

**Alignment:** Align the dorsal surfaces of the radial carpal bone and third metacarpal bone with the plate to produce the correct alignment for the arthrodesis.

**Stabilization:** Flex the carpus and remove the articular cartilage from the middle carpal, intercarpal, and carpometacarpal joint surfaces with a bone curette or high-speed burr, following the contours of the bone ends (Plate 13B). Harvest cancellous bone and place the graft within the prepared joints (Plate 13C). Position a veterinary T plate distally on the dorsal surface of the radial carpal bone and third metacarpal bone. It is imperative that the plate be distal to the articular cartilage on the radial carpal bone to avoid interference with the radius. Secure the plate to the radial carpal bone. Select screws that are slightly shorter than the measured length to avoid interference with palmar soft tissues. Reduce the plate to the third metacarpal bone (see Plate 13C). Starting with the most distal plate hole, fill the remaining plate holes, securing the plate to the third metacarpal bone (Plate 13D).[1]

### CAUTIONS
All articular cartilage must be removed. The plate must not interfere with the articular surface of the radial carpal bone or with the radius when the limb is extended. Tourniquet use should be limited to 60 minutes.

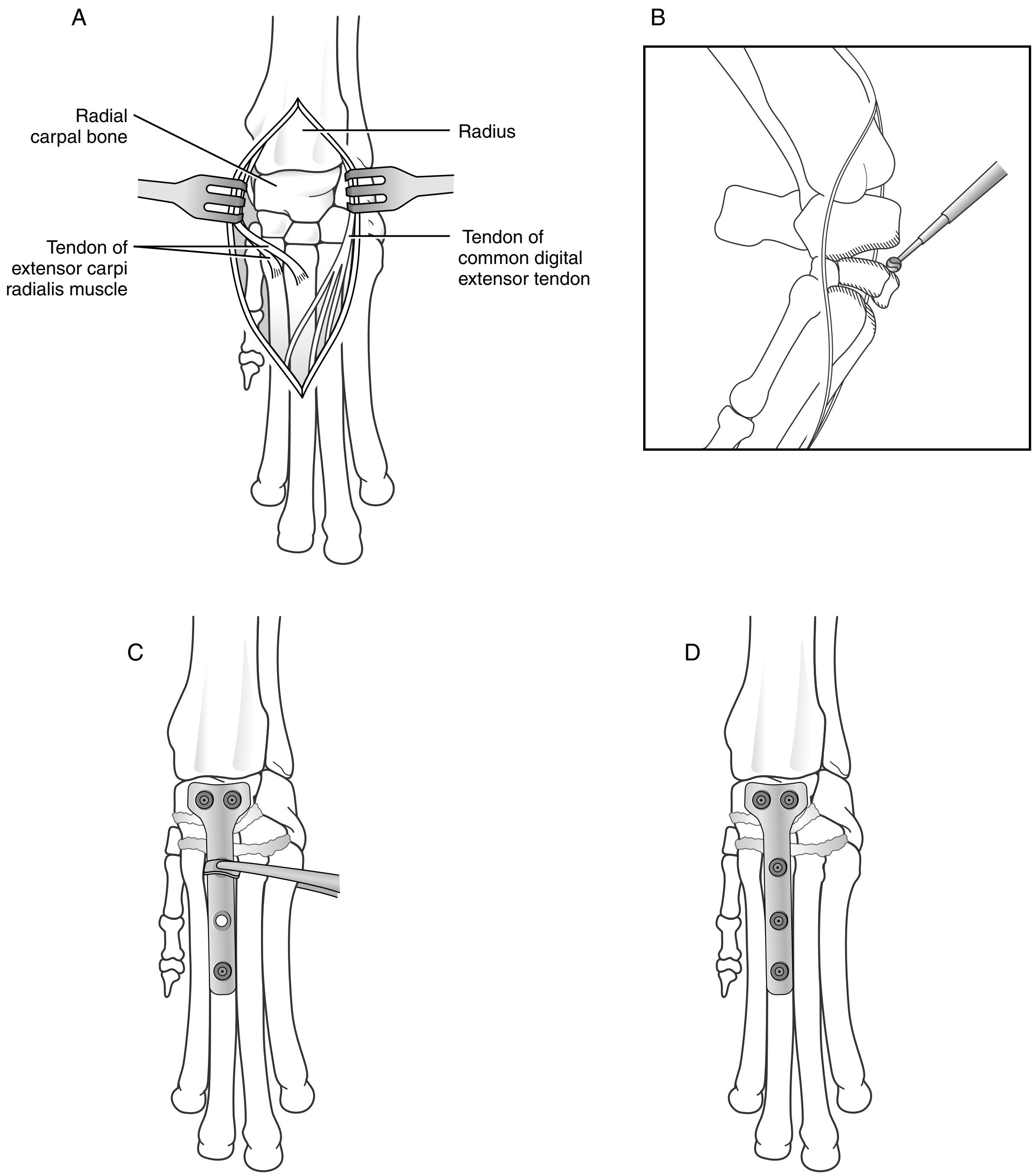
### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for limb alignment and implant placement.

### POSTOPERATIVE CARE
A soft, padded bandage should be placed to control bleeding and swelling. Casting should be delayed for 48 to 72 hours if a tourniquet has been used. A bivalve cast should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Implants may need to be removed after 6 to 12 months to avoid soft tissue irritation.

### EXPECTED OUTCOME
Bone healing is expected in 12 to 18 weeks. A decrease in range of motion in the antebrachial carpal joint is usually seen. Near-normal function of the treated limb can be expected unless undiagnosed antebrachial carpal joint injuries are present.

### Reference
1. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.

# PLATE 13


A
Radial
carpal bone
Radius
Tendon of
extensor carpi
radialis muscle
Tendon of
common digital
extensor tendon
B
C
D

## CARPUS

# Chapter 14 Partial Carpal Arthrodesis with Intramedullary Pins

### INDICATIONS

Candidates have hyperextension of the middle carpal and carpometacarpal joints.[1,2]

### OBJECTIVES

- To fuse the bones of the middle carpal and carpometacarpal joints in a functional position

### ANATOMIC CONSIDERATIONS

The carpus consists of the radius, ulna, proximal (radial, ulnar, and accessory) carpal bones, distal row (II, III, and IV) carpal bones, and the metacarpal bones, forming the antebrachiocarpal, middle carpal, intercarpal, and carpometacarpal joints.

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, bone curette, high-speed drill and burrs, intramedullary pins or Kirschner wires, Jacob pin chuck, pin or wire cutters

### PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from shoulder to digits. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal shoulder or ilial wing for cancellous bone graft harvest. Consider using a tourniquet to control bleeding.

### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue over the dorsal surface of the joint from the distal third of the radius to the distal third of the metacarpal bones. Elevate and retract the carpal extensor tendons medially and the digital extensor tendons laterally to expose the distal radius, the carpus, and the proximal two thirds of the third metatarsal bone. Incise the joint capsule to enter each middle and distal joint space and expose the articular surfaces (Plate 14A).

**Alignment:** Flex the antebrachial carpal joint 90 degrees and apply proximal and palmar pressure to the metacarpal bones while placing the intramedullary pins to align the dorsal surfaces of the radial carpal bone and metacarpal bones correctly for the arthrodesis[1] (see Plate 14C).

**Stabilization:** Flex the carpus and remove the articular cartilage from the middle carpal, intercarpal, and carpometacarpal joint surfaces with a bone curette or high-speed burr, following the contours of the bone ends (Plate 14B). Harvest cancellous bone and place the graft within the prepared joints. Create burr slots in the dorsal surface of the distal third of the third and fourth metacarpal bones. Drive small intermedullary pins or Kirschner wires through the slots proximally into the base of the bones. Reduce the subluxation and align the carpus as described previously. Drive the pins into the radial carpal bone (Plate 14C). Back the pins out a few millimeters, and then cut and bend the ends into hooks. Reseat the pins and rotate the hooks flat against the bones (Plate 14D).[1,2]

### CAUTIONS

All articular cartilage must be removed. The slots will have to be long enough to allow the pins to bend as they are driven proximally. The carpus must be flexed 90 degrees and pressure placed on the metacarpal bones to align the carpal bones with the metacarpal bones while the pins are placed. The pins should not penetrate the radial carpal bone articular surface. Tourniquet use should be limited to 60 minutes.

### POSTOPERATIVE EVALUATION

Radiographs should be evaluated for limb alignment and implant placement.

### POSTOPERATIVE CARE

A soft, padded bandage should be placed to control bleeding and swelling. Casting should be delayed for 48 to 72 hours if a tourniquet has been used. A bivalve cast should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Implants are generally removed after healing to avoid soft tissue irritation.

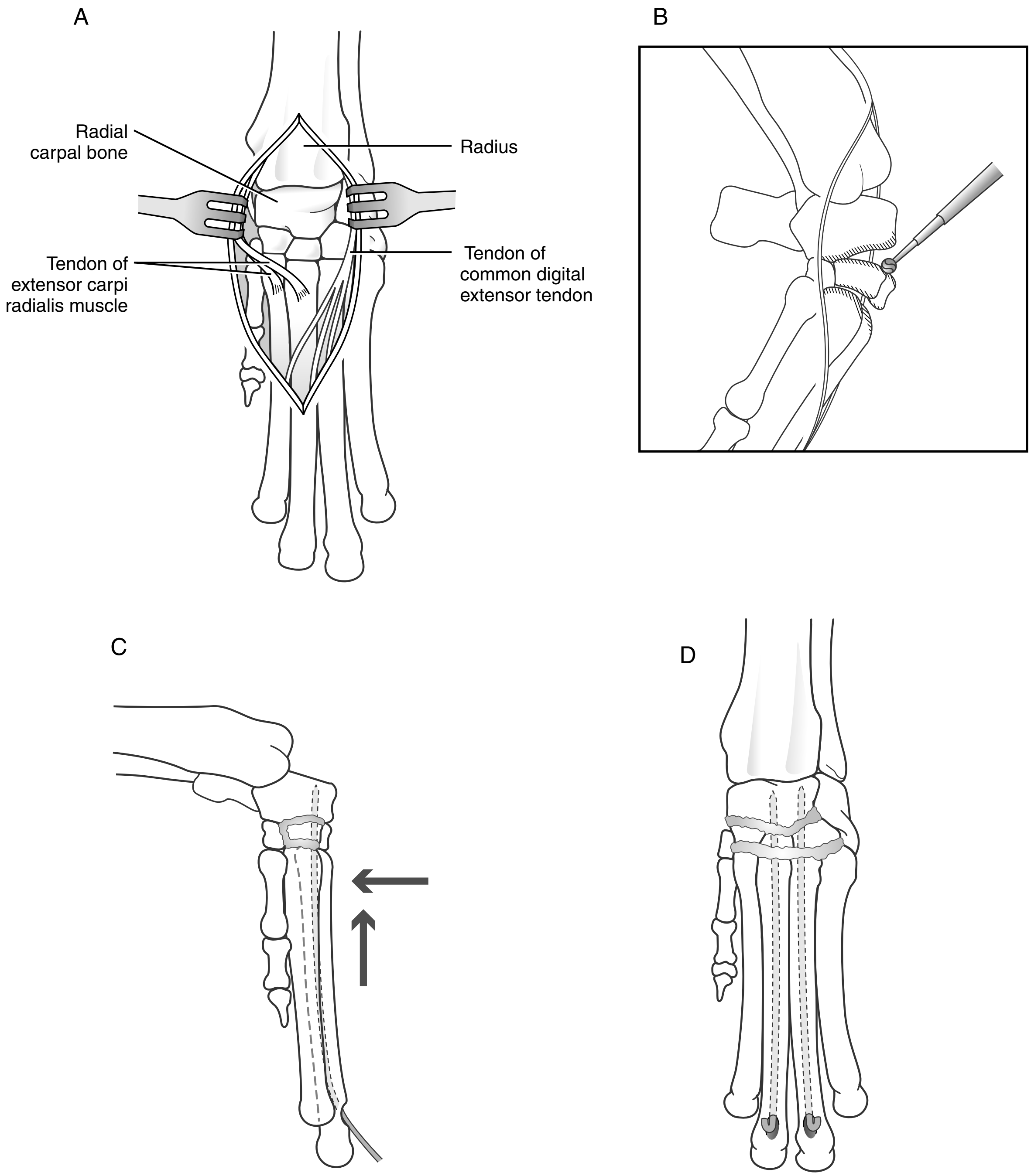
### EXPECTED OUTCOME

Bone healing is expected in 12 to 18 weeks. A decrease in range of motion in the antebrachial carpal joint is usually seen. Lameness is eliminated or improved in two thirds of the dogs.[2] Hyperextension may persist in some dogs, especially if antebrachialcarpal injuries have been overlooked.

#### References

1. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.
2. Willer RL, Johnson KA, Turner TM, et al: Partial carpal arthrodesis for third-degree carpal sprains: A review of 45 carpi. Vet Surg 92:334, 1990.

# PLATE 14


A
B
C
D
Radial carpal bone
Radius
Tendon of extensor carpi radialis muscle
Tendon of common digital extensor tendon

## HIP

# Chapter 15 Extracapsular Stabilization of Hip Luxation (Suture Anchors or Screw and Washer)

### INDICATIONS[1]

Open reduction and stabilization is indicated in animals with chronic luxations, failed closed reductions, excessive postreduction instability, intra-articular fractures, concurrent pelvic fractures, or other fractures of the affected limb that prevent closed reduction.

### OBJECTIVES

- To restore normal stability, congruency, mobility, and function to the coxofemoral joint

### ANATOMIC CONSIDERATIONS[2]

Osseous anatomic landmarks for the coxofemoral joint are the greater trochanter of the femur and the ischial tuberosity and ilial wing of the pelvis. The curvilinear incision should center on the cranial edge of the greater tubercle. Distally, it extends cranial and parallel to the proximal third of the shaft of the femur. Muscular landmarks include the biceps femoris, the gluteals, and the vastus lateralis. Reduce the hip prior to starting the surgical approach to establish normal tissue relationships.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, wire driver, intramedullary pins or Kirschner wires, mallet, 20- to 60-pound nylon* and a suture anchor system†

Alternatively, a bone tunnel and screw and washer combination may be used if a suture anchor system is not available or if the animal is not large enough to accommodate the suture anchor system. Additional instrumentation needed for this technique includes a high-speed drill, bone screw and washer, drill bit, tap, depth gauge, and screwdriver.

### PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Approach:** A trochanteric osteotomy is not always necessary to reduce and stabilize the hip; however, chronic cases may benefit from the additional exposure of an osteotomy.

**Craniolateral Approach:**[1] Use a craniolateral approach to the coxofemoral joint. Incise the skin and subcutaneous tissue 5 cm proximal to the greater trochanter, curving distally adjacent to the cranial ridge of the trochanter and extending distally from 5 cm over the proximal femur. Incise between the tensor fasciae latae muscle and deep border of the biceps femoris muscle and superficial gluteal muscle. Retract the tensor fasciae latae cranially, the biceps caudally, and the middle gluteal muscle proximally. Incise the deep gluteal muscle close to its attachment on the trochanter for one third to one half of its width. Incise the joint capsule (or enlarge the traumatic tear) parallel to the long axis of the femoral neck, near its proximal ridge. Continue the joint capsule incision laterally through the point of origin of the vastus lateralis muscle on the cranial face of the proximal femur. Reflect the vastus lateralis distally to expose the hip joint (Plate 15A).

**Dorsal Approach with Trochanteric Osteotomy:**[2] Use a dorsal approach to the coxofemoral joint with an osteotomy of the greater trochanter. Incise the skin over the cranial border of the greater trochanter, from 3 cm to 4 cm proximal to the dorsal ridge of the greater trochanter and curved 3 cm to 4 cm, following the cranial border of the femur. Incise the superficial leaf of the fascia lata, and carry the incision proximally through the insertion of the tensor fasciae latae muscle at the greater trochanter and along the cranial border of the superficial gluteal muscle. Incise through the insertion of the superficial gluteal muscle at the third trochanter. Reflect the superficial gluteal muscle proximally and the biceps femoris caudally to find and visualize the course of the sciatic nerve. Perform an osteotomy of the greater trochanter with an osteotome and mallet or with Gigli wire. Reflect the gluteal muscles and greater trochanter from the joint capsule with a periosteal elevator, and incise both structures together at the trochanter fossa. Elevate the gemellus muscle from the caudolateral surface of the acetabulum with a periosteal elevator. Use a suture to retract the muscle proximally and caudally. Incise the joint capsule (see Plate 15A).

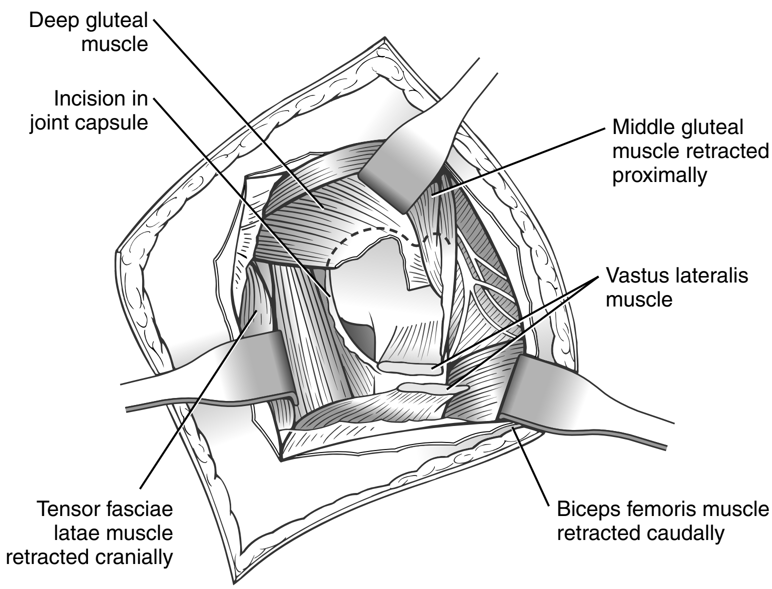
Explore the hip joint prior to stabilizing the joint to assess cartilage viability and surrounding soft-tissue injury. If the joint integrity is intact, a number of hip-stabilizing techniques are available.

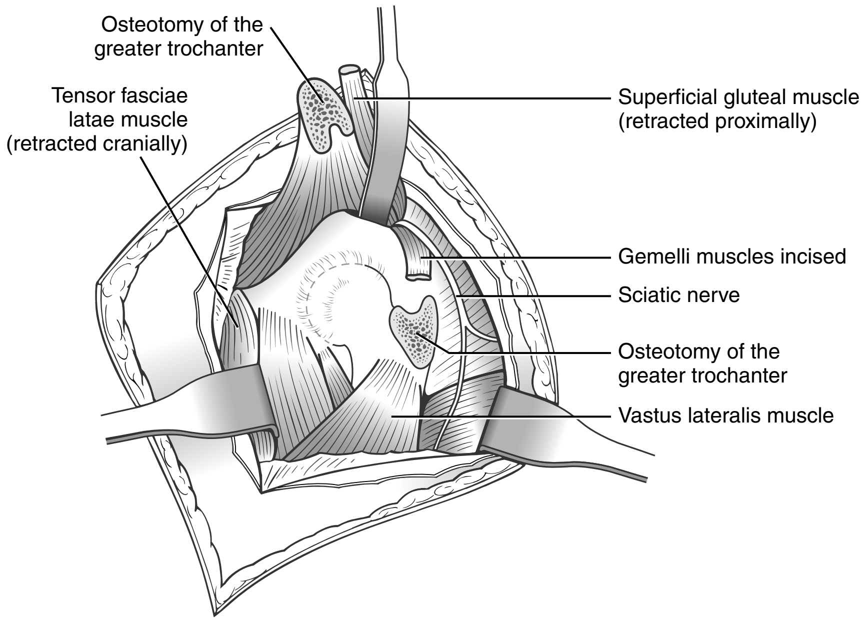
*Continued*

*Mason Nylon Leader Line, Mason Tackle Company, Otisville, Michigan.
†Bone Biter Suture Anchor System, Warsaw, Indiana.

# PLATE 15

A


Deep gluteal muscle
Incision in joint capsule
Middle gluteal muscle retracted proximally
Vastus lateralis muscle
Tensor fasciae latae muscle retracted cranially
Biceps femoris muscle retracted caudally


Osteotomy of the greater trochanter
Tensor fasciae latae muscle (retracted cranially)
Superficial gluteal muscle (retracted proximally)
Gemelli muscles incised
Sciatic nerve
Osteotomy of the greater trochanter
Vastus lateralis muscle

**Stabilization:** To achieve successful reduction and stabilization of the coxofemoral joint, the use of one or more of the following techniques may be necessary: Suture anchors, screws and washers, and wire sutures may be employed for added stability when the capsule cannot be securely closed and imbricated.

**Stabilization with Capsular Repair and Imbrication:** Luxate the femoral head to visually inspect the cartilage surface for damage. Débride any remaining fibrous tissue, hematoma, and fracture fragments from the acetabular socket. Reduce the femoral head and imbricate the joint capsule with nonabsorbable monofilament material using an interrupted or cruciate pattern (Plate 15B). Place the joint through a range of motion. If the joint is stable, joint capsule repair and imbrication alone can constitute the reconstructive procedure.

**Stabilization with Screw and Washer:**[3] Drill two holes into the craniodorsal aspect of the acetabular rim at the 10-o'clock and 1-o'clock positions. Measure, tap, and select two appropriate-length screws, adding 2 mm to the screw length to accommodate the washer. Drill, measure, tap, and insert a third screw and washer in the trochanteric fossa, or drill a bone tunnel through the femoral neck in the trochanteric fossa to accept the suture. Pass heavy, nonabsorbable suture or cerclage wire between the acetabular screws and trochanteric fossa (Plate 15C). Place the joint through a range of motion to ensure stability and function.

**Stabilization with the Suture Anchor System:** Drill two holes into the craniodorsal aspect of the acetabular rim at the 10-o'clock and 1-o'clock positions. Insert suture anchors threaded with heavy, nonabsorbable suture into each of these holes. Drill and insert a third suture anchor thread with the suture from the acetabular anchors into the trochanteric fossa (Plate 15D). Tie the sutures with the hip at a normal angle of flexion and slight abduction and internal rotation. Place the joint through a range of motion to ensure stability and function.

**Closure:** Reattach the external rotator muscles as necessary. If a trochanteric osteotomy has been performed, reattach the trochanter in a caudodistal position on the femur to promote joint stability and femoral adduction and internal rotation (Plate 15E1). Stabilize the greater trochanter with two Kirschner wires and a tension band (Plate 15E2). Suture the fascial layers, subcutaneous tissue, and skin.

## CAUTIONS[4]

The most common cause of coxofemoral luxation in the dog is motor vehicular trauma; concurrent injuries should therefore be ruled out. Open reduction may need to be delayed until the animal has been adequately stabilized. A femoral head and neck excision or total hip replacement should be considered if coxofemoral integrity is questionable.

## POSTOPERATIVE EVALUATION

The joint should be radiographed to assess implant positioning and joint congruency. Joint stability and range of motion should be evaluated at 2 to 3 days to assess hip position.

## POSTOPERATIVE CARE

An Ehmer bandage can be used to assist hip reduction in the early postoperative period. The bandage should be removed 4 to 7 days after reduction. Cage confinement may be adequate for dogs with stable hips. Leash activity is required for an additional 3 weeks, and the animal should gradually be returned to full activity over a 2-week period. Reexamination is advisable 3 days after removal of the Ehmer bandage and before resumption of unsupervised activity.

## EXPECTED OUTCOME[4]

The success rate for maintaining reduction and regaining good to excellent limb function with closed reduction is about 50%. The rate is lower in patients with poor conformation of the hip joint secondary to hip dysplasia or previous trauma. Clinical studies indicate that the success for surgical intervention following failure of closed reduction does not differ from the success rate for surgical reduction as a primary treatment. Therefore, it is reasonable to attempt closed reduction in patients with a hip luxation. Regarding maintenance of reduction with good to excellent limb function following open reduction, the success rate is approximately 85% to 90%. The results do not appear to favor any one reconstruction technique. Mild to moderate degenerative joint disease may be expected in cases with questionable cartilage viability or obvious cartilage trauma. If cartilage viability or reduction is questionable, salvaging limb function with a femoral head and neck ostectomy or a total hip replacement should be considered. The long-term prognosis with open reduction is good to excellent if the joint integrity is intact.

### References

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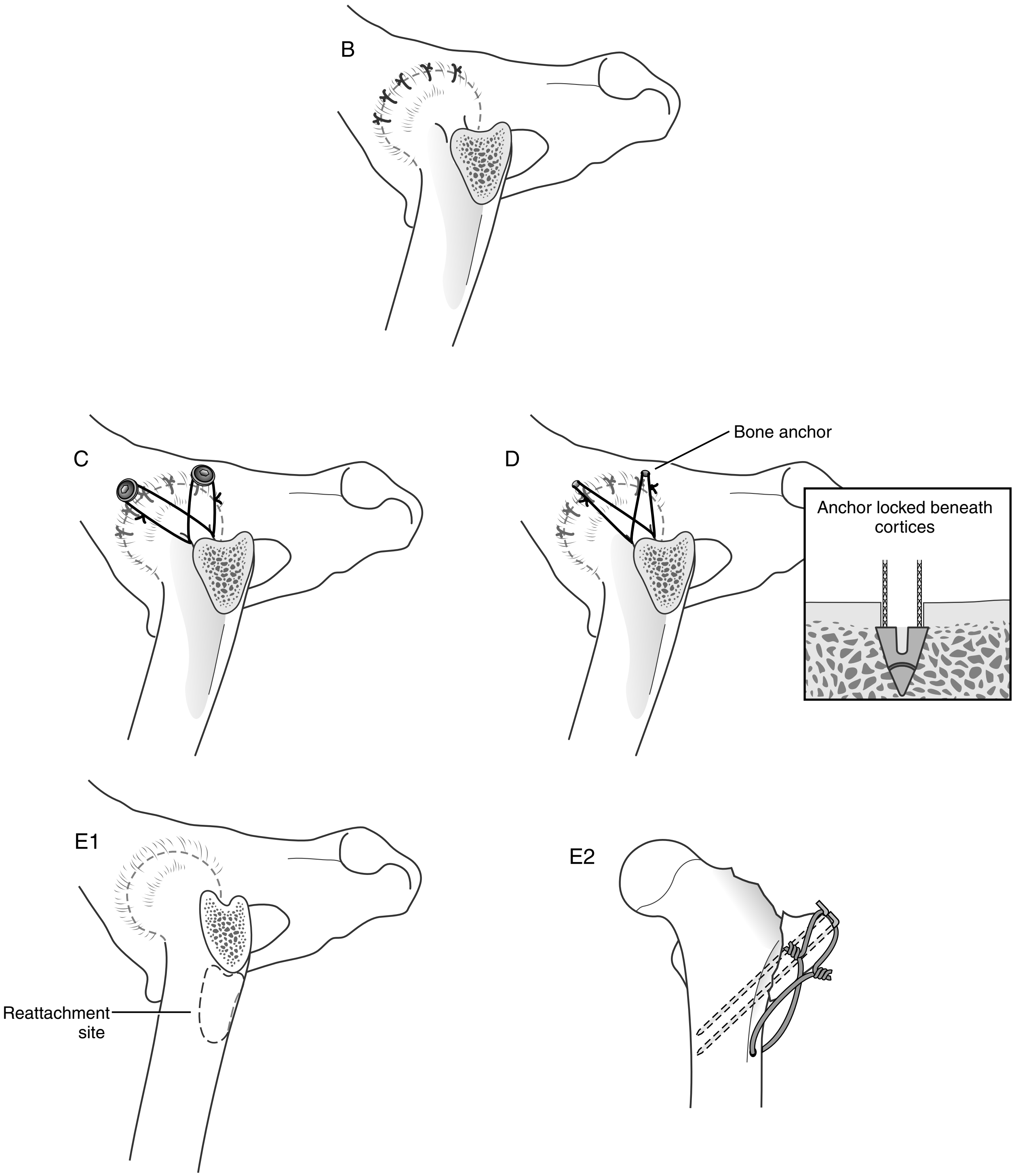
2. Piermattei DL, Johnson KA: Approach to the craniodorsal aspect of the hip joint through a craniolateral incision. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Braden T, Johnson M: Technique and indications of a prosthetic capsule for repair of recurrent and chronic coxofemoral luxations. Vet Comp Orthop Traumatol 1:26–29, 1988.
4. Bone DL, Walker M, Cantwell HD: Traumatic coxofemoral luxation in dogs: Results of repair. Vet Surg 13(4):263–270, 1984.

# PLATE 15


B
C
D
Bone anchor
Anchor locked beneath cortices
E1
Reattachment site
E2

HIP

# CHAPTER 16 Intracapsular Stabilization of Hip Luxation with Modified Toggle Pin

## INDICATIONS

Open reduction and stabilization is indicated in animals with chronic luxations, failed closed reductions, excessive postreduction instability, intra-articular fractures, concurrent pelvic fractures, or other fractures of the affected limb that prevent closed reduction.

## OBJECTIVES

- To restore normal stability, congruency, mobility, and function to the coxofemoral joint

## ANATOMIC CONSIDERATIONS

Osseous anatomic landmarks for the coxofemoral joint are the greater trochanter of the femur and ischial tuberosity and the ilial wing of the pelvis. The curvilinear incision should center on cranial edge of the greater tubercle. Distally it extends cranial and parallel to the proximal third of the shaft of the femur. Muscular landmarks include the biceps femoris, the gluteals, and the vastus lateralis. Soft tissue bruising and swelling often distort the normal anatomy. To establish normal tissue relationships, the hip should be reduced before the surgical approach is begun.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, high-speed drill, C-arm aiming device, toggle pin or rod and toggle rod insertion device.*

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

## PROCEDURE

**Approach:** A trochanteric osteotomy is not always necessary to reduce and stabilize the hip; however, chronic cases may benefit from the additional exposure of an osteotomy.

**Craniolateral Approach:**[1] Perform a craniolateral approach to the coxofemoral joint. Incise the skin and subcutaneous tissue 5 cm proximal to the greater trochanter, curving distally adjacent to the cranial ridge of the trochanter and extending distally from 5 cm over the proximal femur. Incise between the tensor fasciae latae muscle and deep border of the biceps femoris muscle and superficial gluteal muscle. Retract the tensor fasciae latae cranially, the biceps caudally, and the middle gluteal muscle proximally. Incise the deep gluteal muscle close to its attachment on the trochanter for one third to one half of its width. Incise the joint capsule (or enlarge the traumatic tear) parallel to the long axis of the femoral neck near its proximal ridge. Continue the joint capsule incision laterally through the point of origin of the vastus lateralis muscle on the cranial face of the proximal femur. Reflect the vastus lateralis distally to expose the hip joint (Plate 16A).

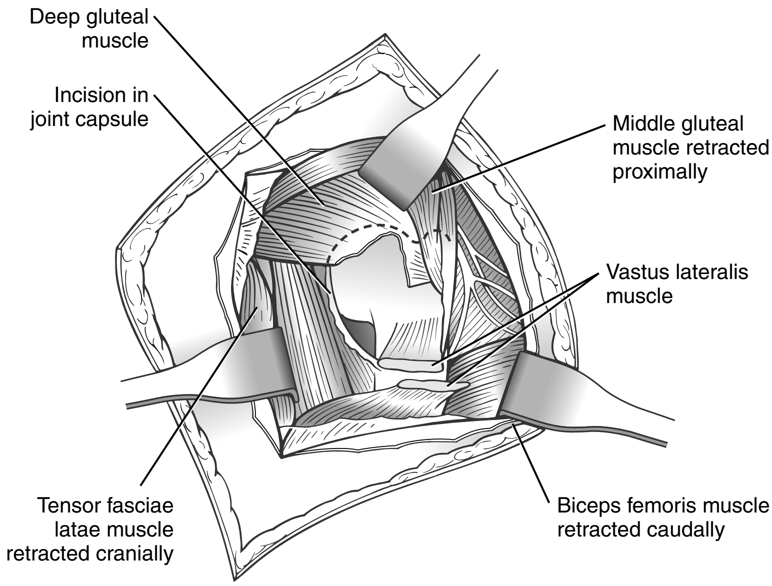
**Dorsal Approach with Trochanteric Osteotomy:**[2] Use a dorsal approach to the coxofemoral joint with an osteotomy of the greater trochanter. Incise the skin over the cranial border of the greater trochanter, from 3 to 4 cm proximal to the dorsal ridge of the greater trochanter and curved 3 to 4 cm, following the cranial border of the femur. Incise the superficial leaf of the fascia lata and carry the incision proximally through the insertion of the tensor fasciae latae muscle at the greater trochanter and along the cranial border of the superficial gluteal muscle. Incise through the insertion of the superficial gluteal muscle at the third trochanter. Reflect the superficial gluteal muscle proximally and the biceps femoris caudally to find and visualize the course of the sciatic nerve. Perform an osteotomy of the greater trochanter with an osteotome and mallet or with Gigli wire (see Plate 16A). Reflect the gluteal muscles and greater trochanter from the joint capsule with a periosteal elevator. Elevate the gemellus muscle from the caudolateral surface of the acetabulum with a periosteal elevator. Use a suture to retract the muscle proximally and caudally (see Plate 16A). Incise the joint capsule, and explore the hip joint prior to stabilizing the joint to assess cartilage viability and surrounding soft-tissue injury.

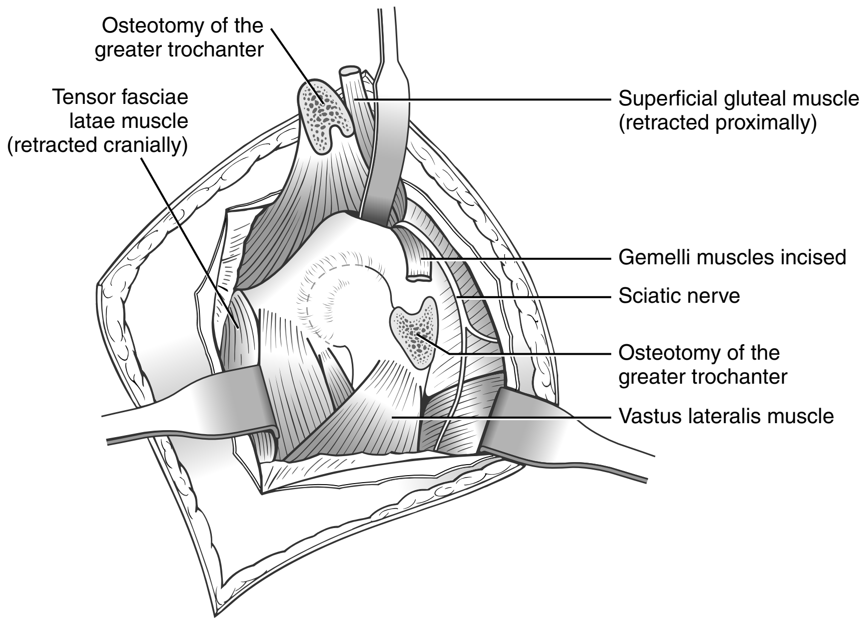
*Continued*

*Securos Coxofemoral Luxation Management System, Charlton, Massachusetts.

# PLATE 16

A


Deep gluteal muscle
Incision in joint capsule
Middle gluteal muscle retracted proximally
Vastus lateralis muscle
Tensor fasciae latae muscle retracted cranially
Biceps femoris muscle retracted caudally


Osteotomy of the greater trochanter
Tensor fasciae latae muscle (retracted cranially)
Superficial gluteal muscle (retracted proximally)
Gemelli muscles incised
Sciatic nerve
Osteotomy of the greater trochanter
Vastus lateralis muscle

**Toggle Pin Stabilization:**[3] Luxate the femoral head to visually inspect the cartilage surface for damage. Débride any remaining fibrous tissue, hematoma, and fracture fragments from the acetabular socket. Drill the acetabular tunnel into the origin of the round ligament with a 3.5-mm drill bit (Plate 16B). Drill the femoral tunnel from the lateral subtrochanteric area to the fovea capitis using a C-arm aiming device and a 2.5-mm drill bit (Plate 16C). Thread four strands of 0 or 1 monofilament nonabsorbable suture material through the toggle pin or rod. Position the toggle device into the acetabular hole and lock it into position on the medial cortex of the acetabulum (Plate 16D). Thread the sutures through the femoral head and neck (Plate 16E). Reduce the femoral head and drill a second transverse bone tunnel cranial to caudal in the subtrochanteric region of the femur, slightly proximal to the exit hole of the suture (Plate 16F1). Pull one pair of the sutures through the second femoral tunnel and snugly tie them to the opposite sutures (Plate 16F2).

**Capsular Repair and Imbrication:** Imbricate the joint capsule with nonabsorbable monofilament material using an interrupted or cruciate pattern. Place the joint through a range of motion.

**Closure:** Reattach the external rotator muscles as necessary. Reduce and stabilize the greater trochanter with two Kirchner wires and a tension band. Suture the fascial layers, subcutaneous tissue, and skin.

## CAUTIONS[4]

The sciatic nerve courses dorsomedial to the acetabulum; to avoid damaging this nerve, caution must be exercised when performing the trochanteric osteotomy. When implanting toggle pins, passage of suture back through one arm of the toggle pin in the 3-o'clock and 9-o'clock positions prevents rotation and eliminates uncertainty with regard to final orientation after insertion.

## POSTOPERATIVE EVALUATION

The joint should be radiographed to assess implant positioning and joint congruency. Joint stability and range of motion should be evaluated at 2 to 3 days to assess continued need for assisted weight bearing.

## POSTOPERATIVE CARE

A belly band sling should be used outside for the first 2 to 3 days to prevent uncontrolled use of the limb. Exercise should be restricted and the animal should be confined to a kennel for the first 4 to 6 weeks. Then normal activity can be slowly reintroduced.

## EXPECTED OUTCOME[3]

Outcome is usually good to excellent. Mild to moderate degenerative joint disease and gait abnormalities may be expected in cases with questionable cartilage viability or obvious cartilage trauma. If cartilage viability or reduction is questionable, a femoral head and neck ostectomy or total hip replacement should be considered to salvage limb function.

### References


1. Piermattei DL, Johnson KA: Approach to the craniodorsal aspect of the hip joint through a craniolateral incision. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Piermattei DL, Johnson KA: Approach to the craniodorsal and caudodorsal aspects of the hip joint by osteotomy of the greater trochanter. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
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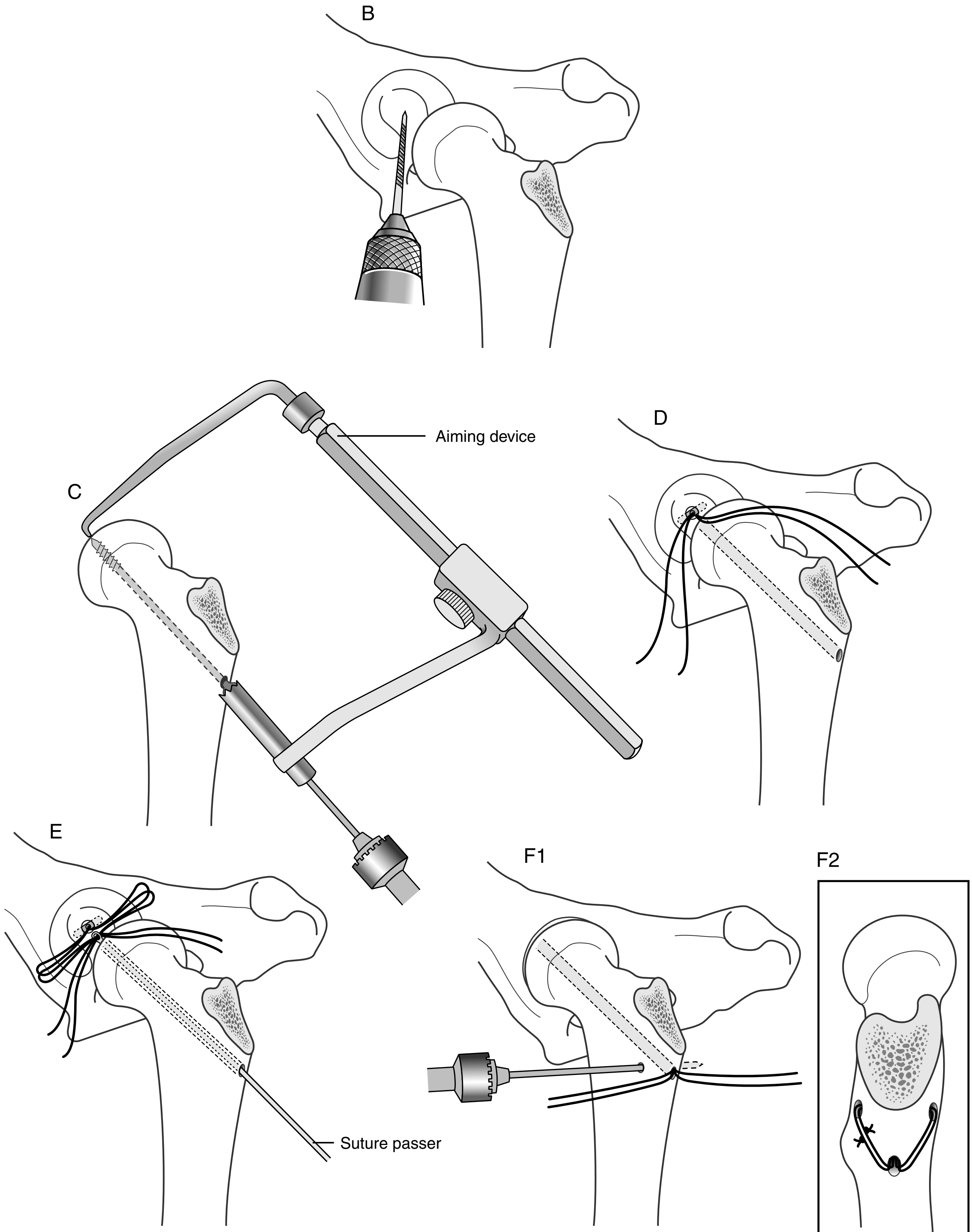
4. Flynn MF, Edmiston DN, Roe SC, et al: Biomechanical evaluation of a toggle pin technique for management of coxofemoral luxation. Vet Surg 23(5):311–321, 1994.

# PLATE 16



## HIP

# Chapter 17 Femoral Head and Neck Ostectomy with Joint Capsule Interpolation

### INDICATIONS[1]

Candidates include dogs with recurrent or chronic coxofemoral luxation, intra-articular coxofemoral fractures that are not amenable to reduction and stabilization, degenerative joint disease secondary to hip dysplasia, and avascular necrosis of the femoral head and neck.

### OBJECTIVES[1]

- To relieve pain and salvage limb function in cases of irreparable damage to the coxofemoral joint

### ANATOMIC CONSIDERATION

Osseous anatomic landmarks for the coxofemoral joint are the greater trochanter of the femur and ischial tuberosity and the ilial wing of the pelvis. The curvilinear incision should center on the cranial edge of the greater tubercle. Distally it extends cranial and parallel to the proximal third of the shaft of the femur. Muscular landmarks include the biceps femoris, the gluteals, and the vastus lateralis. To establish normal tissue relationships, the hip should be reduced before the surgical approach is begun.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, oscillating saw, osteotome and mallet or Gigli wire, rongeur, bone file

### PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Approach:**[2] Use a craniolateral approach to the coxofemoral joint. Incise the skin and subcutaneous tissue 5 cm proximal to the greater trochanter, curving distally adjacent to the cranial ridge of the trochanter and extending distally from 5 cm over the proximal femur. Incise between the tensor fasciae latae muscle and deep border of the biceps femoris muscle and superficial gluteal muscle. Retract the tensor fasciae latae cranially, the biceps caudally, and the middle gluteal muscle proximally. Incise the deep gluteal muscle close to its attachment on the trochanter for one third to one half of its width. Incise the joint capsule parallel to the long axis of the femoral neck near its proximal ridge. Continue the joint capsule incision laterally through the point of origin of the vastus lateralis muscle on the cranial face of the proximal femur. Reflect the vastus lateralis distally to expose the head and neck of the femur (Plate 17A).

**Femoral Head and Neck Excision:** Subluxate the femoral head by placing lateral traction with pointed reduction forceps on the greater trochanter. Sever the round ligament, if it is intact, with Mayo scissors, and fully luxate the hip. Rotate the limb externally so that the patella is directed at the ceiling and the femur is parallel to the operating table (Plate 17B). Visualize the osteotomy line from the medial aspect of the great trochanter to the most proximal aspect of the lesser or second trochanter (Plate 17C). Direct the saw blade or osteotome caudally to ensure complete excision of the femoral neck and head (Plate 17D). Perform the osteotomy and grasp the head and neck with pointed reduction forceps. Remove the femoral head and neck by severing the remaining medial joint capsule attachments. Palpate the osteotomy for irregularities, and remove any sharp prominences with rongeurs or a bone file. Return the leg to normal standing position, and place it through a range of motion, putting medial pressure on the greater trochanter. If there is excessive crepitus or bone-on-bone contact between the femur and acetabulum, remove more of the femoral neck with rongeur, file, or oscillating saw. Flush the joint and suture the joint capsule over the acetabular fossa. The deep gluteal may also be sutured over the acetabulum if joint capsule coverage is deemed insufficient. Closure is routine.

### CAUTIONS

Proper orientation of the osteotomy is essential to ensure complete removal of the femoral head and neck. Soft tissue interpolation will not compensate for a poor cut.

### POSTOPERATIVE EVALUATION

Postoperative radiographs are indicated to evaluate the osteotomy. Limb function and range of motion should be evaluated at suture removal and at 6 to 8 weeks.

### POSTOPERATIVE CARE

Exercise and physical therapy after surgery should be encouraged. Frequent leash walks and passive range-of-motion exercise will improve limb function and use.

### EXPECTED OUTCOME[1]

Results of this surgery vary among animals. Factors reported to influence limb function include patient temperament, concurrent orthopedic disorders, body weight, chronicity of lameness before surgery, preexisting muscle atrophy, extent of surgically induced trauma, completeness of excision, and postoperative activity and physical therapy. Of these factors, body weight has been implicated as critical. Dogs that weigh less than 17 kg are reported to have good to excellent clinical results. Decreased efficacy has been attributed to greater body mass and increased bony contact between the femur and acetabulum during weight bearing.

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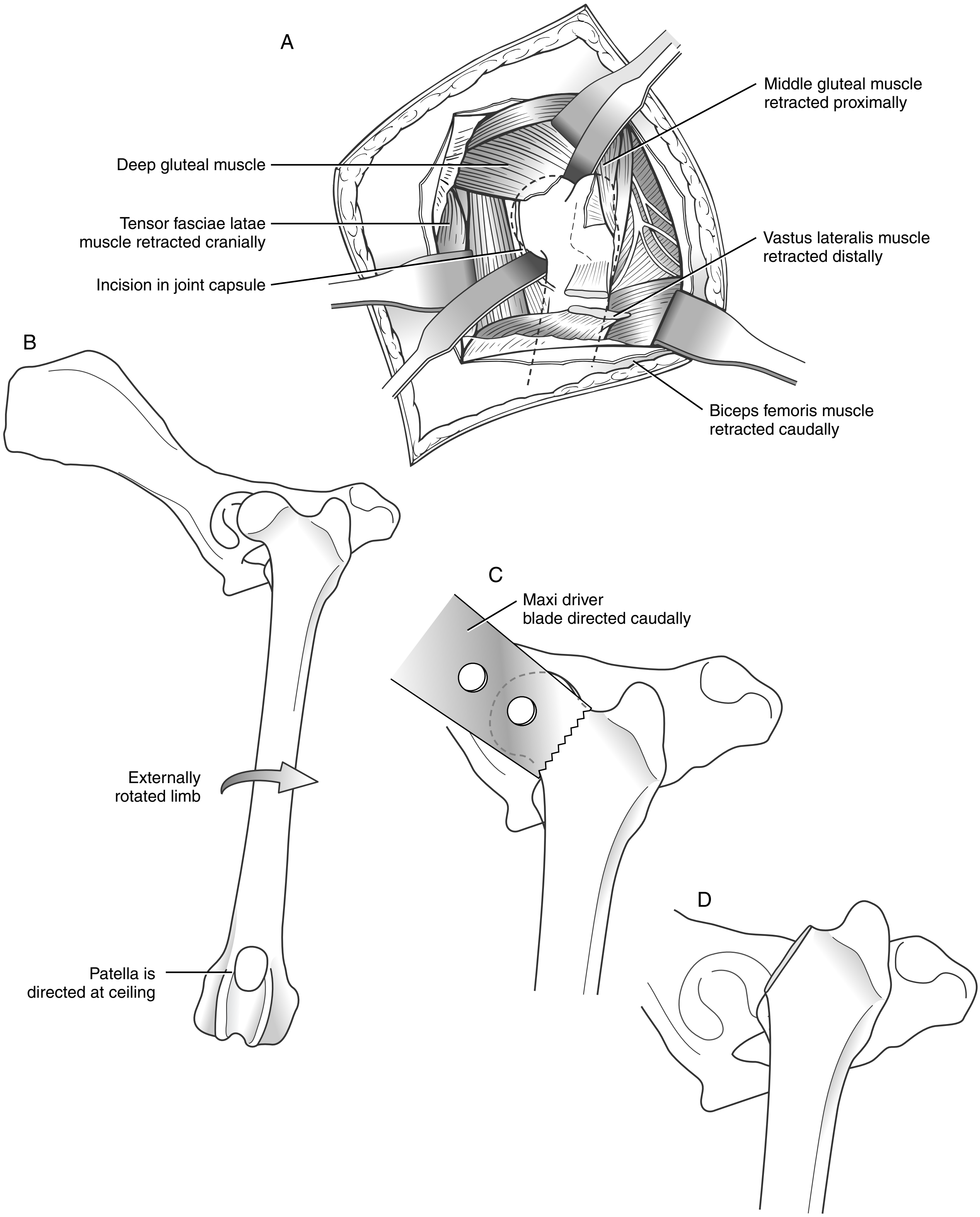
# PLATE 17


A
Middle gluteal muscle
retracted proximally
Deep gluteal muscle
Tensor fasciae latae
muscle retracted cranially
Vastus lateralis muscle
retracted distally
Incision in joint capsule
B
Biceps femoris muscle
retracted caudally
C
Maxi driver
blade directed caudally
Externally
rotated limb
D
Patella is
directed at ceiling

## HIP

# CHAPTER 18 Triple Pelvic Osteotomy

### INDICATIONS[1]

Candidates include immature dogs with coxofemoral laxity and subluxation with minimal radiographic signs of degenerative joint disease.

### OBJECTIVES[2]

- To improve joint stability and function by providing greater dorsal coverage of the femoral head by rotating the dorsal rim of the acetabulum laterally

### ANATOMIC CONSIDERATIONS

Three separate surgical approaches and osteotomies of the pelvis are necessary to free the acetabular segment for axial rotation and improved dorsal femoral head coverage. The pubic osteotomy is performed first and includes removal of the pubic ramus. Osseus anatomic landmarks include the pelvic symphysis, the iliopubic eminence, and the ventral aspect of the coxofemoral joint. Pertinent soft tissue landmarks include the origin of the pectineus muscle on the iliopectineal eminence, the prepubic tendon, and the adductor and gracilis muscles. Care should be taken to protect the obturator nerve as it courses through the cranial portion of the obturator foramen. Osseus anatomic landmarks for the ischial osteotomy include the tuber ischii laterally and the obturator foramen. Muscular landmarks include the internal obturator and the semitendinous and semimembranosus muscles.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, oscillating saw, osteotome and mallet, Gigli wire or reciprocating saw, rongeur, two Hohmann retractors, Kern bone-holding forceps, plating equipment, drill, and Canine Pelvic Osteotomy plate*

### PREPARATION AND POSITIONING

Prepare the entire hindquarter circumferentially to allow access to the pubis, tuber ischii, and ilium from dorsal and ventral midline to mid-tibia. Place a pursestring suture to prevent fecal contamination. Position the animal in dorsal recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

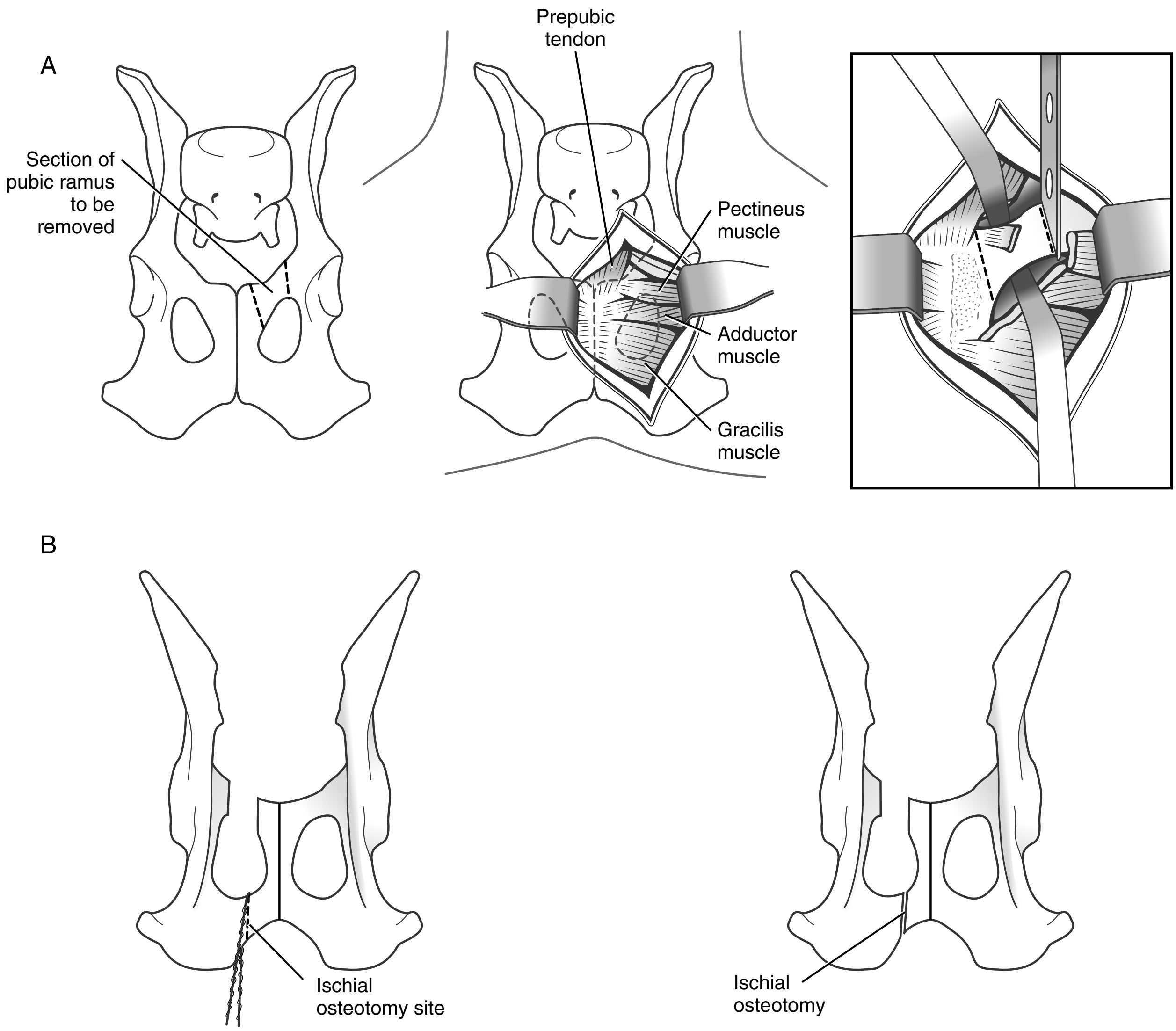
**Pubic Ostectomy:**[3] With the dog in dorsal recumbency, incise the skin and subcutaneous tissues over the pubis, centering on the pectineal muscle as it inserts on the iliopectineal eminence. Elevate the gracilis and adductor muscles from the pubis, and severe the prepubic tendon and pectineus from its cranial aspect. Place two Hohmann retractors ventral to the proposed osteotomy sites to protect the underlying soft tissues and the obturator nerve (Plate 18A). Using an oscillating saw, Gigli wire, or osteotome and mallet, perform the first osteotomy medial to the iliopubic eminence, and the second osteotomy near the medial limit of the obturator foramen. Remove and preserve the segment of bone in a blood-soaked gauze as a corticocancellous graft for the ilial osteotomy. Suture the gracilis muscle to the prepubic tendon to prevent inguinal herniation. Closure is routine.

**Ischial Osteotomy:**[3] With the dog in lateral recumbency, incise the skin and subcutaneous tissue sagittally over the ischial shelf, midway between midline and the tuber ischii. Elevate the internal obturator, semimembranous, and semitendinosus muscles off of the ischial shelf. Perform an osteotomy of the ischium beginning from the most lateral aspect of the obturator foramen with a reciprocating saw or Gigli wire (Plate 18B). The osteotomy is not stabilized. Closure is routine.

*Continued*

*Canine Pelvic Osteotomy Plate, Slocum Enterprises, Eugene, Oregon.

# PLATE 18


A
Section of pubic ramus to be removed
Prepubic tendon
Pectineus muscle
Adductor muscle
Gracilis muscle
B
Ischial osteotomy site
Ischial osteotomy

**Ilial Osteotomy and Stabilization:**[3,4] Incise the skin and subcutaneous tissue from the center of the iliac crest to the greater trochanter. Following muscle planes, incise the deep gluteal fascia between the tensor fascia latae and the middle gluteal muscle from the ventral iliac spin to the cranial border of the biceps femoris muscle. Preserving the cranial gluteal artery, vein, and nerve, sharply elevate the origin of the middle and deep gluteal muscles cranially and dorsally to expose the ilial shaft. Cauterize the iliolumbar vessels as necessary. Continue elevating the soft tissues off of the ilial wing medially, being careful not to injure the sciatic nerve. Palpate the caudal extent of the sacrum and position two large, blunt Hohmann retractors medial to the ilium to protect the sciatic nerve (Plate 18C). Perform the osteotomy of the ilial wing with an oscillating saw. Be sure the osteotomy is caudal to the sacroiliac joint and perpendicular to a reference pin positioned parallel to the ventral third of the ilial wing to the tuber ischii (Plate 18D). Move the acetabular segment cranially and laterally with Kern boneholding forceps, and remove the sharp spike of the ilium of the caudal segment with an oscillating saw or rongeurs. Preserve the bone segment as a corticocancellous graft for the ilial osteotomy. Attach the Canine Pelvic Osteotomy Plate to the caudal segment 3 mm dorsal to the ventral margin with 3.5-mm cortical screws (Plate 18E). Drill, measure, and tap the plate holes in the following order: 1, 2, and 3. Rotate the acetabular segment caudolaterally, and fix the plate to the cranial ilial segment. Drill, measure, and tap the plate holes in the following order: 4, 5, and 6. The small hemi cerclage hole in the caudal half of the plate may be left open or filled with a 2.7-mm screw. The hip should now be stable and the Ortolani sign eliminated. If not, the plate can be removed and replaced with another plate of increased angle. Most coxofemoral joints in dogs are sufficiently stable with 20 to 30 degrees of rotation. Joints that require more rotation may not have sufficient acetabular depth to warrant the triple pelvic osteotomy procedure. Lavage, place the corticocancellous graft along the osteotomy, and suture the deep gluteal to the sartorius fascia. The remainder of the closure is routine.

## CAUTIONS[1]

Caution should be taken to protect the cranial gluteal, obturator, and sciatic nerves. Premature screw loosening and migration are commonly associated with the cranial portion of the plate. Factors associated with decreased screw migration include increasing the depth of sacral purchase in the first and second cranial screw and filling the ischial cerclage hole with a screw or cerclage.

## POSTOPERATIVE EVALUATION

Postoperative radiographs are indicated to evaluate osteotomy and implant position and acetabular coverage. Radiographs should be repeated at 6- to 8-week intervals to evaluate implant position and acetabular coverage until the ilial union is complete.

## POSTOPERATIVE CARE

The animal should be confined to a small area or kennel until the ilial union is evident. Activity should be limited to outside leash walks for urination and defecation. Care should be taken to avoid stairs and slippery surfaces.

## EXPECTED OUTCOME[5,6]

Outcome is usually good to excellent. Force plate analysis confirms that weight-bearing forces improve in operated versus nonoperated hips. Ninety-two percent of the clinical signs associated with lameness and gait abnormalities resolve with minimal progression of degenerative joint disease in dogs undergoing this procedure. In a separate clinical study, locomotor, physical, and owner's evaluation demonstrate the superiority of the triple pelvic osteotomy over medical treatment and excision arthroplasty.

### References

1. Simmons S, Johnson AL, Schaeffer DJ: Risk factors for screw migration after triple pelvic osteotomy. J Am Anim Hosp Assoc 37(3):269–273, 2001.
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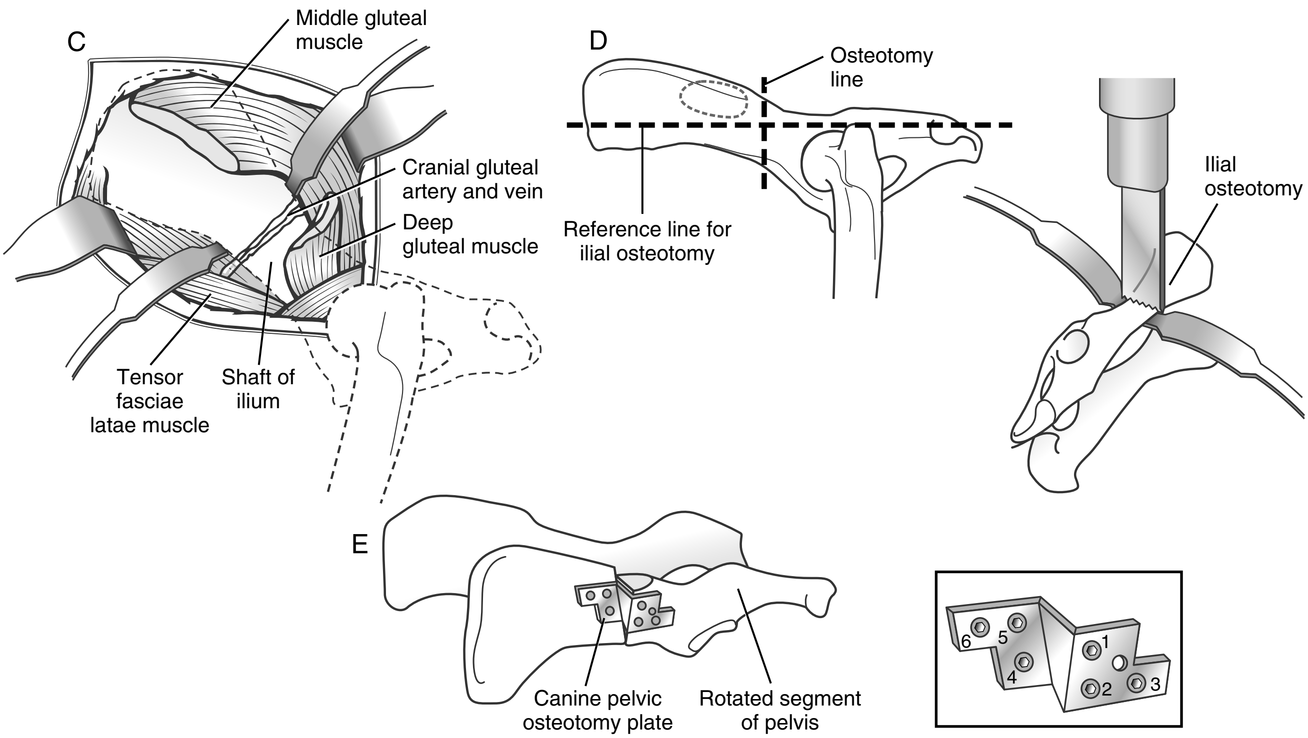
6. McLaughin RM, Miller CW, Taves CL, et al: Force plate analysis of triple pelvic osteotomy for the treatment of canine hip dysplasia. Vet Surg 20:291–297, 1991.

# PLATE 18


C
Middle gluteal muscle
Cranial gluteal artery and vein
Deep gluteal muscle
Tensor fasciae latae muscle
Shaft of ilium
D
Osteotomy line
Reference line for ilial osteotomy
Ilial osteotomy
E
Canine pelvic osteotomy plate
Rotated segment of pelvis
6
5
4
1
2
3

## STIFLE

# Chapter 19 Medial Patella Luxation Stabilized with Wedge Recession Trochleoplasty, Desmotomy, Tibial Tuberosity Transposition, and Retinacular Imbrication

### INDICATIONS

Candidates include clinically lame animals with Putmann's grade II and above patella luxations.

### OBJECTIVES

- To improve limb function and prevent degenerative joint disease by anatomic realignment and stabilization of the patella within the trochlear groove

### ANATOMIC CONSIDERATIONS[1,2]

The patella is the largest sesamoid bone in the body; it is located within the tendon of insertion of the quadriceps muscle group. The quadriceps muscle group, formed by the rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius muscles, converges on the patella and continues as the patellar ligament to insert on the tibial tuberosity. The vastus lateralis and medialis have additional attachments to the patella by medial and lateral parapatellar fibrocartilages, which aid in stifle stability through contact with the ridges of the femoral trochlear. Originating from the fabella and merging with the medial and lateral parapatellar fibrocartilages are the collagen fibers of the medial and lateral retinacula. The patella articulates within the trochlear groove, which is formed by the trochlear ridges of the medial and lateral condyle. The medial trochlear ridge is thicker than the lateral in normal dogs. Proper anatomic alignment of the extensor mechanism is a straight line of force; this is necessary for stability of the patella. The patella functions in the extensor mechanism of the stifle to provide cranial and rotary stability to the joint and serves as a lever arm, preserving even tension of the extensor mechanism during extension of the stifle.

### EQUIPMENT

- Standard surgical pack, small Hohmann retractor, fine-toothed saw,* bone cutters or osteotome and mallet, Freer periosteal elevator, Kirschner wires, wire driver

### PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to below the tarsus. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

### PROCEDURE[2,3]

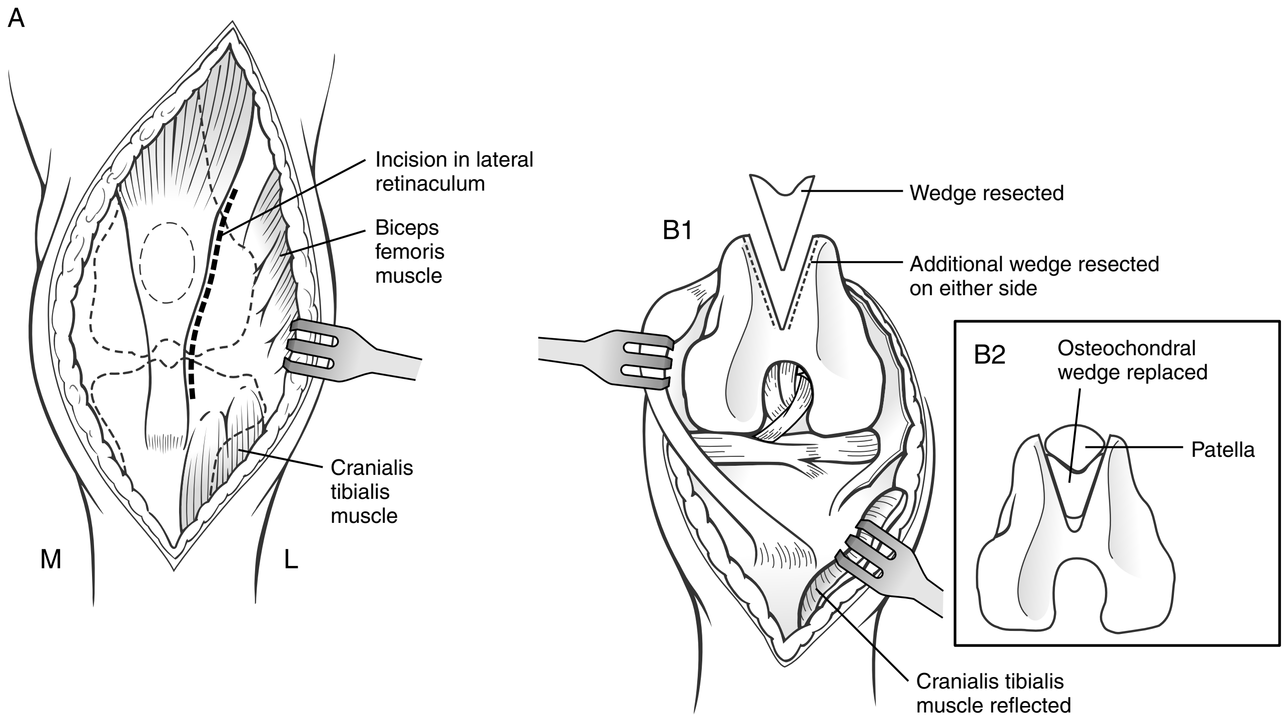
**Lateral Arthrotomy and Medial Desmotomy:** Incise the skin and subcutaneous tissue in a curvilinear fashion on the craniolateral aspect of the stifle (Plate 19A). The middle third of the incision should center on the patellar tendon. Reflect the skin and subcutaneous tissue laterally with blunt dissection. Return the patella to its normal orientation within the trochlear groove, and incise the lateral retinaculum and joint capsule from the cupola to the tibial plateau to release the patella and expose the joint. If the cranial sartorius and vastus medialis muscles inhibit patellar alignment, release the insertions of these muscles at the proximal patella. Examine the cruciate ligaments and menisci to check for tears caused by stifle instability, and excise as necessary. Delay closure of the joint until patella alignment and stability are assessed.

**Wedge Recession Trochleoplasty:** With the stifle in flexion and the patella luxated, cut the abaxial and axial margins of the wedge osteotomy using the fine-toothed saw (Plate 19B1). Keep the margins of the cut wide enough to accommodate the width of the patella. Remove the wedge and deepen the recession in the trochlea by removing additional bone from either side of the trochlear ridge with a file or an additional osteotomy, sliced parallel to the original cut. Resect the basilar surface of the osteochondral wedge with rongeurs to allow the cartilage to seat deeply into the new femoral groove patella (Plate 19B2). Additional trochlear depth can be achieved by rotating the wedge 180 degrees. Replace the patella, and examine limb alignment and patellar stability. With the stifle and tarsus flexed at 90 degrees, the patella, tibial tuberosity, and tarsus should follow the same linear orientation. After evaluating limb alignment, flex and extend the stifle while internally and externally rotating the pes. If the patella luxates or appears malaligned, a desmotomy and tibial tubercle transposition are indicated.

*Continued*

*X-ACTO Inc., Long Island City, New York.

# PLATE 19


A
Incision in lateral retinaculum
Biceps femoris muscle
Cranialis tibialis muscle
M
L
B1
Wedge resected
Additional wedge resected on either side
Cranialis tibialis muscle reflected
B2
Osteochondral wedge replaced
Patella

**Tibial Tubercle Transposition:** Incise the lateral retinaculum and joint capsule, extending the parapatellar incision distally to the tibial tubercle. Elevate the cranial tibial muscle from the tibia to the level of the long digital extensor tendon. Perform a partial osteotomy of the tibial tubercle, preserving the distal periosteal attachment of the tibial tubercle to serve as a biological tension band using bone cutters or an osteotome and mallet (Plate 19C1). Rongeur an osseus bed for the tibial tubercle to reside in, and with the stifle and tarsus flexed at 90 degrees, lever the tibial tubercle laterally with a periosteal elevator so that it is in alignment with the patella and tarsus. Stabilize the tubercle with two divergent Kirschner wires directed caudally and slightly proximally, engaging but not extending beyond the caudal cortex of the tibia (Plate 19C2). Reevaluate patellar alignment and stability, and relocate the tuberosity if needed. Cut and bend the Kirschner wires to prevent soft tissue irritation and facilitate removal if migration occurs.

**Joint Capsule Closure and Retinacular Imbrication:** Excise excessive lateral joint capsule and perform a balanced closure of the joint capsule and retinaculum. Check patellar stability after each imbricating suture. Imbricate the lateral joint capsule and lateral patellar tendon. Recheck patellar stability. Close the lateral and medial retinaculum with a vest-over-pants pattern (modified Mayo mattress pattern) (Plate 19D). After each suture is placed, evaluate patellar stability. Closure of the medial joint capsule may not be indicated in higher grades of patellar luxation. Allow the medal arthrotomy to separate, and do not suture the cut edges if medial luxation is severe. Close the subcutaneous tissue and skin over the arthrotomy and retinacular incisions.

## CAUTIONS[4]

The most common complication associated with surgical repair of patella luxation is recurrence of the luxation. Correction of the malalignment of the extensor mechanism via tibial tubercle transposition is imperative to a successful outcome of the surgery. Retinacular imbrication and joint capsule closure should be evaluated after each imbricating suture to ensure a balanced and stable closure.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for patellar alignment and implant placement. Radiographs should be repeated every 6 to 8 weeks until the osteotomy site is healed.

## POSTOPERATIVE CARE

The limb should be placed in a soft, padded bandage for 1 to 2 days. Activity should be restricted to walks on a leash until the osteotomy site is healed. Passive range-of-motion exercises may help maintain muscle mass and stifle range of motion.

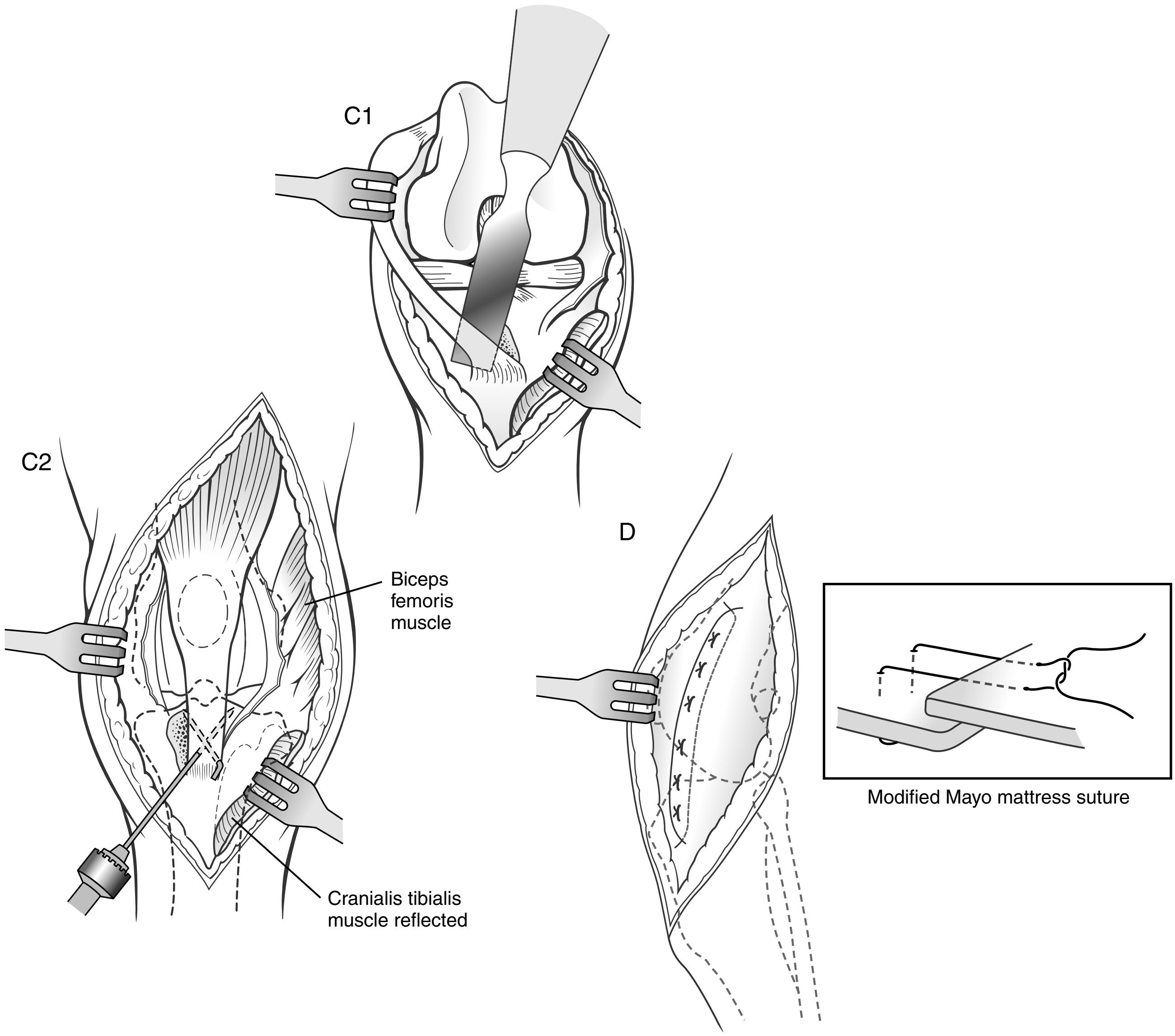
## EXPECTED OUTCOME[3]

Outcome is usually good to excellent. The prognosis depends on the age of the patient at the time of surgery, the body weight and condition score, and the amount of degenerative joint disease present prior to surgery. Degenerative joint disease progresses despite surgical correction and is positively correlated with the animal's age at surgery.

### References

1. Roush JK: Canine patellar luxation. Vet Clin North Amer 23:855–875, 1992.
2. L'Eplattenier H, Montavon P: Patellar luxation in dogs and cats: Pathogenesis and diagnosis. Compend Contin Educ Pract Vet 24:234–239, 2002.
3. L'Eplattenier H, Montavon P: Patellar luxation in dogs and cats: Management and prevention. Compend Contin Educ Pract Vet 24:292–300, 2002.
4. Willauer CC, Vasseur PB: Clinical results of surgical correction of medial luxation of the patella in dogs. Vet Surg 16:31–36, 1987.

# PLATE 19


C1
C2
Biceps femoris muscle
Cranialis tibialis muscle reflected
D
Modified Mayo mattress suture

## STIFLE

# Chapter 20 Deranged Stifle Luxation Stabilized with Suture Anchors, Screws, and Suture

### INDICATIONS[1–4]

Surgical stabilization and internal fixation is indicated in animals with gross instability of the stifle resulting from multiple ligament injury. The most common structures injured in the luxated stifle are the cranial and caudal cruciate, and either the lateral or medial collateral ligament. Reconstruction of the collateral and cranial cruciate ligaments and careful repair or removal of damaged menisci and joint capsule is an effective treatment method for medium and large dogs. Reconstruction of the caudal cruciate ligament and postoperative limb support is not found to be essential.

### OBJECTIVES

- To restore normal stability, congruency, mobility, and function to the stifle joint

### ANATOMIC CONSIDERATIONS[2,4]

The stifle joint is primarily stabilized by the cranial and caudal cruciate ligaments, the medial and lateral collateral ligaments, the joint capsule, and menisci. Additional stability may be provided by the patellar tendon, quadriceps, and popliteal musculature.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), periosteal elevator, Jacob chuck and key, intramedullary pins, mallet, 20- to 80-pound fishing leader line,* suture anchor system,† and crimp clamp system‡

Alternatively, a bone tunnel and screw and washer combination may be used if a suture anchor system is not available or if the animal is not large enough to accommodate the suture anchor system. Additional instrumentation needed for this technique includes a high-speed drill, bone screw and washer, drill bit, tap, depth gauge, screwdriver, and baby Hohmann retractor and baby Ochsner forceps for joint inspection and cruciate ligament débridement.

### PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to below the tarsus. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

### PROCEDURE

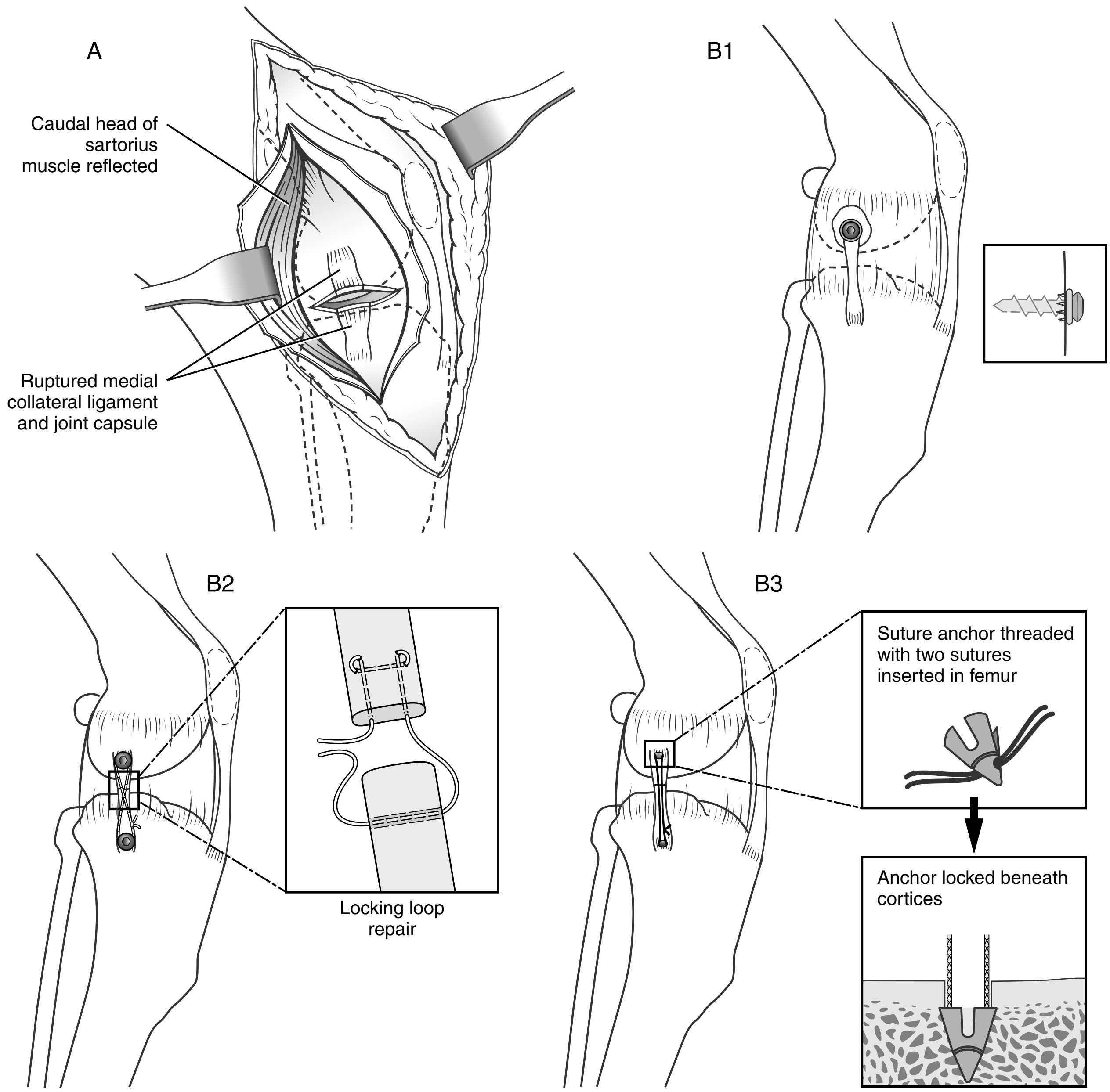
**Approach:**[5–7] Incise the skin and subcutaneous tissue in a curvilinear fashion on the craniolateral aspect of the stifle. The middle third of the incision should center on the patellar tendon. Reflect the skin and subcutaneous tissue medially and laterally with blunt dissection. Perform a medial arthrotomy, and incise the joint capsule from the cupula to the tibial plateau to expose the joint. Luxate the patella, and flex the limb. Examine the cruciate ligaments and menisci to check for tears, and excise/débride as necessary. Lavage and close the joint. To expose the medial collateral ligament, sharply incise the fascia of the caudal belly of the sartorius and elevate its insertion caudally to the level of the ligament (Plate 20A). To expose the lateral collateral ligament, incise the aponeurosis of the biceps femoris muscle just cranial to the muscle fibers and elevate the biceps femoris and attached fascia lata caudally to the level of the ligament. Before cranial cruciate repair is begun, stabilize the collateral ligament(s) to restore normal joint alignment and congruity.

**Collateral Ligament Repair:** Inspect the ligament for tears or avulsions. Repair avulsed intact ligaments with a screw and spiked plastic washer§ (Plate 20B1). As a general rule, repair mid-substance tears with a locking loop suture (Plate 20B2). Then protect the repaired ligament with screws, washers, and heavy suture; wire placed in a figure-eight suture pattern; or suture anchors (Plate 20B3).

*Continued*

*The 20-, 40-, 60-, 80-, 100-pound test is available through Mason Tackle Company, Otisville, Michigan.
†Innovative Animal Products, Rochester, Minnesota.
‡Securos Veterinary Orthopedics, Charlton, Massachusetts.
§Synthes, Monument, Colorado.

# PLATE 20


A
Caudal head of sartorius muscle reflected
Ruptured medial collateral ligament and joint capsule
B1
B2
Locking loop repair
B3
Suture anchor threaded with two sutures inserted in femur
Anchor locked beneath cortices

**Cranial Cruciate Ligament Repair:** To expose the lateral collateral ligament, incise the aponeurosis of the biceps femoris muscle just cranial to the muscle fibers, and bluntly elevate the biceps femoris and attached fascia lata caudally to the level of the ligament. Palpate the fabella and fibular head for proper anatomic orientation of the lateral fabellar suture. Pass the appropriate-size monofilament fishing leader line through the eye of a Martin uterine needle, and pass the needle around the cranial half of the fabella from proximal to distal. As a general rule, use 1 pound of test per pound of body weight. Drill a hole with intramedullary pin and Jacob chuck of sufficient size to pass the eye of the needle through the tibial crest from lateral to medial. The hole should be proximal to the most prominent point of the tibial tuberosity, in order to estimate the insertion of the cranial cruciate ligament. Pass the suture under the soft tissues of the cranial tibia to avoid muscle entrapment and premature loosening of the lateral fabellar suture from tissue necrosis. Pass the leader line from lateral to medial through the hole in the tibial crest and then under the patellar ligament immediately proximal to the tibial tuberosity. Cut the leader line in half to remove the needle, obtaining two sutures to tie. Flex the stifle to a normal standing angle, hold the tibia caudally and rotated externally to remove drawer motion, and tie each suture individually. Using the Securos crimp clamp system, slide one suture end at a time through the surgical crimp clamps and pull the ends so that the loop becomes taut (Plate 20C). Slide the additional crimp clamps on each end of the suture, positioning them 2 mm to 3 mm from the center crimp clamp. Use the crimp tool to firmly crimp the clamp on the individual strands. Slide the slotted tips of the tensioning device over the suture, and squeeze the arms of the tensioning device one click at a time, palpating for drawer and range of motion (Plate 20D). Once the appropriate amount of tension is obtained, crimp the middle clamp holding the two sutures three times, once in the middle and once on either end (Plates 20E1 and 20E2). Alternatively, use a sliding half hitch or a clamped square knot to stabilize the stifle. Check the stifle for range of motion and cranial drawer after each suture is tied. Imbricate the lateral fascia covering of the biceps femoris with a vest-over-pants closure.

## CAUTIONS[3]

Preoperative palpation should be performed and stress radiographs of the stifle joint should be taken under sedation or general anesthesia for proper assessment of the suspected injuries. Stifle joint stability should be assessed in all planes with the joint held in extension, normal standing angle, and 90 degrees flexion while maintaining the tibia in neutral position; however, in many cases surgical inspection of the stifle is often necessary for definitive diagnosis.

## POSTOPERATIVE EVALUATION

The range of motion should be evaluated, and the stifle should be checked for cranial drawer before the patient awakens. The stifle should be radiographed to assess implant positioning and joint congruency.

## POSTOPERATIVE CARE

Exercise should be restricted to outside leash walks for urination and defecation, and the animal should be confined to a kennel for the first 4 to 6 weeks. Then the animal's activity should slowly be returned to normal.

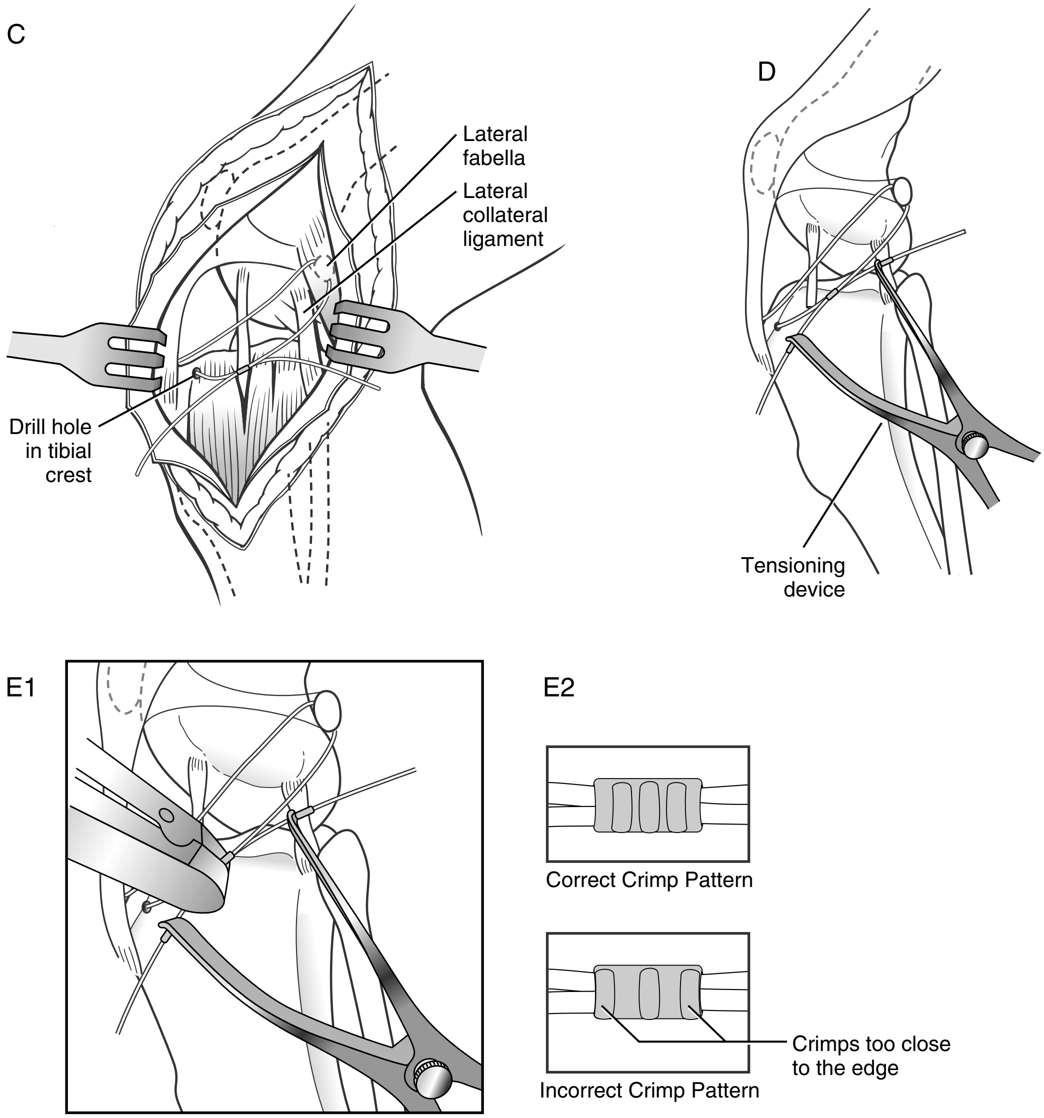
## EXPECTED OUTCOME[3]

Because of the traumatic nature of this disease, concomitant injuries are common and must be addressed prior to surgery; however, they do not justify a worse prognosis in dogs with stifle luxation. Delaying surgery to stabilize the patient is often necessary and also does not contribute to any difference in outcome. The long-term prognosis with stifle stabilization is fair to good, despite decreases in range of motion and reductions of muscle mass of the affected limb. Mild to moderate degenerative joint disease and gait abnormalities may be expected in cases with questionable cartilage viability or obvious cartilage trauma.

### References


1. Aron DN: Traumatic dislocation of the stifle joint: Treatment of 12 dogs and one cat. J Am Anim Hosp Assoc 22:333–340, 1988.
2. Welches CD, Scavelli TD: Transarticular pinning to repair luxation of the stifle joint in dogs and cats: A retrospective study of 10 cases. J Am Anim Hosp Assoc 26:207–214, 1990.
3. Hulse DA, Shires P: Multiple ligament injury of the stifle joint in the dog. J Am Anim Hosp Assoc 22:105–110, 1986.
4. Bruce WJ: Multiple ligamentous injuries of the canine stifle joint: A study of 12 cases. J Small Anim Pract 39:333–340, 1998.
5. Piermattei DL, Johnson KA: Approach to the stifle joint through a medial incision. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
6. Piermattei DL, Johnson KA: Approach to the medial collateral ligament and caudomedial part of the stifle joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
7. Piermattei DL, Johnson KA: Approach to the lateral collateral ligament and caudolateral part of the stifle joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.

# PLATE 20


C
Lateral fabella
Lateral collateral ligament
Drill hole in tibial crest
D
Tensioning device
E1
E2
Correct Crimp Pattern
Crimps too close to the edge
Incorrect Crimp Pattern

STIFLE

# Chapter 21 Cranial Cruciate Repair with a Lateral Fabellar Suture

## INDICATIONS
Candidates include animals with stifle instability caused by partial or complete cranial cruciate ligament injury as diagnosed via palpation or arthrotomy.

## OBJECTIVES
- To improve limb function by stabilization of the stifle and to prevent cranial displacement of the tibial plateau via an external suture strut to temporarily support the limb in neutral drawer position

## ANATOMIC CONSIDERATIONS[1]
The cranial cruciate ligament is composed of two elements: (1) the craniomedial and (2) the caudal lateral band. It has three important functions in defining stifle motion and stability. Together the bands work to limit joint hyperextension and internal rotation and cranial displacement of the tibial plateau. The smaller craniomedial band remains taut (and thus restricts motion) in both extension and flexion of the stifle joint. The more substantial caudolateral band is taut in only extension. This seemingly minute piece of anatomic trivia is important in understanding the clinical signs associated with partial and complete cranial cruciate injury. If the craniomedial band is disrupted, which is more commonly seen in the dog, cranial drawer will be only elicited in flexion, because the caudolateral band is lax with the stifle held in this position. If the caudolateral band is disrupted, there may be no drawer palpable, because the craniomedial band is still present and taut in both flexion and extension. If both bands are torn, drawer will be palpable in both flexion and extension.

## EQUIPMENT
- Standard surgical pack, one medium or large Gelpi retractor (depending on the size of the dog), periosteal elevator, Jacob chuck and key, intramedullary pin, 20- to 80-pound fishing leader line,* Martin uterine needles, and crimp clamp system†

Additional instrumentation needed for this technique includes a baby Hohmann retractor, baby Ochsner forceps, and a no. 11 blade for joint inspection and cruciate ligament débridement.

## PREPARATION AND POSITIONING
Prepare the leg circumferentially from dorsal midline to below the tarsus. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

## PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue in a curvilinear fashion on the craniolateral aspect of the stifle. The middle third of the incision should center on the patellar tendon. Reflect the skin and subcutaneous tissue medially and laterally with blunt dissection.

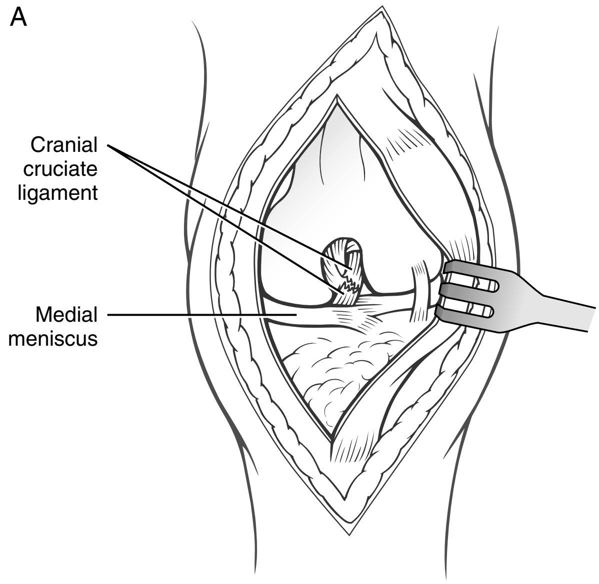
**Arthrotomy:** Perform a medial arthrotomy, and incise the joint capsule from the cupula to the tibial plateau to expose the joint. Luxate the patella and flex the limb. Examine the cruciate ligaments and menisci to check for tears, and excise/débride as necessary. To débride the injured cruciate ligament, use a no. 11 blade and incise the origins of the ligament within the intercondylar notch of the caudomedial portion of the lateral condyle (Plate 21A). Take care not to injure the caudal cruciate ligaments where they cross each other near attachments in the intercondylar fossa of the femur. This may be achieved with three incisions. Lavage and close the joint in one or two layers, making sure to appose the synovial layer with either method.

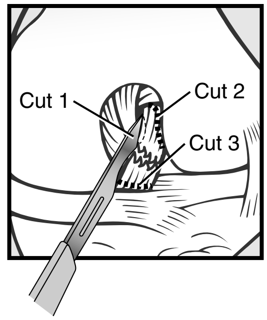
*Continued*

*The 20-, 40-, 60-, 80-, 100-pound test is available through Mason Tackle Company, Otisville, Michigan.
†Innovative Animal Products, Rochester, Minnesota.

# PLATE 21

A



**Lateral Fabellar Suture:**[2,3] To expose the lateral collateral ligament, incise the aponeurosis of the biceps femoris muscle just cranial to the muscle fibers, and bluntly elevate the biceps femoris and attached fascia lata caudally to the level of the ligament (Plate 21B). Palpate the fabella and fibular head for proper anatomic orientation of the lateral fabellar suture. Pass the appropriate-size monofilament fishing leader line through the eye of a Martin uterine needle, and pass the needle around the cranial half of the fabella from proximal to distal. As a general rule, use 1 pound of test per pound of body weight. Drill a hole with intramedullary pin and Jacob chuck of sufficient size to pass the eye of the needle through the tibial crest from lateral to medial. Make the hole proximal to the most prominent point of the tibial tuberosity in order to estimate the insertion of the cranial cruciate ligament. Pass the suture under the soft tissues of the cranial tibia to avoid muscle entrapment and premature loosening of the lateral fabellar suture from tissue necrosis. Pass the leader line from lateral to medial through the hole in the tibial crest and then under the patellar ligament immediately proximal to the tibial tuberosity. Cut the leader line in half to remove the needle, obtaining two sutures to tie. Flex the stifle to a normal standing angle, hold the tibia caudally and rotated externally to remove drawer motion, and tie each suture individually. Using the Securos[‡] crimp clamp system, slide one suture end at a time through the surgical crimp clamps and pull the ends so that the loop becomes taut. Slide the additional crimp clamps on each individual end of the suture, positioning them 2 mm to 3 mm from the center crimp clamp (Plate 21C). Use the crimp tool to firmly crimp the clamp on the individual strands. Slide the slotted tips of the tensioning device over the suture, and squeeze the arms of the tensioning device one click at a time, palpating for drawer and range of motion (Plate 21D). Once the appropriate amount of tension is obtained, crimp the middle clamp holding the two sutures three times, once in the middle and once on either end (Plate 21E1). Alternatively, use a sliding half hitch or a clamped square knot to stabilize the stifle. Check the stifle for range of motion and cranial drawer after each suture is tied. Imbricate the lateral fascia covering of the biceps femoris with a vest-over-pants closure (Plate 21E2) from the patella to the tibial crest to cover the sutures and help prevent seroma formation (Plate 21E3).

## CAUTIONS[2,4]

Activity should be restricted to short walks on a leash to prevent premature breakdown of the stifle stabilization. Risk of early failure may be higher with poor fabella anchorage; therefore, particular attention should be paid to needle position relative to fabella anatomy. Meniscal damage is reported in 45% of cranial cruciate rupture, with the medial meniscus being most commonly affected. Careful assessment of both menisci is important because damaged menisci should be partially débrided or excised.

## POSTOPERATIVE EVALUATION[4]

The range of motion should be evaluated and the stifle for cranial drawer should be checked before the patient awakens. It is not necessary to radiograph the stifle to assess implant positioning and joint congruency in this repair.

## POSTOPERATIVE CARE

The leg should be placed in a soft, padded bandage for 24 hours to cover the wound and provide support. Exercise should be restricted and the animal should be confined to a kennel for the first 4 to 6 weeks. Then normal activity should slowly be reintroduced.

## EXPECTED OUTCOME

Osteoarthritis is a common sequela to cranial cruciate rupture, particularly when meniscal damage is present. However, the prognosis is good to excellent with proper postoperative care and confinement.

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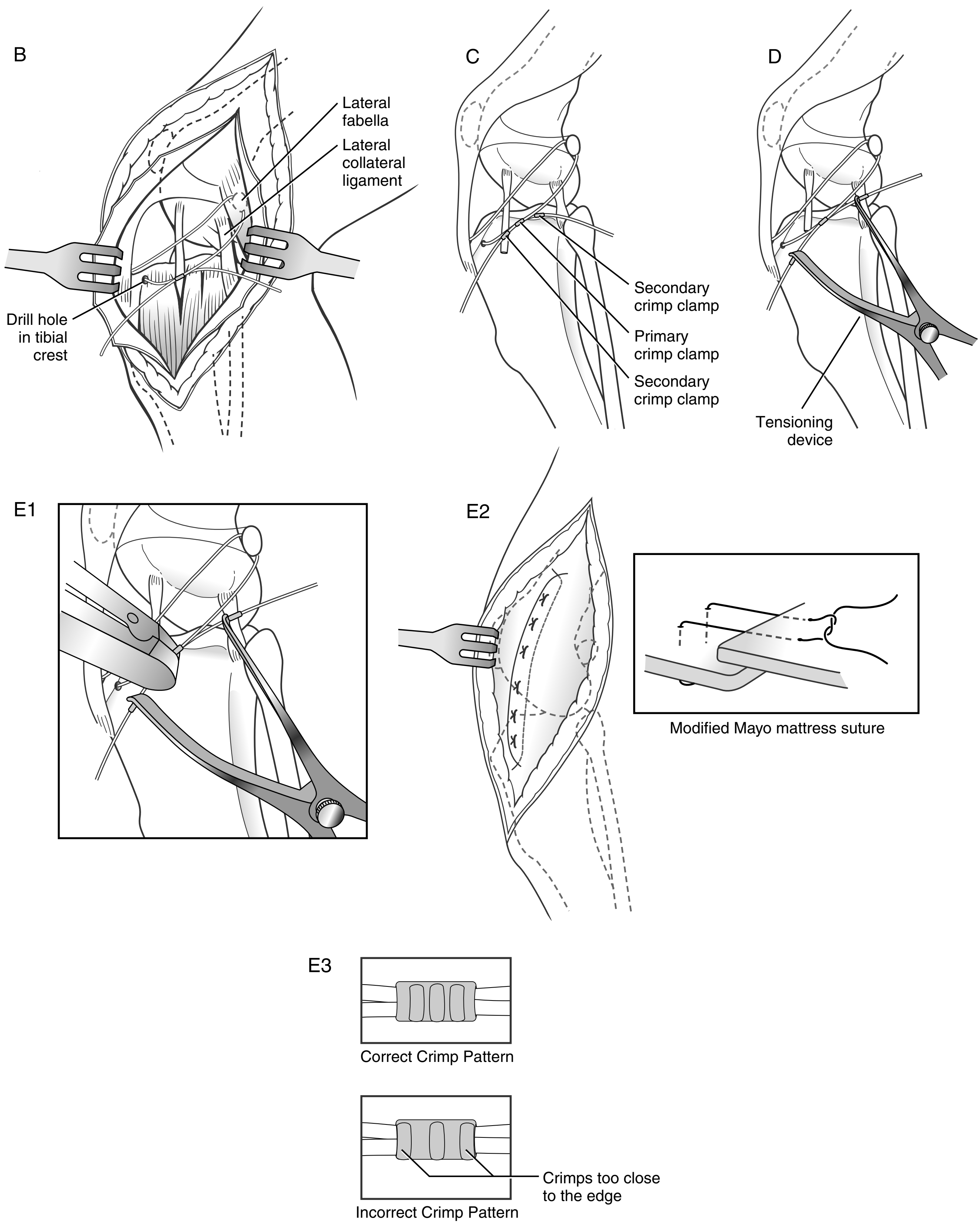
4. Stork CK, Gibson NR, Owen MR, et al: Radiographic features of a lateral extracapsular wire suture in the canine cranial cruciate deficient stifle. J Small Anim Pract 42:487–490, 2001.

[‡]Securos Veterinary Orthopedics, Charlton, Massachusetts.

# PLATE 21


B
Lateral fabella
Lateral collateral ligament
Drill hole in tibial crest
C
Secondary crimp clamp
Primary crimp clamp
Secondary crimp clamp
D
Tensioning device
E1
E2
Modified Mayo mattress suture
E3
Correct Crimp Pattern
Crimps too close to the edge
Incorrect Crimp Pattern

STIFLE

# Chapter 22 Cranial Cruciate Repair with Intra-articular Repair

## INDICATIONS

Candidates include animals with stifle instability caused by partial or complete cranial cruciate ligament injury as diagnosed via palpation or arthrotomy.

## OBJECTIVES

- To improve limb function and prevent degenerative joint disease by stabilization of the stifle, and to prevent cranial displacement of the tibial plateau by replacing the cranial crucial ligament with an autogenous internal graft

## ANATOMIC CONSIDERATIONS[1]

The cranial cruciate ligament is composed of two elements: (1) the craniomedial and (2) the caudal lateral band. It has three important functions in defining stifle motion and stability. Together the bands work to limit joint hyperextension and internal rotation and cranial displacement of the tibial plateau. The smaller craniomedial band remains taut (and thus restricts motion) in both extension and flexion of the stifle joint. The more substantial caudolateral band is taut in only extension. This seemingly minute piece of anatomic trivia is important in understanding the clinical signs associated with partial and complete cranial cruciate injury. If the craniomedial band is disrupted, which is more commonly seen in the dog with partial cranial cruciate injury, cranial drawer will be elicited only in flexion, because the caudolateral band is lax with the stifle held in this position. If the caudolateral band is disrupted, there may be no palpable drawer at all, because the craniomedial band is still present and taut in both flexion and extension. If both bands are torn, drawer will be palpable in both flexion and extension.

## EQUIPMENT

- Standard surgical pack, one medium or large Gelpi retractor (depending on the size of the dog), periosteal elevator, drill, drill bit, screws, plastic washers, rongeurs, bone rasp, curette, straight needle and/or cerclage wire

Additional instrumentation needed for this technique includes baby Hohmann retractor, baby Ochsner forceps, and a no. 11 blade for joint inspection and cruciate ligament débridement.

## PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to below the tarsus. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

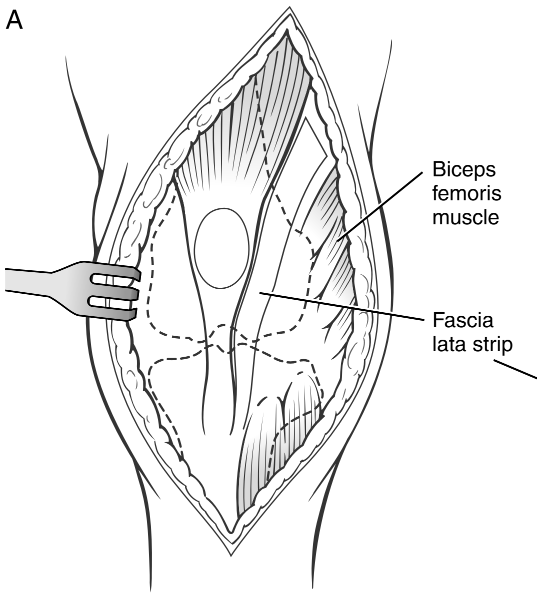
## PROCEDURE

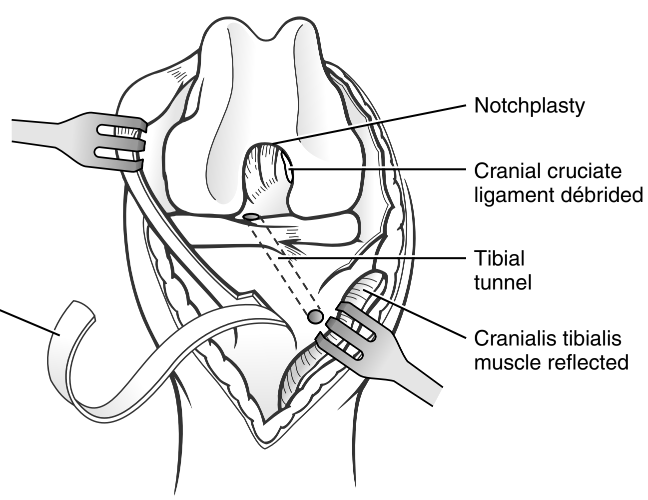
**Approach:** Incise the skin and subcutaneous tissue in a curvilinear fashion on the craniolateral aspect of the stifle. Center the middle third of the incision on the patellar tendon. Reflect the skin and subcutaneous tissue medially and laterally with blunt dissection.

**Arthrotomy and Notchplasty:**[2,3] Perform a lateral arthrotomy, and incise the joint capsule from the cupula to the tibial plateau to expose the joint, taking care not to damage the long digital extensor tendon (Plate 22A). Luxate the patella and flex the limb. Examine the cruciate ligaments and menisci to check for tears and excise/débride as necessary. To débride the injured cruciate ligament, use a no. 11 blade, and incise the origins of the ligament within the intercondylar notch of the caudomedial portion of the lateral condyle. Take care not to injure the caudal cruciate ligaments where they cross each other near attachments in the intercondylar fossa of the femur. Perform a notchplasty with a bone rasp, curette, or rongeur, removing any osteophytes and widening the lateral wall of the intercondylar notch to allow adequate space to pass the graft and to protect the graft from impingement of the craniolateral wall of the intercondylar fossa (Plate 22B). Lavage the joint and return the patella to its original position.

*Continued*

# PLATE 22


A
Biceps femoris muscle
Fascia lata strip


B
Notchplasty
Cranial cruciate ligament débrided
Tibial tunnel
Cranialis tibialis muscle reflected

**Intracapsular Graft:**[1,2,3] Harvest a 10-cm graft from the craniolateral aspect of the distal fascia lata and lateral third of the patellar tendon, using the arthrotomy incision as the caudal border of the graft. Free the graft and its bony insertion onto the tibial plateau with an osteotome while maintaining its distal fascial attachments (see Plate 22A). Create a tibial tunnel with a drill bit large enough to accept the graft from the cranial surface of the tibia (see Plate 22B). Alternatively, use a guide wire followed by a cannulated drill bit to ensure accuracy of the graft placement. The entry point location of the tunnel is just lateral and distal to the tibial tuberosity, exiting into the joint at the point of insertion of the cranial cruciate ligament (Plate 22C). Place one or two stay sutures in the end of the graft using large diameter monofilament suture (0 or 1) or cerclage wire. Thread the stay suture with a straight needle or loop of cerclage wire through the bone tunnel in the tibia from distal to proximal. Place the graft through the intercondylar notch by passing curved Kelly or Carmalt forceps over the top of the lateral condyle or by creating a separate femoral tunnel extending from the point of origin of the cranial cruciate to the caudolateral aspect of the femoral condyle and passing the straight needle or looped cerclage wire through the tunnel (Plate 22D). Secure the graft to the distal femur by suturing it to the femorofabellar ligament with large (0 to 2) monofilament, with nonabsorbable suture, or with a spiked screw and washer with the stifle in standing flexion (Plate 22E). Check the stifle for range of motion and cranial drawer after the graft is secured.

## CAUTIONS[4,5]

Placing excessive tension on the graft should be avoided, because it will lead to premature failure of the repair. Normally, 2 mm to 3 mm of drawer motion should be detected on palpation. Excessive drawer may then be removed by joint capsule and fascial imbrication; however, many surgeons at this point often reenforce the intracapsular repair with a lateral fabellar suture (see Chapter 21 for details regarding this procedure).

## POSTOPERATIVE EVALUATION[5]

The range of motion should be evaluated, and the stifle should be checked for cranial drawer before the patient awakens. It is not necessary to radiograph the stifle to assess implant positioning and joint congruency in this repair.

## POSTOPERATIVE CARE

The leg should be placed in a soft, padded bandage for 24 hours to cover the wound and provide support. Exercise should be restricted and the animal should be confined to a kennel for the first 4 to 6 weeks. Then normal activity should be slowly reintroduced.

## EXPECTED OUTCOME

Osteoarthritis is a common sequela to cranial cruciate rupture, particularly when meniscal damage is present; however, the prognosis is good to excellent with proper postoperative care and confinement.

### References

1. Hart RC, Hulse DA, Slater MR: Contribution of periarticular tissue to stabilization of the canine stifle joint after cranial cruciate ligament reconstruciton. Vet Comp Orthop Traumatol 16:21–25, 2003.
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4. Lampman TJ, Lund EM, Lipowitz AJ: Cranial cruciate disease: Current status of diagnosis, surgery, and risk for disease. Vet Comp Orthop Traumatol 16:122–126, 2003.
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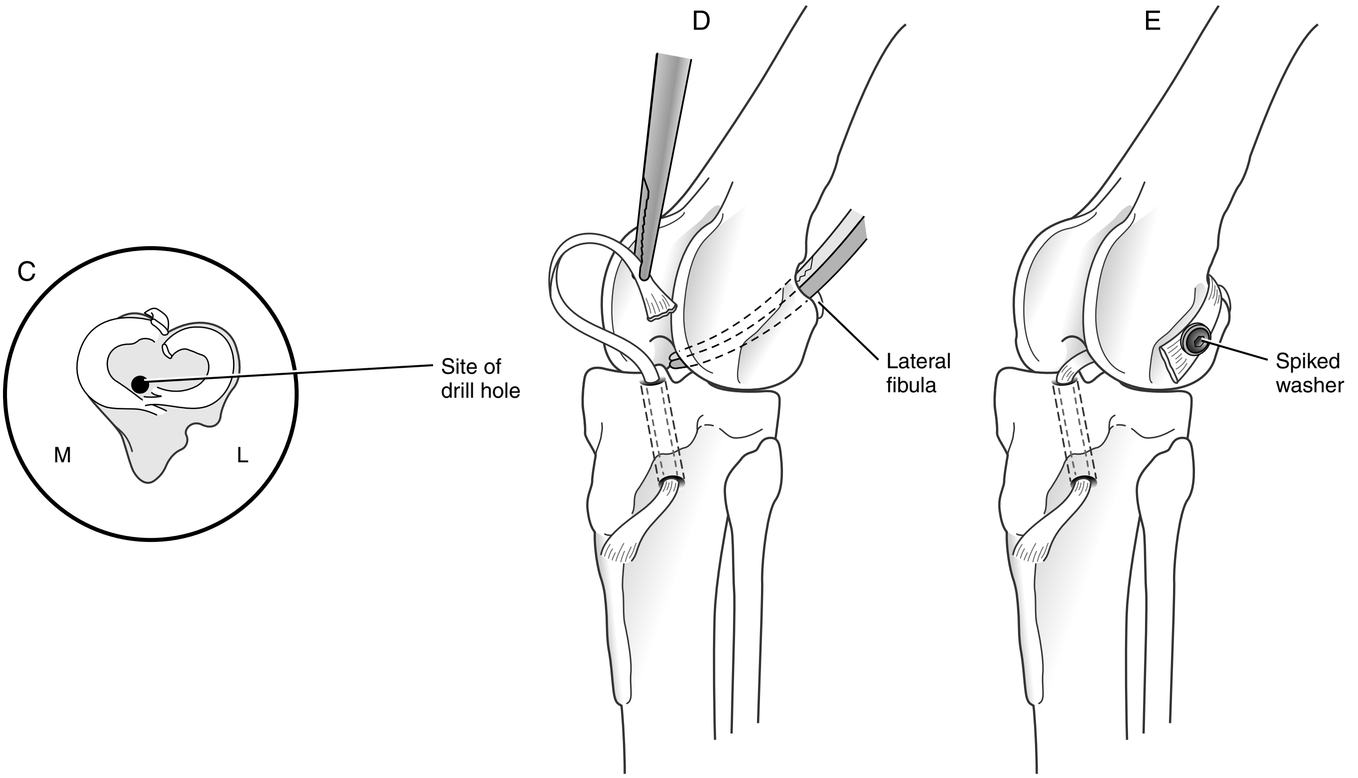
# PLATE 22



# STIFLE

# Chapter 23 Meniscectomy

## INDICATIONS

Candidates include animals with meniscal damage caused by stifle instability from chronic partial or complete cranial cruciate ligament injury or traumatic luxation.

Dogs with meniscal damage usually experience more pain and display more lameness in association with stifle instability than in association with a pure cruciate tear.

## OBJECTIVES

- To improve limb function and decrease pain associated with meniscal injury caused by entrapment of the femoral condyle because of stifle instability

## ANATOMIC CONSIDERATIONS[1]

Dogs and cats have a medial and a lateral menisci that reside within the stifle joint. The functions of the menisci are complex, but these structures are very important to normal stifle biomechanics. They are white, C-shaped, discoid, fibrocartilagenous structures that are wedge-shaped when viewed on cross section. Each meniscus consists of a body and a cranial and caudal pole. The medial meniscus is stabilized by cranial and caudal tibial ligaments, an intermeniscal ligament, and a strong attachment to the medial collateral ligament. The lateral meniscus is less firmly attached via cranial and caudal tibial ligaments, an intermeniscal ligament, and a caudal femoral ligament. The menisci move slightly while the stifle joint moves through its ranges of motion, but because of the presence of more synovial attachment, the caudal tibial ligament, and the lack of a femoral attachment, the medial meniscus moves less than the lateral and therefore may be more predisposed to injury in a cranial cruciate deficient stifle.[2] Once the cranial cruciate ligament is disrupted, cranial displacement of the tibia acts to wedge the posterior horn of the medial meniscus between the tibial plateau and the femoral condyle.[3] Repetitive entrapment between the femoral condyle and tibial plateau results in meniscal injury (particularly to the caudal pole), and increases the likelihood of degenerative joint disease and stifle dysfunction. The medial meniscus has been reported to be damaged in 47% to 80% of cranial cruciate deficient stifles and around 14% of previously repaired cranial cruciate deficient stifles.[4,5]

## EQUIPMENT

- Standard surgical pack, one medium or large Gelpi retractor (depending on the size of the dog), baby Hohmann retractor, baby Ochsner forceps, and a no. 11 or 15 blade for joint inspection and cruciate ligament and meniscal débridement or excision

## PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to below the tarsus. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

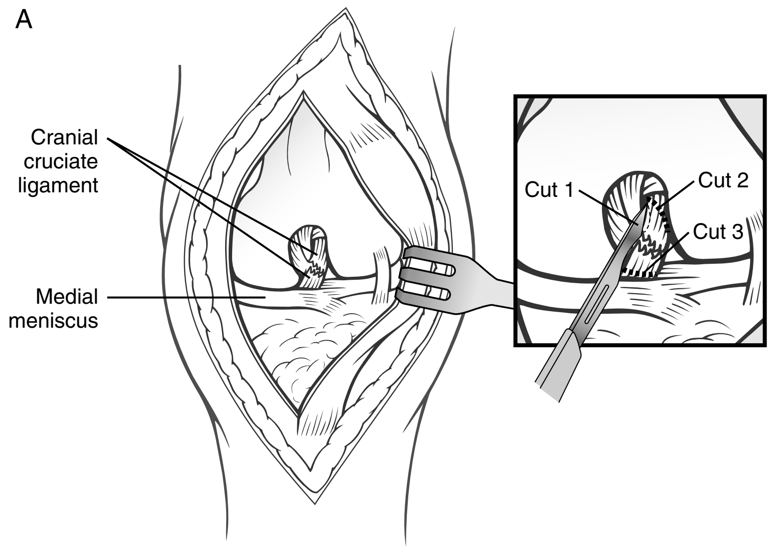
## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue in a curvilinear fashion on the craniolateral aspect of the stifle. Center the middle third of the incision on the patellar tendon. Reflect the skin and subcutaneous tissue medially and laterally with blunt dissection.

**Arthrotomy:** Perform a medial arthrotomy, and incise the joint capsule from the cupula to the tibial plateau to expose the joint. Luxate the patella and flex the limb. Examine the cruciate ligaments and menisci to check for tears and excise/débride as necessary. To débride the injured cruciate ligament, use a no. 11 blade and incise the origins of the ligament within the intercondylar notch of the caudomedial portion of the lateral condyle (Plate 23A). Take care not to injure the caudal cruciate ligaments where they cross each other near attachments in the intercondylar fossa of the femur.

*Continued*

# PLATE 23


A
Cranial cruciate ligament
Medial meniscus
Cut 1
Cut 2
Cut 3

**Meniscectomy:** Using a baby Hohmann retractor, lever the tibial plateau forward by placing the tip of the instrument behind the tibial plateau while holding the stifle at a normal standing angle (Plate 23B). Avoid excessive flexion of the joint, because it will close the joint space and limit visualization of the menisci. Inspect both the medial and lateral menisci for tears or crushing injury (see Plate 23B). If only the caudal pole is affected, perform a partial meniscectomy. Grasp the damage portion of the meniscus firmly with Ochsner forceps and place cranial traction on the damaged pole. Incise the caudal meniscotibial ligament to release the caudal pole with a number 11 or 15 blade (Plate 23C1). Next release the synovium and collateral attachments (if performing a medial meniscectomy) of the body until healthy fibrocartilage is reached and cut perpendicularly across the body of the meniscus to remove the caudal pole (Plate 23C2). If the entire meniscus is damaged, perform a complete meniscotomy. Incise the intermeniscal and cranial tibial attachments of the cranial pole (Plate 23D1). Release the synovium and collateral attachments (if present) while placing lateral traction on the cranial pole of the meniscus with an Ochsner forceps. Finally, incise the caudal meniscotibial ligament to release the caudal pole and remove the meniscus (Plate 23D2).

Lavage and close the joint in one or two layers, making sure to appose the synovial layer with either method. Stabilize the joint with either an extracapsular or intercapsular method to prevent further injury.

## CAUTIONS

Meniscectomy should not be performed unless there is meniscal pathology present, because either partial or complete meniscectomy results in the progression of degenerative joint disease.

## POSTOPERATIVE EVALUATION[6]

The range of motion should be evaluated and the stifle should be checked for cranial drawer before the patient awakens. It is not necessary to radiograph the stifle to assess implant positioning and joint congruency.

## POSTOPERATIVE CARE

The leg should be placed in a soft, padded bandage for 24 hours to cover the wound and provide support. Therapeutic exercise and rehabilitation should be strongly considered for the first 4 to 6 weeks. Then normal activity should be slowly reintroduced.

## EXPECTED OUTCOME[7,8]

A guarded prognosis for full return to function is the general rule when meniscal damage is present, because degenerative joint disease is a common sequela. Aggressive postoperative rehabilitation has been shown to improve the function in the case of dogs with meniscal damage.

### References


1. Flo GL: Meniscal injuries. Vet Clin North Am Small Anim Pract 23(4):831–843, 1993.
2. Arnoczky SP: Pathomechanics of cruciate and meniscal injuries. In Bojrab MJ: Disease Mechanisms in Small Animal Surgery. Philadelphia, Lea & Febiger, 1993.
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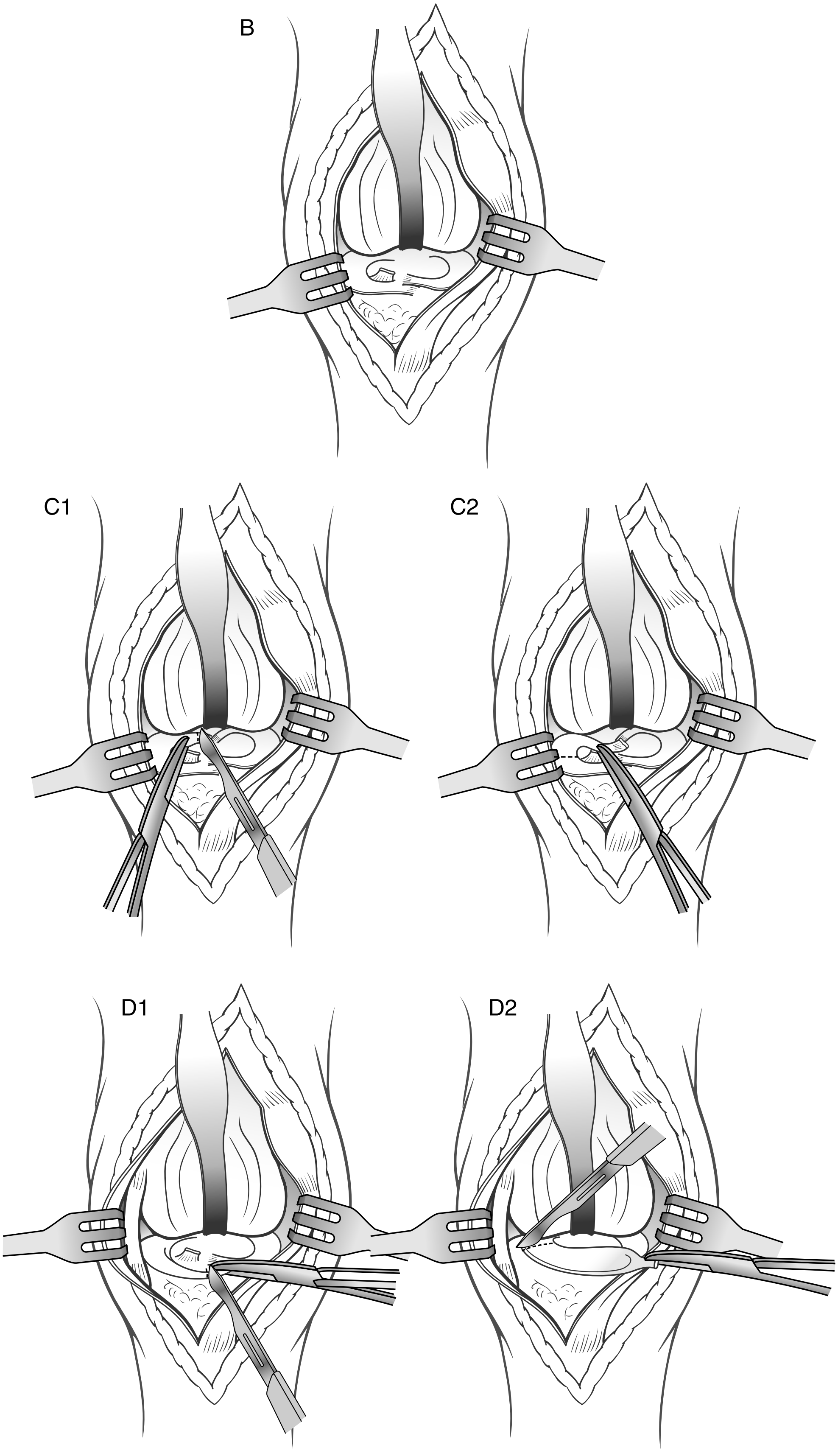
8. Marsolais GS, Dvorak G, Conzemius MG: Effects of postoperative rehabilitation on limb function after cranial cruciate ligament repair in dogs. J Am Vet Med Assoc 220(9):1325–1330, 2002.

# PLATE 23



## STIFLE

# Chapter 24 Stifle Arthrodesis

### INDICATIONS

Candidates include animals with unreconstructable joint fractures, stifle luxation, or severe osteoarthritis. Other candidates have grade 4 patellar luxations that have not responded to conventional treatment.[1,2]

### OBJECTIVES

- To fuse the bones of the femoral tibial joint in a functional position

### ANATOMIC CONSIDERATIONS

The landmarks for the incision are the distal femoral diaphysis, the patella, the tibial tuberosity, and the proximal tibial diaphysis. The tibial tuberosity is osteotomized to gain joint exposure and to provide a flat surface for the plate.

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, oscillating saw, self-centering plate-holding forceps, high-speed drill, wire driver and burrs, Kirschner wires, wire cutters, plating equipment

### PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to the hock. Position the animal in dorsal recumbency. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not needed because of the large cancellous bone contact surfaces at the arthrodesis site.

### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue over the craniolateral aspect of the stifle, extending from the mid-diaphysis of the femur to the mid-diaphysis of the tibia. Incise the lateral retinaculum, and retract the quadriceps muscle and patella medially to expose the distal femur. Elevate the cranial tibial muscle to expose the proximal tibia. Osteotomize the tibial tuberosity to aid exposure of the joint and to prepare a surface for the plate. Excise the menisci and cruciate ligaments. Preserve the collateral ligaments to aid in maintaining alignment (Plate 24A).[1]

**Alignment:** Predetermine the cranial caudal angle for the stifle arthrodesis by observing the normal standing angle of the stifle in the individual patient. Consider adding 10 degrees to the normal angle in large dogs and 5 degrees to the normal angle in small dogs and cats to compensate for the bone loss during the procedure. Commonly, the angle is 135 to 140 degrees for dogs and 120 to 124 degrees for cats (Plate 24B).[1]

**Stabilization:** To determine the ostectomy angles, place three Kirschner wires as follows: Place the first Kirschner wire perpendicular to the tibial diaphysis and in the midsaggital plane. Place the second wire perpendicular to the femoral diaphysis and in the midsaggital plane. Place a third wire into the femur distal to the second wire and at the complementary angle of the selected joint angle (see Plate 24B). Resect the articular portion of the tibia parallel to wire 1 and perpendicular to the long axis of the tibia. Resect the articular surface of the femur parallel to wire 3 and perpendicular to the long axis of the femur (see Plate 24B). Appose the femoral and tibial ostectomy surfaces and temporarily fix them with Kirschner wires (Plate 24C). Ensure that the guiding Kirschner wires are in the same plane to preserve rotational alignment. Remove the guiding Kirschner wires. Resect the trochlear ridges to improve plate contact (see Plate 24B). Apply a plate of appropriate size and contour, allowing at least four screws in the femur and four screws in the tibia. Secure the plate by first placing screws through the most distal and most proximal plate holes (see Plate 24C). If possible, place one or two screws as lag screws across the joint. Fill the remaining plate holes. Remove the stabilizing Kirschner wires. Attach the tibial tuberosity to the medial surface of the tibia with a lag screw (Plate 24D).[1]

### CAUTIONS

Avoid angling the saw blade medially or laterally when performing the tibial and femoral articular ostectomies. Check angular and rotational alignment of the limb carefully before securing the plate.

### POSTOPERATIVE EVALUATION

The axial alignment of the limb and the angle of the arthrodesis should be critically observed. Radiographs for limb alignment and implant placement should be evaluated.

### POSTOPERATIVE CARE

A soft, padded bandage should be placed to control bleeding and swelling. A lateral splint should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks, until bone healing is complete. The plate may be removed 6 to 9 months after bone healing to avoid stress concentration at the distal plate end.

### EXPECTED OUTCOME

The bone usually heals in 12 to 18 weeks. For most pet animals, satisfactory function of the treated limb is seen; however, circumduction of the limb and toe knuckling may occur at faster gaits. Results are best when the correct angle for fusion is achieved. Fracture may occur in the tibia at the end of the plate.

#### References

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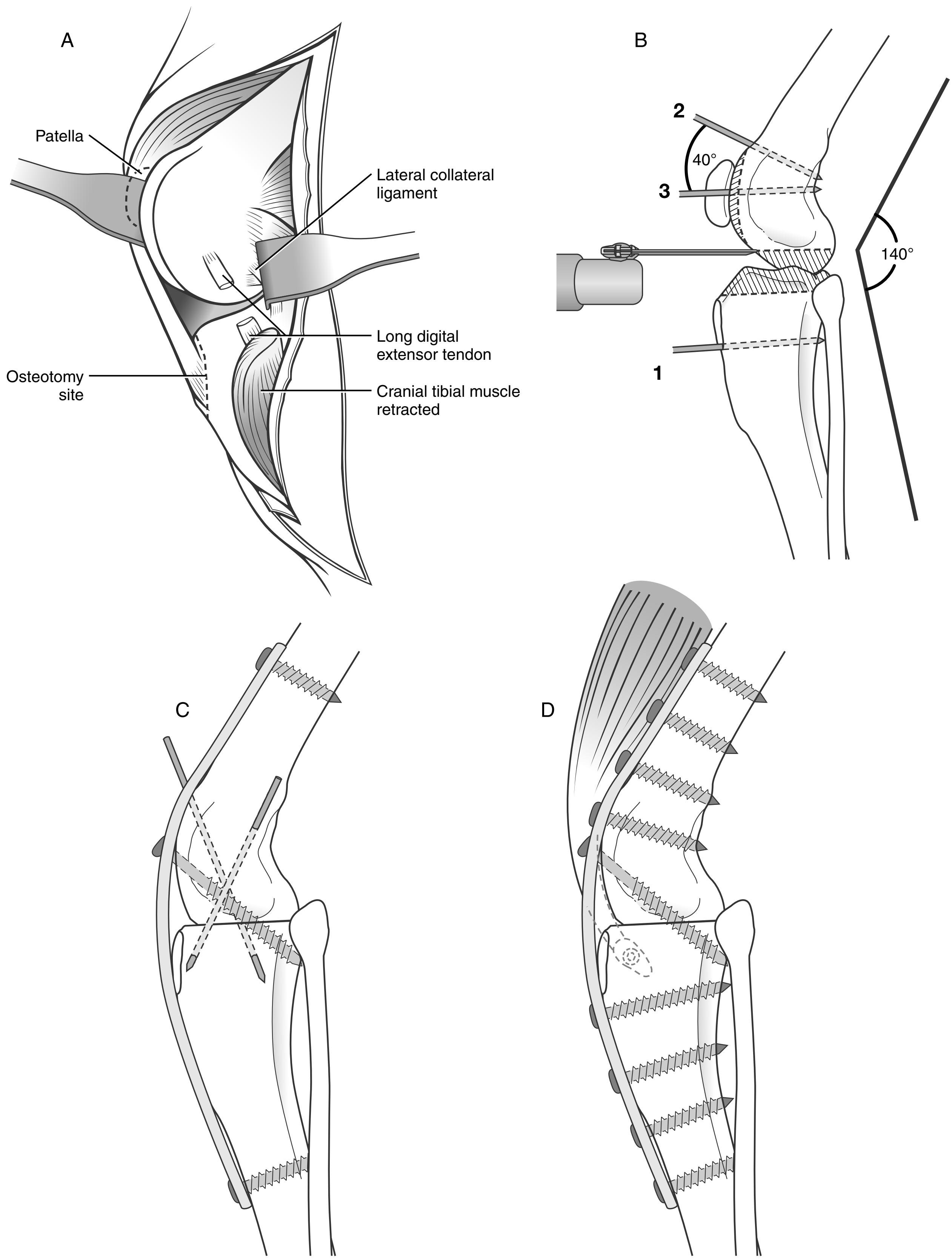
2. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.

# PLATE 24


A
Patella
Lateral collateral ligament
Long digital extensor tendon
Osteotomy site
Cranial tibial muscle retracted
B
2
40°
3
140°
1
C
D

## TARSUS

# CHAPTER 25 Achilles Tendon Repair

### INDICATIONS
Candidates include animals with partial or complete rupture of the Achilles or calcanean tendon.

### OBJECTIVES
- To restore normal weight bearing and limb function and eliminate the plantigrade stance associated with the injury

### ANATOMIC CONSIDERATIONS[1–4]
The Achilles tendon (AT) is the largest tendon complex in the dog. It consists of the combined tendinous insertion of five separate muscles: (1) the gastrocnemius, (2) the superficial digital flexor, and (3–5) the combined tendon of the biceps femoris, the semitendinosus, and the gracilis. Tendon injuries may be classified into three general types. Type 1 involves a complete disruption of the tendon apparatus. On physical examination, the hock may be fully flexed, with no tension placed on the Achilles mechanism. Dogs with this injury have a characteristic plantigrade stance, with the metatarsals and digits lying flat on the floor. Type 2 involves a lengthened AT system. Three subclassifications of this category are recognized: (1) type 2a is a musculotendinous rupture; (2) type 2b is an AT rupture with an intact paratenon or tendon sheath; and (3) type 2c is partial AT rupture, with an intact superficial digital flexor tendon. Dogs that have a type 2c AT injury display a characteristic “crab-like” stance, with a hyperflexed tarsus with contracture of the toes. The superficial digital flexor tendon is placed under considerable tension with partial disruption of the AT, which pulls on its insertions on the palmar surface of the proximal end of the middle phalanges of digits II, III, IV, and V, contracting the toes. In type 3 injuries, the AT is intact but inflamed. AT injuries may be acute or chronic in duration. Type 2 injuries are more common than full AT tears (i.e., type 1). Chronic injuries are technically more difficult to repair because tendon contracture and fibrosis hamper identification and apposition.

### EQUIPMENT
- Surgical pack, Gelpi retractors or Senn retractors, pointed reduction forceps, Kirschner wires or small Steinmann pins for large dogs, pin chuck or high-speed wire driver, cerclage wire, snub-nosed wire twisters, wire cutter, heavy-gauge monofilament nonabsorbable suture for tendon repair, external skeletal fixation set, equipment for casting and bandage material

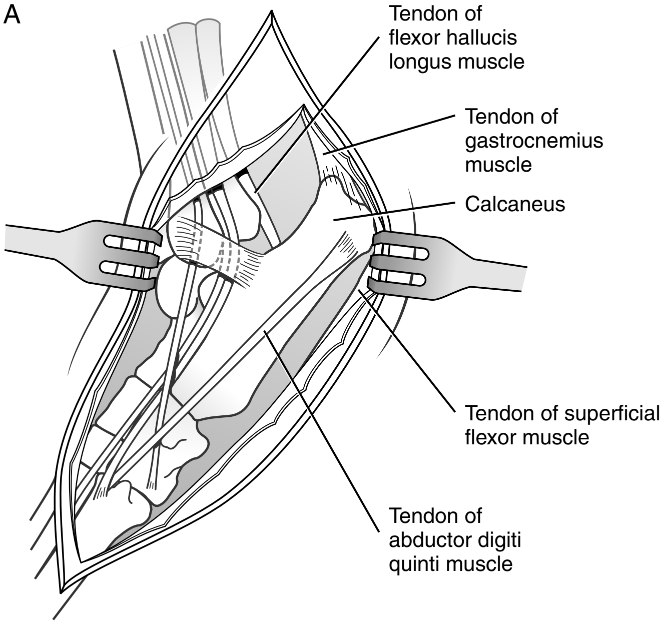
### PREPARATION AND POSITIONING
Prepare the leg circumferentially from dorsal midline to the phalanges. Use a hanging leg preparation, with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

### PROCEDURE
**Approach:[5]** With the tarsus extended, incise the skin 3 cm to 4 cm proximal to the injury on the caudolateral aspect of the common calcanean tendon to the level of the fourth tarsal bone (Plate 25A). Reflect the skin and subcutaneous tissue to expose the deep fascia. Incise the deep fascia and lateral retinaculum along the lateral border of the superficial digital tendon, exposing the injured AT apparatus. Extend the incision proximally as needed to expose the injured tendon.

*Continued*

# PLATE 25

A


Tendon of
flexor hallucis
longus muscle
Tendon of
gastrocnemius
muscle
Calcaneus
Tendon of superficial
flexor muscle
Tendon of
abductor digiti
quinti muscle

**Acute Midsubstance Tendon Repair:** Identify the three separate tendons and attempt apposition. Using a monofilament nonabsorbable suture (0 to 1 for large dogs; 2-0 – to 3-0 for cats and small dogs), suture each tendon separately using a three-loop pulley pattern with the tarsus in extension (Plate 25B). Make the first two passes with the needle from near to far, and orient the third and fourth passes 120 degrees from the previous two sutures and in the middle. Redirect the final fifth and sixth passes 120 degrees, and place them far to near.

**Chronic Midsubstance Tendon Repair:** Ideally, the fibrotic scar should be sharply resected until normal tendon is identified. Most often, however, this is not possible because of tendon retraction and contracture. Resect as much scar tissue as possible to permit apposition of the tendon ends. Because the individual tendons will probably be undistinguishable in the fibrotic scar, the AT apparatus is repaired using a single locking-loop pattern.

**Avulsed Achilles Tendon Repair:**[6] Sharply débride the AT using a scalpel blade or Mayo scissors. Using a Jacob chuck or mini-driver, create a bone tunnel from lateral to medial of sufficient size to pass the suture through. Place the suture through the bone tunnel using a straight needle or bent pin (Plate 25C). Secure the tendon to the calcaneus using a locking-loop suture pattern.

**Fracture of the Calcaneal Bone:** Fracture of the calcaneus is treated with a tension band wire (Plate 25D). See Chapter 81 for details.

## CAUTIONS[1,7]

Débridement of the AT should be performed in a stepwise fashion. Excessive resection will prevent apposition of the tendon ends and complicate recovery. Tarsal immobilization and support is critical to wound healing and to preventing catastrophic failure of the AT repair. External coaptation (i.e., lateral splints or bivalved casts) or transarticular fixation should be placed with the tarsus in a slightly extended but weight-bearing position.

## POSTOPERATIVE EVALUATION[3]

Radiographs are not necessary unless a tension band or transarticular fixator is placed. Ultrasound can be used to monitor tendon healing. Full healing and reorganization of the AT is a slow process that may go on for years.

## POSTOPERATIVE CARE[7]

External coaptation or transarticular fixation is necessary to protect the repair for the first 6 to 8 weeks. Exercise should be restricted until the tendon heals. Then the animal should slowly be returned to normal activity.

## EXPECTED OUTCOME[7]

The expectation for return to full athletic ability is guarded; however, most animals will be able to function very well as pets. Tarsal arthrodesis may be employed if, despite repair, pain and dysfunction persist.

### References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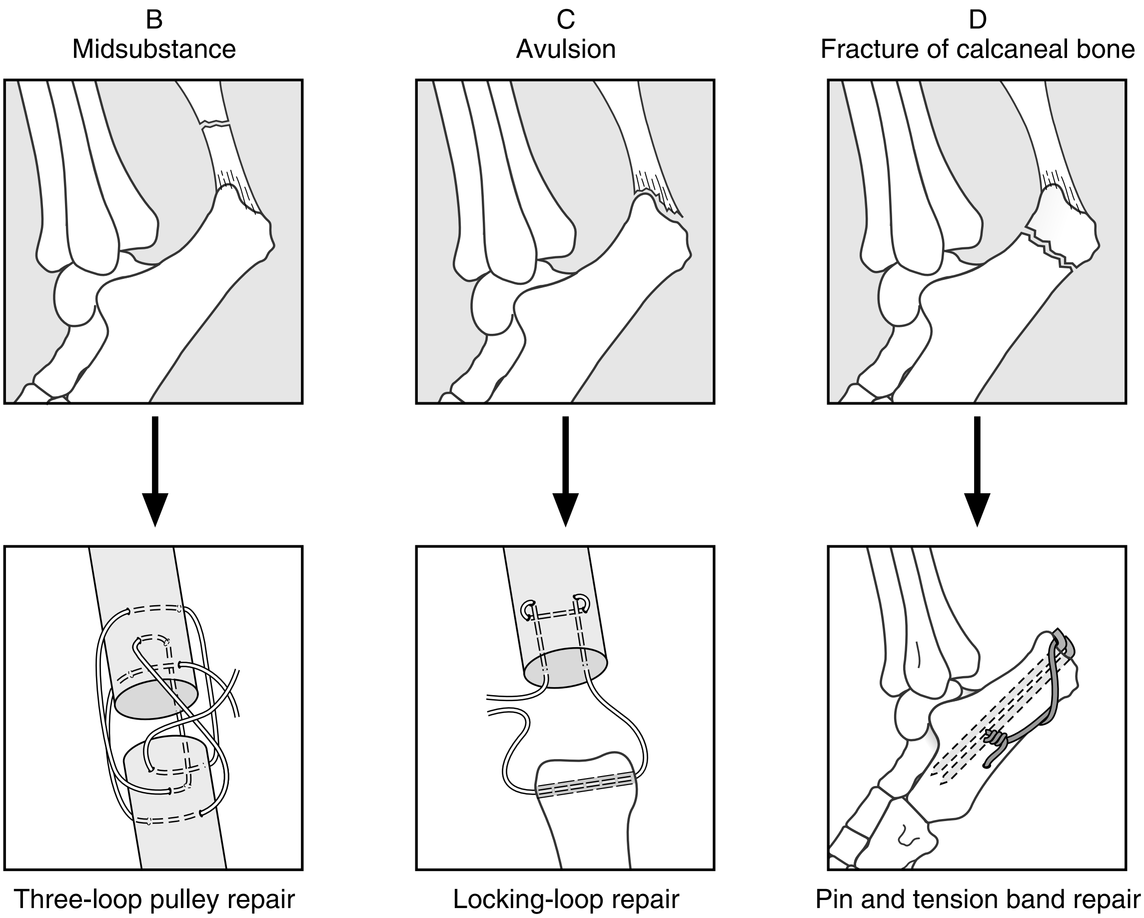
6. Guerin S, Burbidge H, Firth E, Fox S: Achilles tenorrhaphy in five dogs: A modified surgical technique and evaluation of a cranial half cast. Vet Comp Orthop Traumatol 11:205–211, 1998.
7. de Haan JJ, Goring RL, Renburg C, Bertrand S: Modified transarticular external skeletal fixation for support of Achilles tenorrhaphy in four dogs. Vet Comp Orthop Traumatol 8:32–35, 1995.

# PLATE 25


B
Midsubstance
C
Avulsion
D
Fracture of calcaneal bone
Three-loop pulley repair
Locking-loop repair
Pin and tension band repair

## TARSUS

# CHAPTER 26 Shearing Injury with Tarsal Luxation

### INDICATIONS

Candidates include animals with shearing wounds to the tarsus sustained from motor vehicle trauma.

### OBJECTIVES

- To restore stability to the tarsal joint and salvage joint function while allowing soft tissue healing to occur

### ANATOMIC CONSIDERATIONS[1,2]

The tarsus is composed of six separate anatomic joints: (1) the talocrural or tarsocrural joint, (2) the talocalcaneal joint, (3) the talocalcaneocentral joint, (4) the calcaneoquartal joint, (5) the centrodistal joint intertarsal joint, and (6) the tarsometatarsal joint. Functionally, however, the joint can be separated into four compartments: (1) the talocrural, (2) the proximal intertarsal joint (consisting of the calcaneoquartal and the talcalcaneocentral joint), (3) the distal intertarsal joint (centrodistal joint), and (4) the tarsometatarsal joint. The majority of movement of the tarsus is at the talocrural joint, between the tibia and talus. Joint stability is provided by the medial and lateral collateral ligaments, which are composed of long and short components originating on the malleoli of the tibia and fibula, respectively. The long component of the medial collateral ligament inserts on the proximal portion of the second metatarsus, whereas the short component attaches to the talus. The long component of the lateral collateral inserts on the proximal aspect of the fifth metatarsal, and the short component attaches to the body of the calcaneus. Injury to the medial aspect of the tarsus is more common than injury to the lateral aspect; however, both have been reported in the literature.

### EQUIPMENT

- Surgical pack, Gelpi retractors or Senn retractors, pointed reduction forceps, periosteal elevator, snub-nosed wire twisters, heavy-gauge monofilament nonabsorbable fishing leader line for collateral ligament repair, high-speed drill, bone screw and washer, drill bit, tap, depth gauge, screwdriver, pin chuck and key, low-speed drill, external skeletal fixation set, equipment for casting and bandage material

### PREPARATION AND POSITIONING

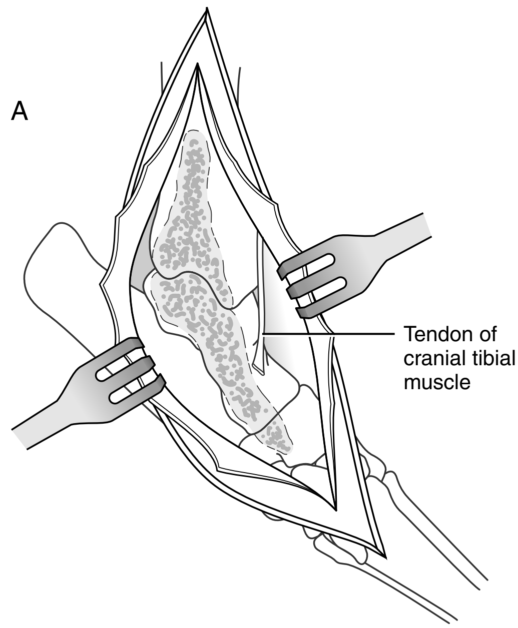
Prepare the leg circumferentially from dorsal midline to the phalanges. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the stifle joint during surgery.

### PROCEDURE

**Approach:**[3] Center a curvilinear incision over the talocrural joint along the medial aspect of limb, exposing the distal tibial to the level of the tarsometatarsal joint. Retract the subcutaneous and crural fascia and expose the medial ridge of the talus by incising the joint capsule cranial to the collateral ligament. If the shearing injury is extensive, removing much of the covering soft tissues, much of this approach may be unnecessary (Plate 26A).

*Continued*

# PLATE 26



**Prosthetic Ligament Repair:**[2] Drill, measure, and tap a bicortical screw hole into the distal aspect of the tibia at the level of the medial malleolus, being careful to avoid the joint surface. Place a screw and washer to prevent subsidence into the metaphyseal bone and to prevent ligature slippage. Place two additional screws and washers in similar fashion into the body of the talus (aiming distally to avoid the trochlear sulcus) and into the head of the talus, which is located midway between the medial trochlear ridge and the intertarsal articular surface. Depending on the size of the animal, utilize 20- to 60-pound test of monofilament fishing leader line to place two independent suture loops for the long and short components of the medial collateral ligament. Tie the sutures independently: tie the short component with the tarsus held in flexion and the long component with the tarsus held in extension. The sutures should be taut, but not overly tight, to avoid compromising joint range of motion (Plate 26B).

Prosthetic ligament repair for a lateral shearing injury is very similar to the medial repair just described (Plate 26C). The proximal screw and washer is placed in the distal fibula/tibia, taking care to avoid the joint. The distal two screws and washers are positioned in the base of the coracoid process, midway between the base of the coracoid process and the proximal intertarsal joint (Plate 26D).

**Transarticular External Skeletal Fixation:**[2,4] Place a type I or II transarticular external fixator with two pins through the tibia (one proximal and one distal), one pin in the calcaneus, and one pin into the metatarsal bones 2 and 3. Position the tarsus in a normal standing angle and immobilize it for 6 to 8 weeks, depending on the severity of soft tissue trauma.

## CAUTIONS

Lavage and wound débridement of the tarsus should be performed once the patient is stabilized. Excessive débridement should be avoided early on, because—given the right conditions and wound care—the soft tissue coverage, which is a premium, will survive despite extensive damage. The use of sterile wet-to-dry bandages until healthy granulation tissue is present is an excellent way to improve wound quality without surgical débridement.

## POSTOPERATIVE EVALUATION[4]

The wound should be evaluated at least daily for the first 7 to 10 days, until healthy granulation tissue is present or as tissue viability dictates. A nonadherent bandage can then be placed over the wound and the dressing changed less frequently. Radiographs should be repeated every 6 to 8 weeks until the soft tissues heal to evaluate limb alignment, apposition of the fracture-luxation, and apparatus integrity.

## POSTOPERATIVE CARE[2,4,5]

External coaptation or transarticular fixation is necessary in order to protect the repair for the first 6 to 8 weeks. Exercise should be restricted until the fixator is removed and the soft tissues heal. Then the animal should slowly be returned to normal activity.

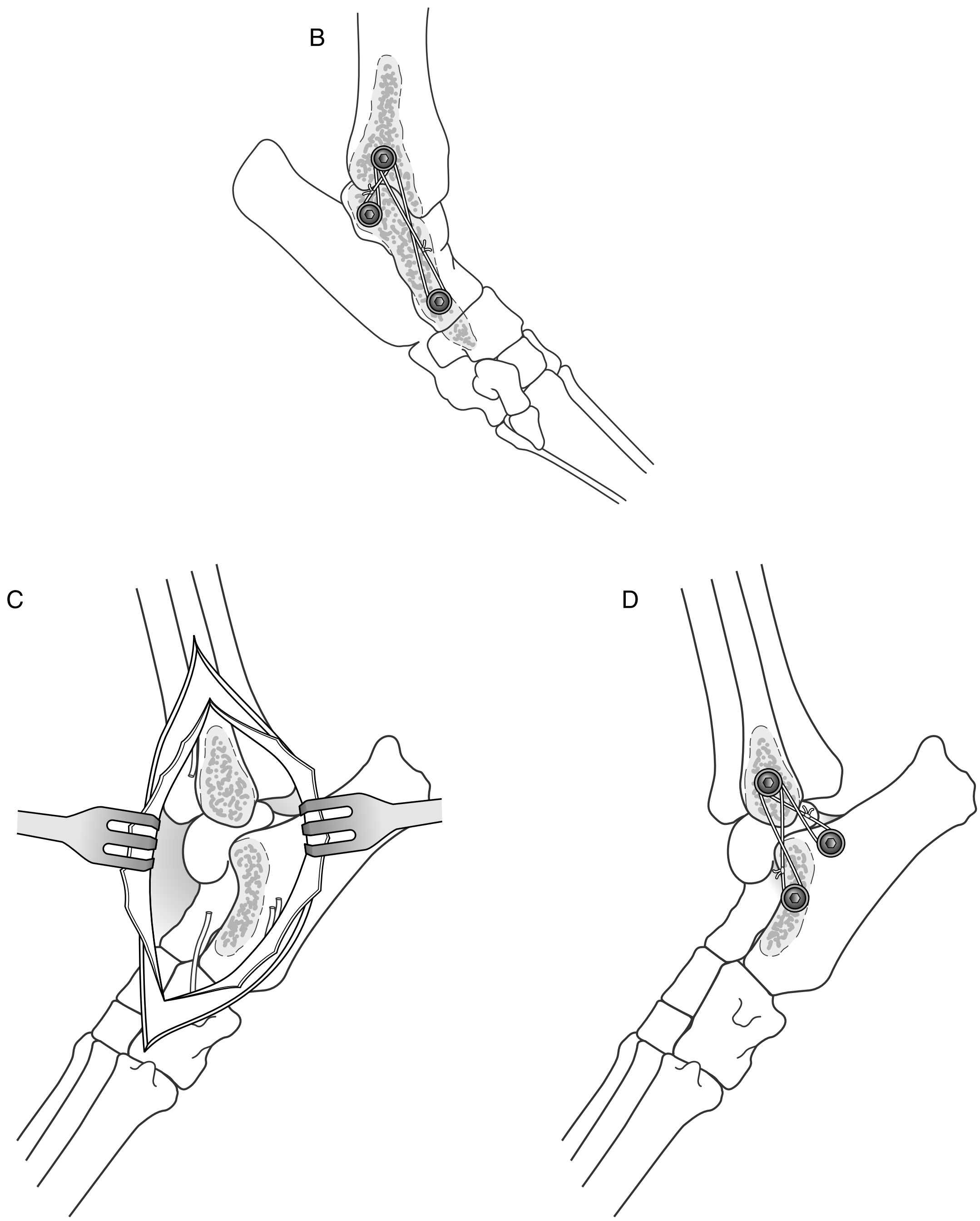
## EXPECTED OUTCOME[6]

There is a 75% chance of good to excellent function, despite progressive degenerative joint disease and restricted range of motion of the tarsal joint. Pantarsal arthrodesis may be employed if pain and dysfunction persist despite repair.

### References

1. Benson JA, Boudrieu RA: Severe carpal and tarsal shearing injuries treated with immediate arthrodesis in seven dogs. J Am Anim Hosp Assoc 38:370–380, 2002.
2. Harasen GLG: Tarsal shearing injury in the dog. Can Vet J 41: 940–943, 2000.
3. Piermattei DL, Johnson KA: Approach to the medial malleolus and talocrural joint. In An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
4. Kraus KH, Toombs JP, Ness MG: Transarticular case studies. In External Fixation in Small Animal Practice. Blackwell Sciences, Oxford, England, 2003.
5. de Haan JJ, Goring RL, Renberg C, Bertrand S: Modified transarticular external skeletal fixation for support of Achilles tenorrhaphy in four dogs. Vet Comp Orthop Traumatol 8:32–35, 1995.
6. Diamond DW, Besso J, Boudrieu RA: Evaluation of joint stabilization for treatment of shearing injuries of the tarsus in 20 dogs. J Am Anim Hosp Assoc 35:147–153, 1999.

# PLATE 26



# TARSUS

# Chapter 27 Osteochondrosis of the Lateral Trochlear Ridge of the Talus

## INDICATIONS

Candidates include dogs with persistent lameness and pain of the tarsus caused by osteochondrosis (OCD) that is not responsive to conservative management.

## OBJECTIVES

- To improve limb function by removal of the entire OCD flap, curettage of the adjacent diseased cartilage, and forage to provide blood supply to the exposed subchondral bone via forage

## ANATOMIC CONSIDERATIONS[1–5]

The tarsus is the third most common joint to be affected by OCD, with a reported incidence of 9%. Forty-four percent of the tarsal lesions are bilateral, although the typical presenting complaint of a dog with tarsal OCD is a unilateral lameness. Seventy-five percent of the OCD lesions of the tarsus occur on the plantar half of the medial trochlear ridge of the talus, and 25% occur on the lateral ridge. Because of the diversity of the lesion location, the surgical approach used to expose the lesion is as important as the surgical débridement and curettage. Both medial and lateral approaches have been described. A combined dorsomedial and plantaromedial approach exposes all but 4% of the medial trochlear ridge of the talus. Similarly, a combined dorsolateral and plantarolateral approach exposes the entire lateral trochlear ridge, with the central 20% of the lateral ridge being accessible from either individual approach.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), blunt Hohmann retractor, bone curettes, pin chuck or high-speed wire driver, Kirschner wires or small Steinmann pin for forage

## PREPARATION AND POSITIONING

Prepare the leg circumferentially from dorsal midline to the phalanges. Use a hanging leg preparation, with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the tarsus during surgery.

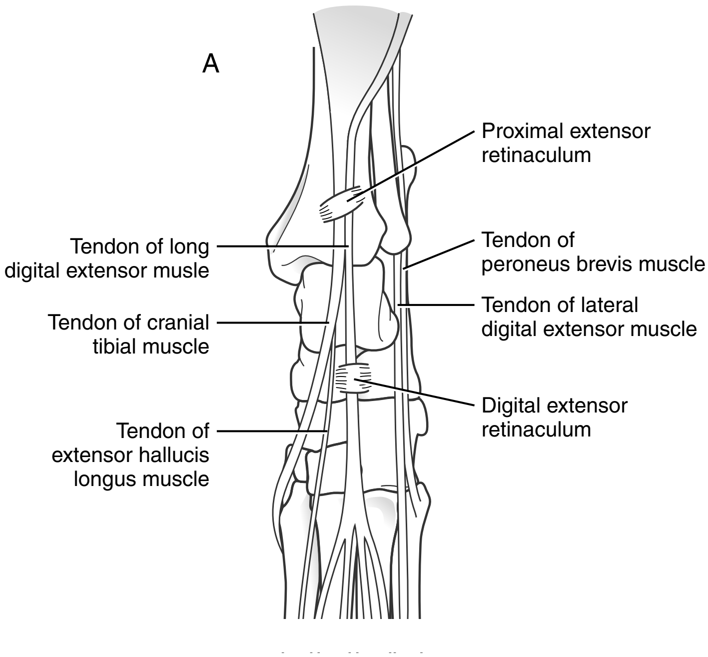
## PROCEDURE

**Dorsolateral Approach:**[2,4–6] Flex and extend the tarsus to accurately identify dorsal aspect of the lateral trochlear ridge via palpation. Center a curvilinear 4-cm to 5-cm incision over the trochlear ridge from the distal tibia and fibula to the distal intertarsal joint. Retract the skin and subcutaneous tissues with a Gelpi or Senn retractor to improve visualization of the tendons of the long digital extensor muscle, the cranial tibial muscle, the extensor hallucis longus muscle, the dorsal branch of the lateral saphenous vein, and the superficial peroneal nerve (Plate 27A). Retract these structures laterally. Retract the tendons of the peroneus longus, the lateral digital extensor, and the peroneus brevis in a plantar direction. Incise the deep fascia and adherent joint capsule longitudinally along the midline of the palpable portion of the lateral trochlear ridge, preserving the lateral collateral ligament of the tarsus. If necessary, extend the joint capsular incision into the periosteum at the junction of the distal tibia and fibula to increase the exposure of the trochlea (Plate 27B).

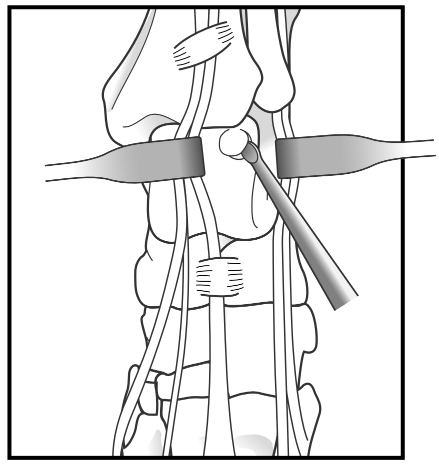
*Continued*

## PLATE 27

A


Proximal extensor
retinaculum
Tendon of long
digital extensor musle
Tendon of
peroneus brevis muscle
Tendon of cranial
tibial muscle
Tendon of lateral
digital extensor muscle
Digital extensor
retinaculum
Tendon of
extensor hallucis
longus muscle

B



**Plantarolateral Approach:**[2,4–6] Flex and extend the tarsus to accurately identify the plantar aspect of the lateral trochlear ridge of the talus via palpation. Center a curvilinear 4-cm to 5-cm incision over the plantar aspect of the trochlear ridge. Retract the skin and subcutaneous tissue with a Gelpi or Senn retractor to improve visualization of the tendons of the peroneus brevis, the lateral digital extensor, and the peroneus longus muscles (Plate 27C). Retract these structures dorsally. Retract the plantar branch of the lateral saphenous vein, and a branch of the caudal cutaneous sural nerve, in a plantar direction, preserving the lateral collateral ligament. Incise the joint capsule longitudinally along the center of the palpable portion of the lateral trochlear ridge. If necessary, extend the joint capsular incision into the periosteum at the junction of the distal tibia and fibula to increase the exposure of the trochlear ridge (Plate 27D).

**Curettage:**[2–6] Remove the cartilage flap with thumb or Halstead forceps. Probe the remaining cartilage surrounding the defect with a curette, and remove any abnormal cartilage not adherent to the subchondral bone (see Plates 27B and 27D).

**Forage:** Using a small Kirschner wire or small Steinmann pin, penetrate the sclerotic subchondral bone in multiple sites until it bleeds.

## CAUTIONS[7]

Unlike the more common OCD of the medial trochlear ridge, where the lesion is generally located in the proximal region of the trochlear, lateral trochlear ridge lesions have been reported to arise from both proximal and dorsal aspects of the ridge, thus necessitating a more aggressive surgical exposure. In addition, clinical reports of lateral trochlear ridge OCD lesions describe large, "shelf-like" lesions that may result in significant malarticulation, joint instability, and degenerative joint disease.

## POSTOPERATIVE EVALUATION

No specific postoperative evaluation is required. Note that joint goniometry should be performed preoperatively to provide a baseline assessment of tarsal range of motion and function.

## POSTOPERATIVE CARE

The limb should be bandaged for 2 to 3 days, depending on the degree of swelling. Exercise should be restricted for 4 to 6 weeks until the articular cartilage heals. Passive range-of-motion exercises should be performed two or three times daily for 5 to 10 minutes per session to maintain range of motion and to improve cartilage healing. After 4 to 6 weeks, the animal should slowly be returned to normal activity.

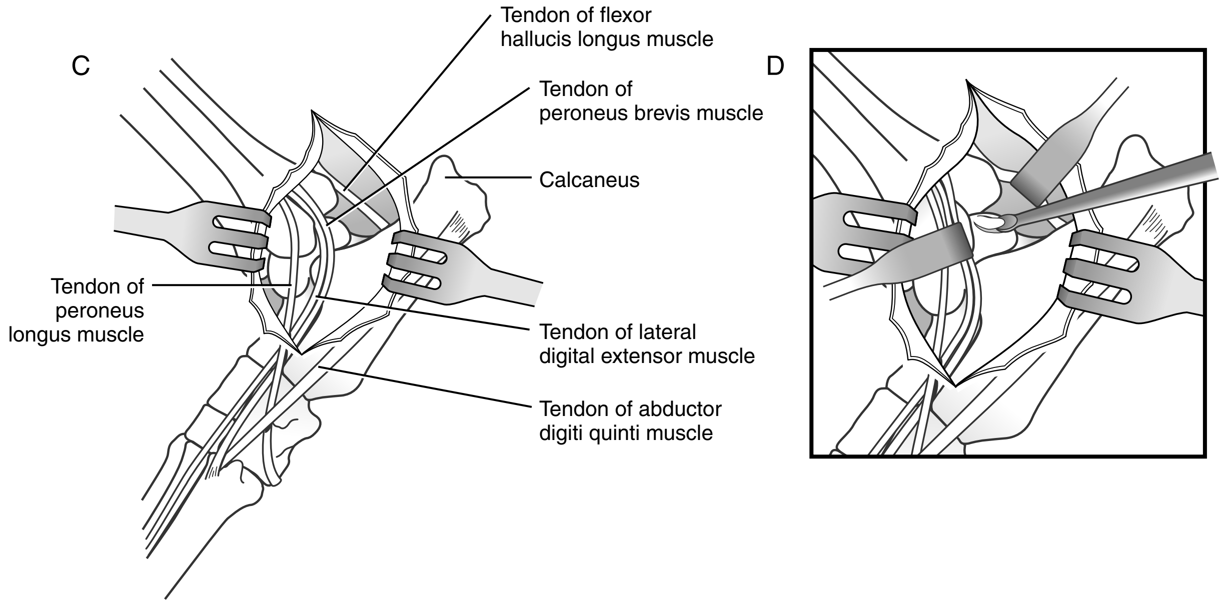
## EXPECTED OUTCOME[5,6,8]

Expected outcome is usually guarded to fair, depending on numerous factors (e.g., unilateral versus bilateral disease, lesion size, surgical approach, and presence of degenerative joint disease). Degenerative joint disease develops regardless of surgical removal of the flap, but it does not correlate with the degree of lameness. Nonetheless, owners should be advised that nonsteroidal anti-inflammatory drugs may be indicated to control the clinical signs of lameness and pain associated with degenerative joint disease.

### References


1. Montgomery RD, Hathcock JJ, Milton JL, Fitch RB: Osteochondrosis dissecans of the canine tarsal joint. Compend Contin Educ Pract Vet 16(7):835–845, 1994.
2. Beale BS, Goring RL, Herrington J, et al: A prospective evaluation of four surgical approaches to the talus of the dog used in the treatment of osteochondritis dissecans. J Am Anim Hosp Assoc 27(2):221–229, 1991.
3. Beale BS, Goring RL: Exposure of the medial and lateral trochlear ridges of the talus in the dog. Part I: Dorsomedial and plantaromedial surgical approaches to the medial trochlear ridge. J Am Anim Hosp Assoc 26(1):13–18, 1990.
4. Goring RL, Beale BS: Exposure of the medial and lateral trochlear ridges of the talus in the dog. Part II: Dorsolateral and plantarolateral surgical approaches to the lateral trochlear ridge. J Am Anim Hosp Assoc 26(1):19–24, 1990.
5. Fitch R, Beale BS: Osteochondrosis of the canine tibiotarsal joint. Vet Clin North Am Small Anim Pract 28(1):95–113, 1998.
6. Smith M, Vasseur P, Morgan J: Clinical evaluation of dogs after surgical and nonsurgical management of osteochondritis dissecans of the talus. J Am Vet Med Assoc 187(1):31–35, 1985.
7. Wisner ER, Berry CR, Morgan JP, et al: Osteochondrosis of the lateral trochlear ridge of the talus in seven Rottweiler dogs. Vet Surg 19(6):435–439, 1990.
8. Diamond DW, Besso J, Boudrieu RA: Evaluation of joint stabilization for treatment of shearing injuries of the tarsus in 20 dogs. J Am Anim Hosp Assoc 35:147–153, 1999.

# PLATE 27


C
D
Tendon of flexor hallucis longus muscle
Tendon of peroneus brevis muscle
Calcaneus
Tendon of peroneus longus muscle
Tendon of lateral digital extensor muscle
Tendon of abductor digiti quinti muscle

## TARSUS

# Chapter 28 Osteochondrosis of the Medial Trochlear Ridge of the Talus

### INDICATIONS[1]

Candidates include dogs with persistent lameness and pain of the tarsus caused by osteochondrosis (OCD) of the medial trochlear ridge that is not responsive to conservative management. The most common location of OCD of the medial trochlear ridge is the plantar aspect, which accounts for more than 80% of all medial trochlear lesions.

### OBJECTIVES

- To improve limb function by removal of the entire OCD flap, curettage of the adjacent diseased cartilage, and forage to provide blood supply to the exposed subchondral bone

### ANATOMIC CONSIDERATIONS[1–5]

Surgical exposure of the tarsus can be achieved through a variety of surgical approaches. The plantaromedial approach is the most commonly used surgical approach, because it exposes 40% of the plantar aspect of the medial trochlear ridge, which is the most common site of OCD in the tarsus.

### EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), blunt Hohmann retractor, bone curettes, pin chuck or high-speed wire driver, Kirschner wires or small Steinmann pin for forage

### PREPARATION AND POSITIONING

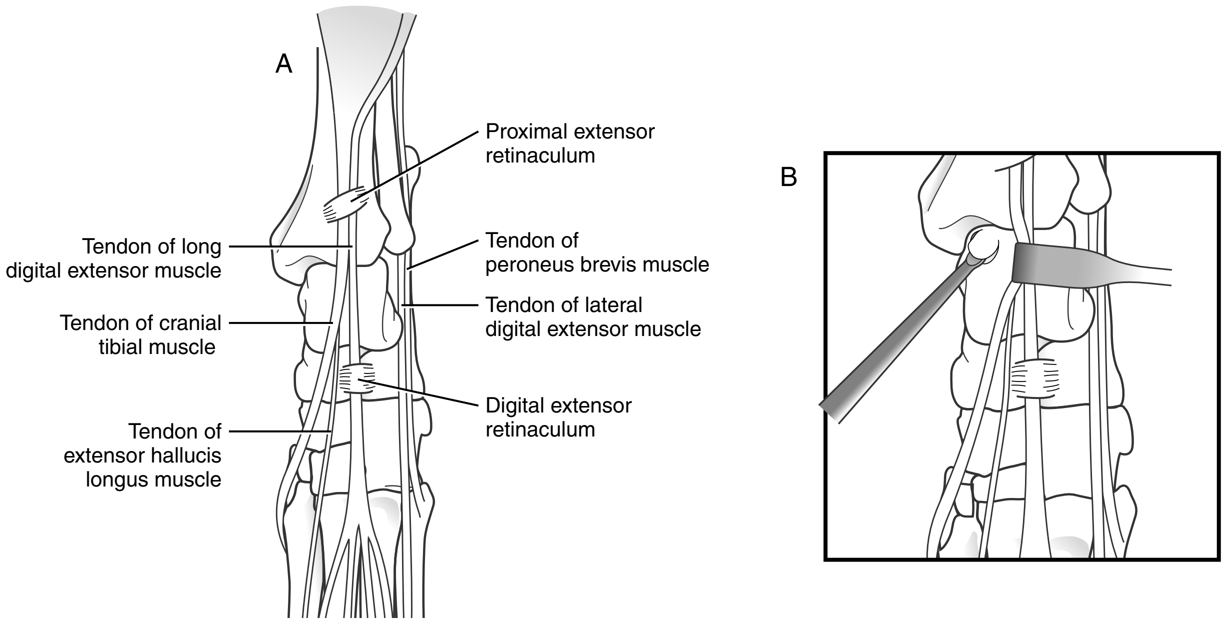
Prepare the leg circumferentially from dorsal midline to the phalanges. Use a hanging leg preparation with the dog in dorsal recumbency at the end of the surgery table to allow for maximal manipulation and visualization of the tarsus during surgery.

### PROCEDURE

**Dorsomedial Approach:**[1–6] Flex and extend the tarsus to accurately identify the dorsal aspect of the medial trochlear ridge via palpation. Center a curvilinear 4-cm to 5-cm incision over the trochlear ridge, from the distal tibia and fibula to the distal intertarsal joint. Retract the skin and subcutaneous tissues with a Gelpi or Senn retractor (Plate 28A). Preserve the distal extensor retinaculum, and laterally retract the tendon of the cranial tibial muscle, the saphenous nerve, the cranial tibial artery and vein, and the dorsal branches of the saphenous artery and vein. Preserve the medial collateral ligament, and longitudinally incise the deep fascia and adherent joint capsule along the palpable midportion of the medial trochlear ridge. If necessary, extend the joint capsular incision into the periosteum at the junction of the distal tibia and fibula to increase the exposure of the trochlea (Plate 28B).

*Continued*

# PLATE 28


A
Proximal extensor retinaculum
Tendon of long digital extensor muscle
Tendon of peroneus brevis muscle
Tendon of lateral digital extensor muscle
Tendon of cranial tibial muscle
Digital extensor retinaculum
Tendon of extensor hallucis longus muscle
B

**Plantaromedial Approach:**[1,3,5,6] Flex and extend the tarsus to accurately identify the plantar aspect of the medial trochlear ridge of the talus via palpation. Center a curvilinear 4-cm to 5-cm incision over the plantar aspect of the trochlear ridge. Retract the skin and subcutaneous tissue with a Gelpi or Senn retractor to improve visualization of the tendons of the medial head of the deep digital flexor muscle, the distal attachment of the caudal tibial muscle, the flexor hallucis longus muscle, and the medial collateral ligament (Plate 28C). Retract the medial head of the deep digital flexor muscle and the caudal tibial tendon dorsally; and laterally retract the flexor hallucis longus, the tibial nerve with its superficial branch, the plantar branches of the medial saphenous vein and saphenous artery, and superficial plantar metatarsal vein. Taking care to preserve the medial collateral ligament, incise the joint capsule longitudinally along the center of the palpable portion of the medial trochlear ridge. If necessary, extend the joint capsular incision into the periosteum at the junction of the distal tibia and fibula to increase the exposure of the trochlear ridge (Plate 28D).

**Curettage:**[1,3–6] Remove the cartilage flap with thumb or Halstead forceps. Probe the remaining cartilage surrounding the defect with a curette, and remove any abnormal cartilage not adherent to the subchondral bone (see Plates 28B and 28D).

**Forage:** Using a small Kirschner wire or small Steinmann pin, penetrate the sclerotic subchondral bone in multiple sites until it bleeds.

## CAUTIONS[1,7,8]

Excellent radiographic technique and positioning is necessary to diagnose OCD lesions within the tarsus. Standard anteroposterior and lateral views of the tarsus provide good visualization of the plantar aspect of the medial trochlear ridge, but additional views may be necessary to fully evaluate the joint. The dorsolateral-plantaromedial oblique projection provides good visualization of the medial trochlear ridge; the dorsomedial-plantarolateral oblique projection highlights the lateral trochlear ridge; and the flexed dorsoplantar projection profiles the central region of both trochlear ridges. Computed tomography and magnetic resonance imaging also provide additional information; however, expense and limited access prohibit their widespread use. Owners should be advised that the nature of the surgical procedure is exploratory and that a negative exploratory is possible and is necessary to rule out OCD. Arthroscopy has greatly improved tarsal joint access and visualization, but it does not completely eliminate the necessity of arthrotomy because of the difficulty of lesion location and treatment.

## POSTOPERATIVE EVALUATION

No specific postoperative evaluation is required. Note that joint goniometry should be performed preoperatively in order to provide a baseline assessment of tarsal range of motion and function.

## POSTOPERATIVE CARE

The limb should be bandaged for 2 to 3 days, depending on the degree of swelling. Exercise should be restricted for 4 to 6 weeks, until the articular cartilage heals. Passive range-of-motion exercises should be performed two or three times daily for 5 to 10 minutes per session to maintain range of motion and to improve cartilage healing. After 4 to 6 weeks, the animal should slowly be returned to normal activity.

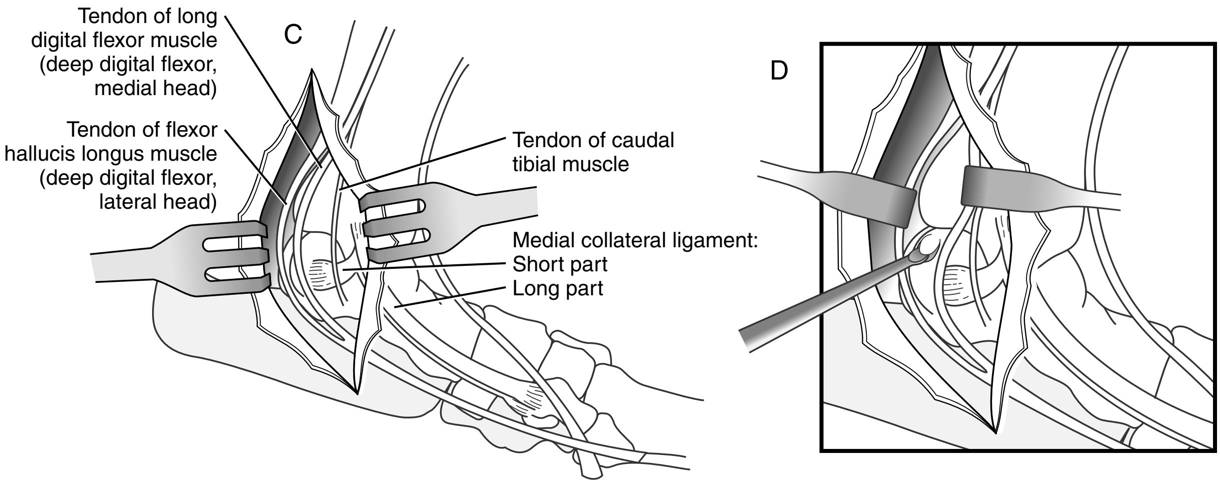
## EXPECTED OUTCOME[1,6,9]

Expected outcome is guarded to fair. Most dogs seem to benefit from early surgical removal of the OCD flap. A decreased success rate has been reported for dogs older than 12 months because of the progression of degenerative joint disease. Débridement and curettage should be kept to a minimum to avoid tarsal instability and joint incongruency.

### References

1. Fitch R, Beale BS: Osteochondrosis of the canine tibiotarsal joint. Vet Clin North Am Small Anim Pract 28(1):95–113, 1998.
2. Montgomery RD, Hathcock JT, Milton JL, Fitch RB: Osteochondrosis dissecans of the canine tarsal joint. Compend Contin Educ Pract Vet 16(7):835–845, 1994.
3. Beale BS, Goring RL, Herrington J, et al: A prospective evaluation of four surgical approaches to the talus of the dog used in the treatment of osteochondritis dissecans. J Am Anim Hosp Assoc 27(2): 221–229, 1991.
4. Beale BS, Goring RL: Exposure of the medial and lateral trochlear ridges of the talus in the dog. Part I: Dorsomedial and plantaromedial surgical approaches to the medial trochlear ridge. J Am Anim Hosp Assoc 26(1):13–18, 1990.
5. Goring RL, Beale BS: Exposure of the medial and lateral trochlear ridges of the talus in the dog. Part II: Dorsolateral and plantarolateral surgical approaches to the lateral trochlear ridge. J Am Anim Hosp Assoc 26(1):19–24, 1990.
6. Smith M, Vasseur P, Morgan J: Clinical evaluation of dogs after surgical and nonsurgical management of osteochondritis dissecans of the talus. J Am Vet Med Assoc 187(1):31–35, 1985.
7. Wisner ER, Berry CR, Morgan JP, et al: Osteochondrosis of the lateral trochlear ridge of the talus in seven rottweiler dogs. Vet Surg 19(6):435–439, 1990.
8. Miyabayashi T, Biller DS, Manley PA, et al: Use of a flexed dorsoplantar radiographic view of the talocrural joint to evaluate lameness in two dogs. J Am Vet Med Assoc 199(5):598–600, 1991.
9. Diamond DW, Besso J, Boudrieu RA: Evaluation of joint stabilization for treatment of shearing injuries of the tarsus in 20 dogs. J Am Anim Hosp Assoc 35:147–153, 1999.

# PLATE 28


Tendon of long digital flexor muscle (deep digital flexor, medial head)
C
Tendon of flexor hallucis longus muscle (deep digital flexor, lateral head)
Tendon of caudal tibial muscle
Medial collateral ligament:
Short part
Long part
D

## TARSUS

# Chapter 29 Pantarsal Arthrodesis

### INDICATIONS

Candidates include animals with severe injury (e.g., fracture, luxation, or shearing injury) of the tibial cochlea and condyles of the talus that precludes maintaining a long-term, pain-free articulation; animals with painful degenerative joint disease that is not responsive to conservative measures; and animals with irreparable Achilles tendon injury and sciatic nerve palsy treated with tendon transfer.[1]

### OBJECTIVES

- To fuse the bones of the tarsocrural, intertarsal, and tarsometatarsal joints in a functional position

### ANATOMIC CONSIDERATIONS

The tarsus consists of the tibia, fibula, proximal tarsal, distal tarsal, and metatarsal bones, forming the tarsocrural, intertarsal, and tarsometatarsal joints. The tarsocrural joint is formed by the fibula and cochlea of the tibia proximally, and by the talus and calcaneus distally. The intertarsal joints are formed by articulations between the tarsal bones, and the tarsometatarsal joints are formed by the articulations between the distal tarsal and metatarsal bones.

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, self-centering plate-holding forceps, bone curette, high-speed drill and burrs, plating equipment

### PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from hip to digits. Position the animal in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal tibia or proximal humerus for cancellous bone graft harvest.

### PROCEDURE

**Approach:** Incise skin and soft tissue over the cranial medial surface of the joint, from the distal third of the tibia to the middle of the metatarsal bones. Elevate and retract the cranial tibial and long digital extensor tendons to expose the distal tibia, the tarsus, and the proximal third of the metatarsal bone. If necessary, transect the cranial tibial tendon and the medial collateral ligament to gain access to the joint. Enter the tarsal joints to expose the articular surfaces (Plate 29A).[1]

**Alignment:** Predetermine the cranial caudal angle for the pantarsal arthrodesis by observing the normal standing angle of the tarsus in the individual patient. The angle is commonly between 135 and 145 degrees[1] (see Plate 29C).

**Stabilization:** Extend the hock and remove the articular cartilage from the talocrural, intertarsal, and tarsometatarsal joint surfaces with a bone curette or high-speed burr, following the contours of the bone ends (see Plate 29A). Harvest cancellous bone, and place the graft within the prepared joints (Plate 29B). Place an appropriate-size bone plate, precontoured to provide the selected joint angle, on the cranial surface of the tibia, the talus, the central tarsal bone, and the third metatarsal bone (see Plates 29B and 29C). Position the acute bend in the plate over the neck of the talus. Ensure adequate plate holes for a minimum of three screws in the tibia and three screws in the metatarsal bone. Mark the level of the distal metatarsal plate screw. Remove the plate, and center the drill on the metatarsal bone. Secure the plate with three screws in the metatarsal bone, check the plate and joint alignment, and secure the plate to the tibia (see Plate 29B). Fill the remaining plate holes. Ensure that at least two plate screws penetrate the calcaneus to secure the joint[1] (see Plate 29C).

### CAUTIONS

All articular cartilage must be removed. Angular and rotational alignment of the limb should be checked carefully before the plate is secured to the tibia.

### POSTOPERATIVE EVALUATION

The axial alignment of the limb and the angle of the arthrodesis should be critically observed. Radiographs should be evaluated for limb alignment and implant placement.

### POSTOPERATIVE CARE

A soft, padded bandage should be placed to control bleeding and swelling. A bivalve cast should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Implants are generally removed after 6 to 12 months to avoid soft tissue irritation and the common sequella of implant loosening.[2]

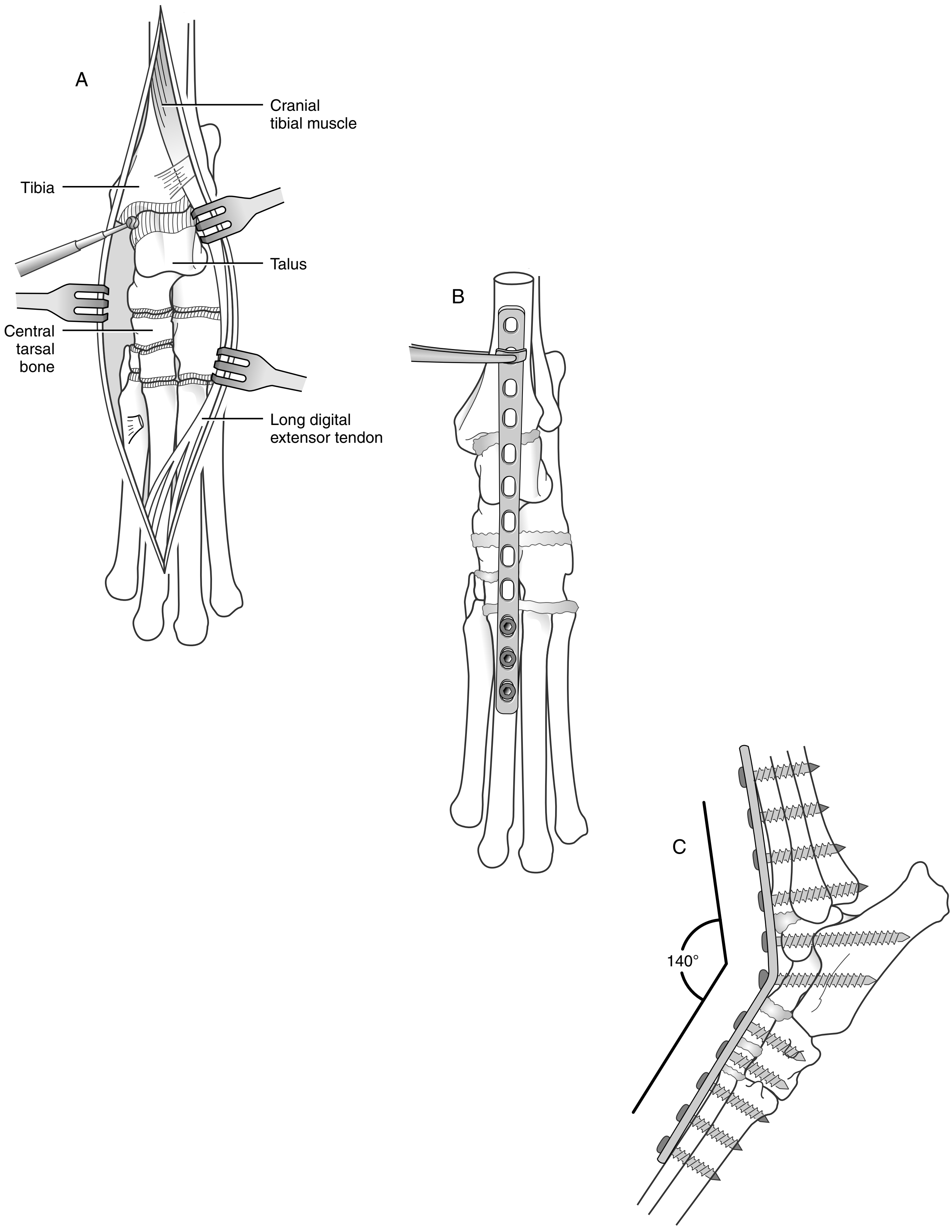
### EXPECTED OUTCOME

Bone healing is expected in 12 to 18 weeks. The animal should have acceptable function of the treated limb, as long as stifle and hip remain free of disease.

#### References

1. Johnson KA: Arthrodesis. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.
2. DeCamp CE, Martinez SA, Johnston SA: Pantarsal arthrodesis in dogs and a cat: 11 cases (1983–1991). J Am Vet Med Assoc 203: 1705, 1993.

# PLATE 29


A
Cranial
tibial muscle
Tibia
Talus
Central
tarsal
bone
Long digital
extensor tendon
B
C
140°

## TARSUS

# Chapter 30 Proximal Intertarsal or Tarsometatarsal Arthrodesis with a Plate

### INDICATIONS
Candidates include animals with severe injury (e.g., fracture, luxation, or shearing injury) of the proximal intertarsal or tarsometatarsal joint.[1]

### OBJECTIVES
- To fuse the bones of the proximal intertarsal, the tarsometatarsal joints, or both in a functional position

### ANATOMIC CONSIDERATIONS
The intertarsal joints are formed by articulations between the tarsal bones. The proximal intertarsal joint is a combination of the talocalcaneocentral joint, formed by the articulation of the talus and central tarsal bone with a continuous joint capsule with the calcaneus, and the calcaneoquartal joint, located between the calcaneus and the fourth tarsal bone. The tarsometatarsal joints are formed by the articulations between the distal tarsal and metatarsal bones.

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, self-centering plate-holding forceps, bone curette, high-speed drill and burrs, plating equipment

### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from hip to digits. Position the animal in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal tibia or proximal humerus for cancellous bone graft harvest.

### PROCEDURE
**Approach:** Incise the skin, subcutaneous tissue, and deep crural fascia over the lateral surface of the tarsometatarsal joint. Retract the superficial and deep digital flexor tendons medially, and elevate the abductor digiti quinti muscle to expose the calcaneus, fourth tarsal bone, and the base of the fifth metatarsal bone. Enter the affected joint(s) to expose the articular surfaces (Plate 30A).

**Alignment:** There is no angle to the partial tarsal arthrodesis. Use a straight plate to align the bones.

**Stabilization:** Stress the paw medially, and remove the articular cartilage from the calcaneoquartal and/or tarsometatarsal joints with a bone curette or high-speed burr, following the contours of the bone ends. Harvest and place the cancellous bone within the prepared joints. Smooth the base of the fifth metatarsal bone, and a portion of the fourth tarsal bone, with the oscillating saw to provide a smooth surface for the plate (Plate 30B). Place an appropriate-size and appropriate-contour plate on the lateral surfaces of the calcaneus, the fourth tarsal bone, and the fifth metatarsal bone. Position the plate with three screw holes over the calcaneus and three screw holes over the metatarsal bones. Place a screw through the proximal plate hole into the calcaneus. Check the plate position, and place a screw through the distal plate hole into metatarsal bones 4 and 5. Fill the remaining plate holes. Ensure that the distal screw into the calcaneus also secures the talus (Plate 30C).[1]

### CAUTIONS
All articular cartilage must be removed. Rotational alignment of the limb should be checked carefully before the plate is secured to the metatarsal bones.

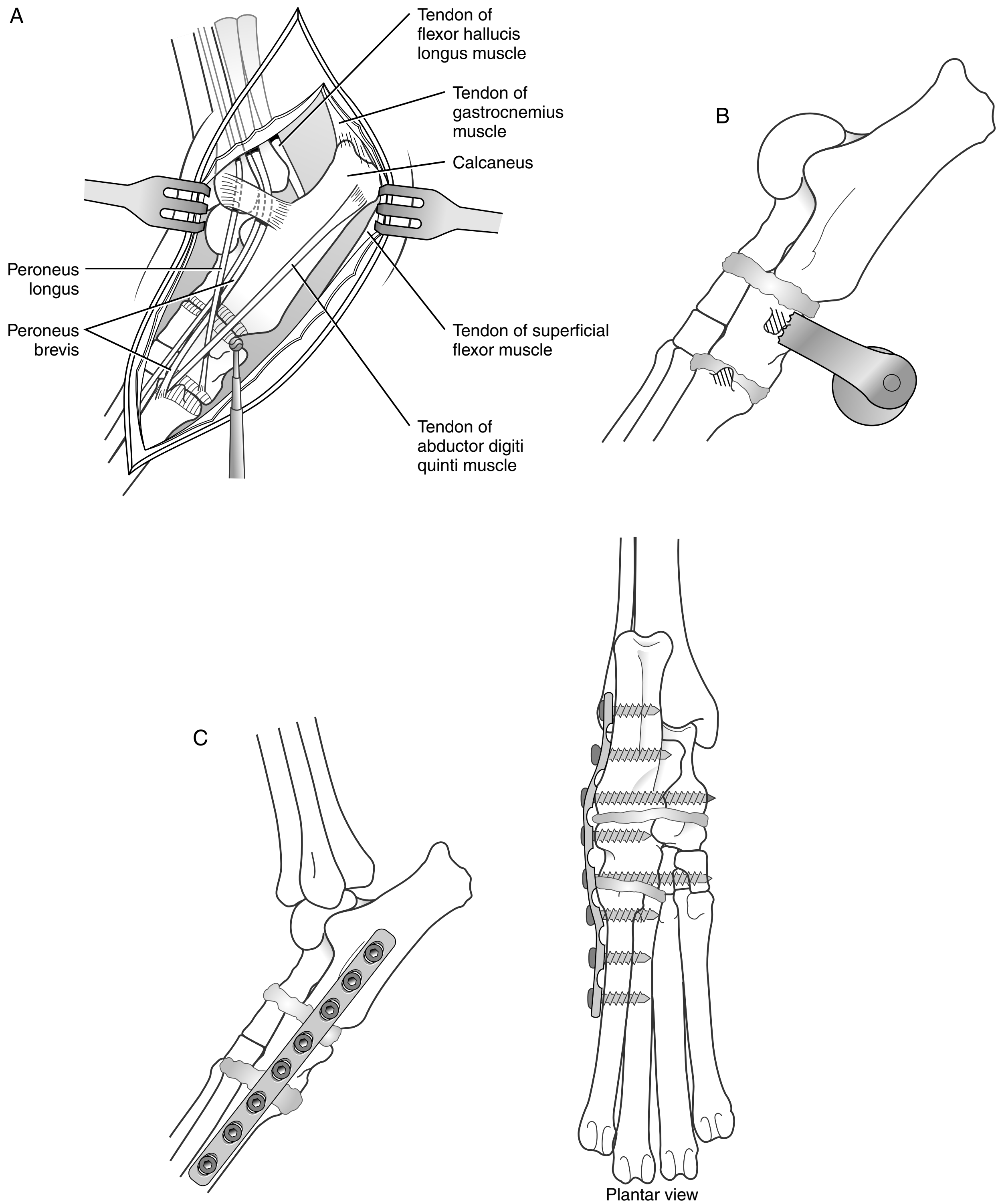
### POSTOPERATIVE EVALUATION
The axial alignment of the limb should be critically observed. Radiographs should be evaluated for limb alignment and implant placement.

### POSTOPERATIVE CARE
A soft, padded bandage should be placed to control bleeding and swelling. A bivalve cast should be used for 6 weeks or until early radiographic evidence of bone bridging is observed.[1] Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Implants, which may loosen as a result of movement of the metatarsal bones, should be removed after joint fusion, usually within 6 to 12 months after surgery.

### EXPECTED OUTCOME
Bone healing is usually expected in 12 to 18 weeks, with animals obtaining near-normal function of the treated limb. Some dogs exhibit lameness, which resolves after implant removal.[2]

#### References
1. Piermattei DL, Flo GL: Fractures and other orthopedic injuries of the tarsus, metatarsus and phalanges. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.
2. Dyce J, Whitelock RG, Robinson KV, et al: Arthrodesis of the tarsometatarsal joint using a laterally applied plate in 10 dogs. J Small Anim Pract 39:19, 1998.

# PLATE 30


A
Tendon of
flexor hallucis
longus muscle
Tendon of
gastrocnemius
muscle
Calcaneus
Peroneus
longus
Peroneus
brevis
Tendon of superficial
flexor muscle
Tendon of
abductor digiti
quinti muscle
B
C
Plantar view

## TARSUS

# CHAPTER 31 Proximal Intertarsal or Tarsometatarsal Arthrodesis with an Intramedullary Pin and Wire

### INDICATIONS

Candidates include animals with subluxation of the proximal intertarsal or tarsometatarsal joints caused by injury of the plantar tarsal fibrocartilage.[1]

### OBJECTIVES

- To fuse the bones of the calcaneoquartal or tarsometatarsal joints in a functional position

### ANATOMIC CONSIDERATIONS

The tarsus consists of the tibia, fibula, and proximal tarsal, distal tarsal, and metatarsal bones forming the tarsocrural, intertarsal, and tarsometatarsal joints. The tarsocrural joint is formed by the fibula and cochlea of the tibia proximally and the talus and calcaneus distally. The intertarsal joints are formed by articulations between the tarsal bones. The proximal intertarsal joint is a combination of the talocalcaneocentral joint, formed by the articulation of the talus and central tarsal bone with a continuous joint capsule with the calcaneus; and the calcaneoquartal joint, located between the calcaneus and the fourth tarsal bone. The tarsometatarsal joints are formed by the articulations between the distal tarsal and metatarsal bones.

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, bone curette, high-speed drill and burrs, Jacob pin chuck, intramedullary (IM) pins, orthopedic wire, wire twister, wire cutter, pin cutter

### PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from hip to digits. Position the animal in lateral recumbency. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal tibia or proximal humerus for cancellous bone graft harvest.

### PROCEDURE

**Approach:** Incise the skin, subcutaneous tissue, and deep crural fascia over the lateral surface of the tarsometatarsal joint. Retract the superficial and deep digital flexor tendons medially, and elevate the abductor digiti quinti muscle to expose the calcaneus, fourth tarsal bone, and the base of the fifth metatarsal bone. Enter the affected joint(s) to expose the articular surfaces (Plate 31A).

**Alignment:** Fuse the proximal intertarsal or tarsometatarsal joints in a straight line. Use an IM pin to align the bones.

**Stabilization:** Remove the articular cartilage from the calcaneoquartal joint, the tarsometatarsal joint, or both (depending on the joints involved) with a bone curette or high-speed burr, following the contours of the bone ends (see Plate 31A). Drill transverse holes in the base of the calcaneus and the fourth tarsal bone (for calcaneoquartal arthrodesis), and place orthopedic wire through the holes, deep to the superficial digital flexor tendon and crossing at the arthrodesis site (Plate 31B). Predrill the calcaneus and place a small IM pin starting at the tuber calcanei, through the calcaneus and the fourth tarsal bone (see Plate 31B). Harvest and place cancellous bone within the prepared joints before tightening the wire. Retract the IM pin 1 cm, cut the pin, and countersink it into the tuber calcanei. Tighten the figure-eight wire (Plate 31C).

Alternatively, to fuse the tarsometatarsal joint, predrill the holes for the figure-eight wire through the calcaneus and the metatarsal bones. Usually only three of the four metatarsal bones will be drilled. Drive the Steinmann pin distally into the base of the fourth metatarsal bone (Plate 31D).[1]

### CAUTIONS

All articular cartilage should be removed. Avoid irritating flexor tendons with the IM pin or wire.

### POSTOPERATIVE EVALUATION

The axial alignment of the limb should be critically observed. Radiographs for limb alignment and implant placement should be evaluated.

### POSTOPERATIVE CARE

A soft, padded bandage should be placed to control bleeding and swelling. A splint should be used for 6 weeks or until early radiographic evidence of bone bridging is observed. Radiographs should be repeated at 6-week intervals until bone healing occurs. The animal should be confined, with activity limited to leash walks until bone healing is complete. Pin migration may occur. Implants should be removed if the soft tissue is irritated.[1]

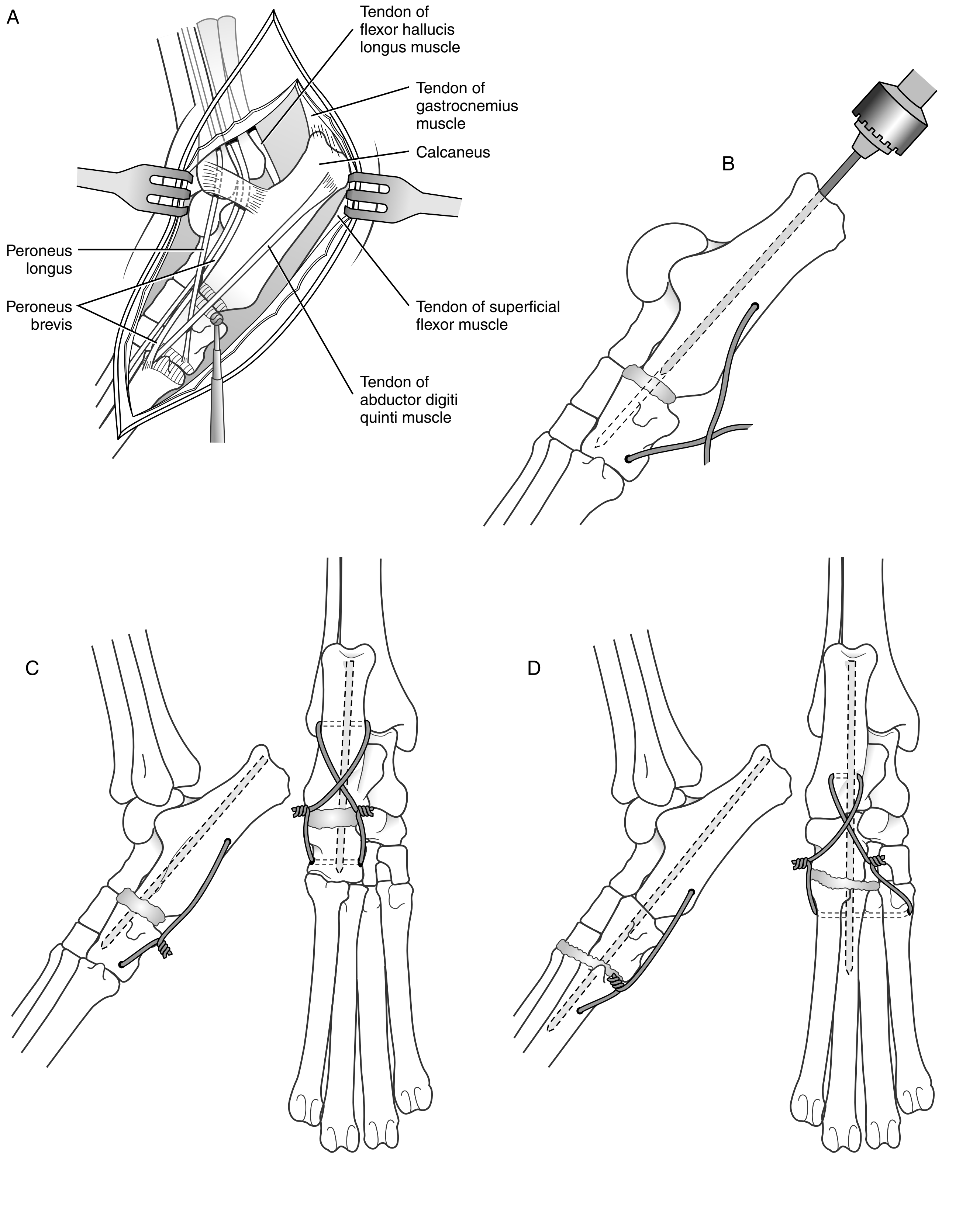
### EXPECTED OUTCOME

Bone healing is usually expected in 12 to 18 weeks. Animals should have near-normal function of the treated limb.

#### Reference

1. Piermattei DL, Flo GL: Fractures and other orthopedic injuries of the tarsus, metatarsus and phalanges. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 31


A
Tendon of
flexor hallucis
longus muscle
Tendon of
gastrocnemius
muscle
Calcaneus
Peroneus
longus
Peroneus
brevis
Tendon of superficial
flexor muscle
Tendon of
abductor digiti
quinti muscle
B
C
D

## AMPUTATIONS

# Chapter 32 Mandibulectomy

### INDICATIONS[1–4]

Mandibulectomy is indicated in the management of tumors involving the jaw, and in the treatment of open or infected mandibular fractures in which surgical repair is not an option because of economic restrictions, osteomyelitis, or severe bone and soft tissue loss. Specifically, a rostral mandibulectomy is indicated for bilateral disease conditions affecting the rostral mandible to the level of the second or third premolars. Rostral hemimandibulectomy is indicated for tumors in the region of the lower canine tooth, incisors, or first premolar that have not crossed the symphysis based on clinical and radiographic evaluation.

### OBJECTIVES[5]

- To remove the rostral mandible or rostral hemimandible and provide the animal with a disease-free, functional, and cosmetic oral cavity

### ANATOMIC CONSIDERATIONS[2,3,5,6]

The oral cavity is a complex structure composed of lips, gingiva, tongue teeth, palate, and salivary glands and ducts. The vascular supply to the mouth is provided by the lingual, major palatine, mandibular alveolar, and facial arteries, which are branches of the external and internal carotid arteries. Anatomic landmarks for the procedure include the incisors, the canine teeth and the second and third premolars, and the mandibular symphysis. Brisk hemorrhage from the mandibular artery may occur at the osteotomy site; this should be identified and either ligated or controlled with bone wax and electrocautery.

### EQUIPMENT

- Standard surgical pack; electrocautery; hemoclips; bone wax or suture material for vascular ligation; periosteal elevator; Senn or Gelpi retractors; and a saw, Gigli wire, or osteotome for osteotomy of the mandible

### PREPARATION AND POSITIONING

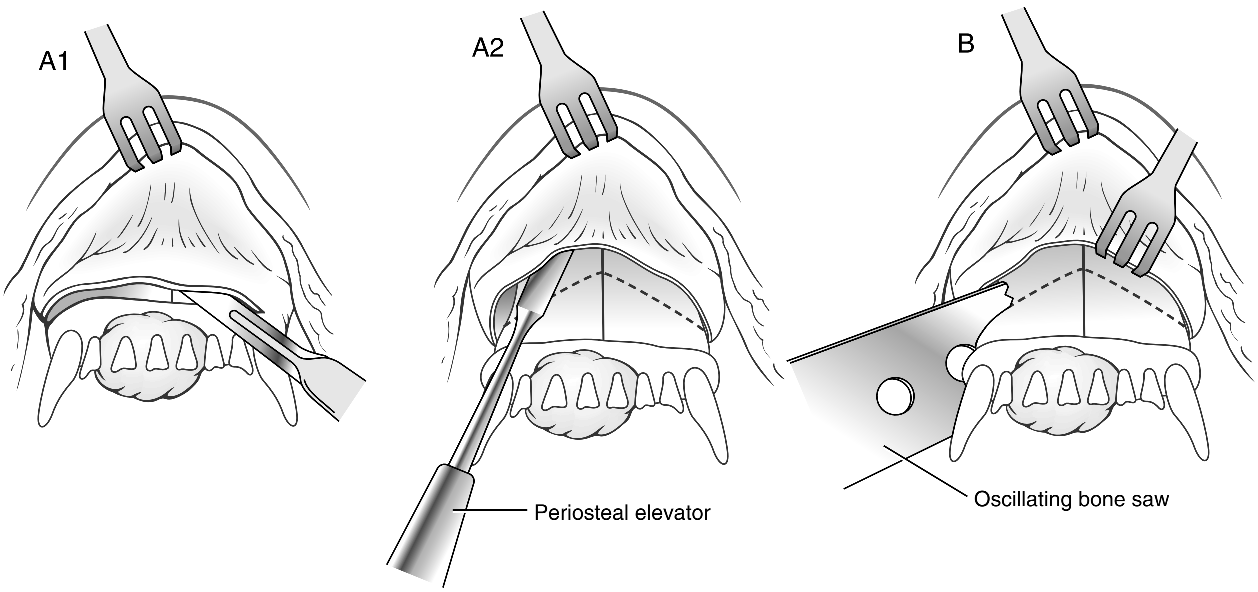
Prepare mandible from the proximal neck to the chin and lateral aspect of the face and cheeks. Correct surgical positioning is imperative to provide optimum visualization of the oral cavity. For the rostral mandibulectomy, position the animal in dorsal recumbency, with the maxilla taped to the operating table to allow maximal exposure to the oral cavity during surgery. For a rostral hemimandibulectomy, position the animal in lateral recumbency, with the affected side up.

### PROCEDURE

**Rostral Mandibulectomy:**[1–3,6] Sharply incise the buccal mucosa along the rostral aspect of the mandible (Plate 32A1). Elevate the subcutaneous tissue and connective tissue from the bone, exposing the ventral and lateral aspects of the mandible (Plate 32A2). Reflect and retract the tissues caudally and laterally to the level of the osteotomy. Perform an osteotomy with an oscillating saw, osteotome, or Gigli wire caudal to the canine teeth or first or second molars (Plate 32B). Locate the mandibular arteries within the intramedullary canal, and ligate. If the arteries retract within the intramedullary canal and cannot be located, use bone wax and electrocautery to staunch the hemorrhage. Incise any remaining connective tissue, remove the rostral mandible, and submit for histopathology and margin evaluation.

*Continued*

# PLATE 32



**Rostral Hemimandibulectomy:**[1–3,6] Sharply incise the buccal mucosa from the mandibular symphysis to the first or second premolar. Elevate the subcutaneous tissue and connective tissue from the bone, exposing the ventral and lateral aspects of the mandible. Reflect and retract the tissues caudally and laterally to the level of the osteotomy (Plate 32C). Separate the mandibular symphysis with an osteotome, and perform an osteotomy with an oscillating saw, osteotome, or Gigli wire caudal to the canine tooth or first or second molar (Plate 32D). Locate the mandibular artery within the intramedullary canal, and ligate. If the arteries retract within the intramedullary canal and cannot be located, use bone wax and electrocautery to staunch the hemorrhage. Incise any remaining connective tissue, remove the rostral hemimandible, and submit for histopathology and margin evaluation.

**Closure:** Replace the lip over the exposed hemimandible(s) and appose the gingiva and sublingual mucosa with simple continuous or interrupted absorbable suture, taking care to avoid entrapment of the salivary ducts (Plate 32E). It may be necessary to remove redundant labial tissue to provide a more cosmetic closure and to prevent excessive drooling (Plates 32F and 32G).

## CAUTIONS[1,3,5,6]

It may be necessary to modify the surgical incision to obtain adequate surgical margins. Preoperative planning is crucial to ensure complete tumor excision. Patients should be thoroughly staged and assessed (e.g., with presurgical incisional biopsy; skull, intraoral, and thoracic radiographs; fine needle aspiration of the local lymph nodes; blood work; coagulation profile; and electrocardiogram) prior to surgery. To decrease the incidence of postoperative infection, perioperative antibiotics are recommended.

## POSTOPERATIVE EVALUATION[1,3,5–7]

The mandible and associated musculature should be submitted for histopathology and margin evaluation. Suture removal is not necessary; however, the oral cavity should be thoroughly examined at 10 to 14 days for postoperative complications. Possible complications include incisional dehiscence, infection, ranulas and sialoceles from iatrogenic salivary duct trauma, subcutaneous emphysema, mandibular drift and instability, abnormal salivation with secondary cheilitis and dermatitis, oral pain, local tumor recurrence, and distant metastatic disease. Owners should also be asked about any problems with prehension or cosmetic concerns. Patients should be evaluated every 3 months with a complete physical and oral examination. Thoracic radiographs are recommended every 3 months in animals with malignant tumors to evaluate for distant metastasis for the first year.

## POSTOPERATIVE CARE

Preemptive multimodal analgesia should be instituted in all patients for the first 48 to 72 hours. Postoperative antibiotics are recommended for the first 5 to 7 days. The patient should be fed moist food formed in individual meatballs to protect the surgical incision. Access to chew toys and rawhide bones should be restricted until the incision is healed.

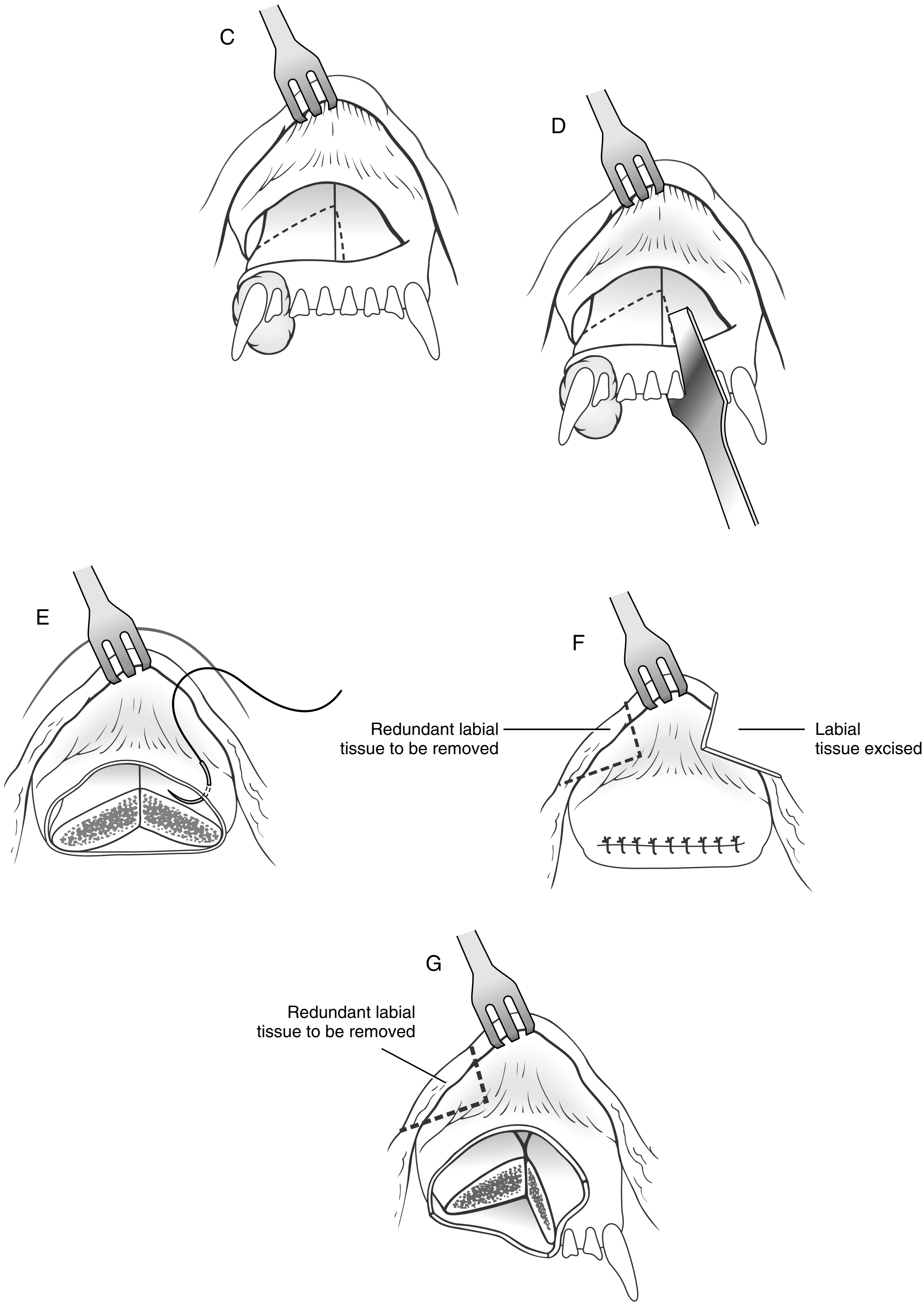
## EXPECTED OUTCOME[1,6,8,9]

In a study evaluating owner satisfaction with partial mandibulectomy or maxillectomy for the treatment of oral tumors, 85% of owners were satisfied with the results from the surgery. Forty-four percent noted a change in prehension and difficulty in eating, but pain was perceived to be reduced in most animals, and cosmesis was acceptable in all 27 cases. Prognosis in dogs with oral neoplasia varies, depending on the histopathologic type of the tumor, tumor size, the amount of bony involvement, presence of regional and distant metastases, the clinical stage of the disease, and the location of the tumor within the oral cavity. The prognosis is excellent for dogs that undergo partial mandibulectomy for the treatment of mandibular fractures, with owner acceptance of the cosmetic appearance and mandibular function reported as good to excellent.

### References


1. White R: Mandibulectomy and maxillectomy in the dog: Long-term survival in 100 cases. J Small Anim Pract 32(2):69–72, 1991.
2. Manfra-Marretta S, Schrader S, Matthiesen D: Problems associated with the management and treatment of jaw fractures. Problems in Vet Med 2(1):220–247, 1990.
3. Salisbury S: Problems and complications associated with maxillectomy, mandibulectomy, and oronasal fistula repair. Problems in Vet Med 3(2):153–169, 1991.
4. Hoelzler M, Holmberg D: Partial mandibulectomy as the treatment of a comminuted mandibular fracture in a dog. Can Vet J 42(2): 143–144, 2001.
5. Matthiesen D, Manfra-Marretta S: Results and complications associated with partial mandibulectomy and mexillectomy techniques. Problems in Vet Med 2(1):248–275, 1990.
6. White R: The oral cavity. In Hedlund C, Taboada J (eds): Clinical Atlas of Ear, Nose and Throat Diseases in Small Animals: The Case-Based. Schlutersche, Hannover, Germany, 2002.
7. Kosovsky JK, Matthiesen DT, Marretta SM, et al: Results of partial mandibulectomy for the treatment of oral tumors in 142 dogs. Vet Surg 20(6):397–401, 1991.
8. Fox LE, Geoghegan SL, Davis LH, et al: Owner satisfaction with partial mandibulectomy or maxillectomy for treatment of oral tumors in 27 dogs. J Am Anim Hosp Assoc 33(1):25–31, 1997.
9. Lantz G, Salisbury S: Partial mandibulectomy for treatment of mandibular fractures in dogs: Eight cases (1981–1984). J Am Vet Med Assoc 191(2):243–245, 1987.

# PLATE 32


C
D
E
F
Redundant labial
tissue to be removed
Labial
tissue excised
G
Redundant labial
tissue to be removed

## AMPUTATIONS

# CHAPTER 33 Forelimb Amputation with Scapulectomy

### INDICATIONS[1]

Forelimb amputation is a salvage procedure indicated for the treatment of neoplasia, osteomyelitis, nonunion fractures, severe trauma with vascular compromise and limb necrosis, paralysis caused by brachial plexus avulsion, and congenital limb deformities.

### OBJECTIVES

- To remove the limb and preserve the animal's quality of life

### ANATOMIC CONSIDERATIONS[2]

Forelimb amputation is most commonly performed by removing the limb at the scapula. More distal procedures have been described, but they are thought to produce less aesthetically pleasing results in short-haired animals because of the scapular spine and acromial prominence. Anatomic landmarks for the procedure include the scapula and associated musculature.

### EQUIPMENT

- Standard surgical pack; electrocautery; hemoclips or ample suture material for vascular ligation; sterile syringe; 25-gauge needle; 1 to 2 mL of 0.5% bupivacaine, not exceeding 1.5 to 2.0 mg/kg of body weight in the dog and 1 mg/kg of body weight in the cat, for brachial plexus injection[3]

### PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Amputation:**[1,4] Incise the skin and subcutaneous tissue in a reverse Y incision from the vertebral border of the scapula to the acromial process, following the scapular spine, and around the forelimb medially (Plate 33A). Reflect the skin, and ligate the axillobrachial and omobrachial veins proximal to the greater tubercle of the humerus (Plate 33B). Ligate the cephalic vein distal to the cleidobrachialis muscle. Using electrocautery for all the muscle incisions, transect the brachiocephalicus muscle through the clavicular tendon. Sever the omotransversarius and trapezius muscles along the cranial and dorsal edge of the spine of the scapula. Sever the latissimus dorsi muscle close to its insertion on the humerus (Plate 33C). Rotate the cranial edge of the scapula laterally, and sever the insertion of the scalenus, rhomboideus, and serratus ventralis muscles (Plate 33D). Block and sever the supraspinatus and brachial plexus nerves. Inject each nerve prior to transection with 0.2 to 0.4 mL bupivacaine until a bleb forms under the epineurium proximal to the cut (Plate 33E). Transfix, ligate, and sever the axillary artery (Plate 33F). Ligate and sever the axillary vein. Disarticulate the limb by transecting the pectoral muscles and ligating and dividing the lateral thoracic vessels.

**Closure:** Inverting the muscle bellies, place interrupted Lembert sutures, with 0 to 2-0 absorbable suture material, in the lateral fascial sheaths of the latissimus dorsi, omotransversarius, and trapezius muscles to the pectoral muscle (Plate 33G). Eliminate the dead space with 2-0 to 3-0 absorbable sutures in an interrupted cruciate or simple interrupted pattern in the subcutaneous tissue. Appose the skin edges with interdermal or skin sutures (Plate 33H).

### CAUTIONS

Patients should be thoroughly assessed before surgery is initiated (e.g., with electrocardiogram, thoracic radiographs, and blood work). Hemodynamically unstable patients should be treated prior to surgery to ensure an uneventful recovery. Whole blood and plasma products should be on hand in the event that major hemorrhage occurs.

### POSTOPERATIVE EVALUATION

If indicated, the entire limb should be submitted for histopathology. Sutures should be removed in 10 to 14 days.

### POSTOPERATIVE CARE

Postoperative bandaging of the wound for 2 to 3 days may be desirable to prevent seroma formation. Preemptive multimodal analgesia should be instituted in all patients for the first 48 to 72 hours. Common parameters to evaluate in the postoperative amputee are heart rate, pulse quality, respiratory rate, capillary refill time, body temperature, electrocardiogram, pulse oximetry, central venous pressure, serial packed cell volume, total protein, serum glucose, and activated clotting times.

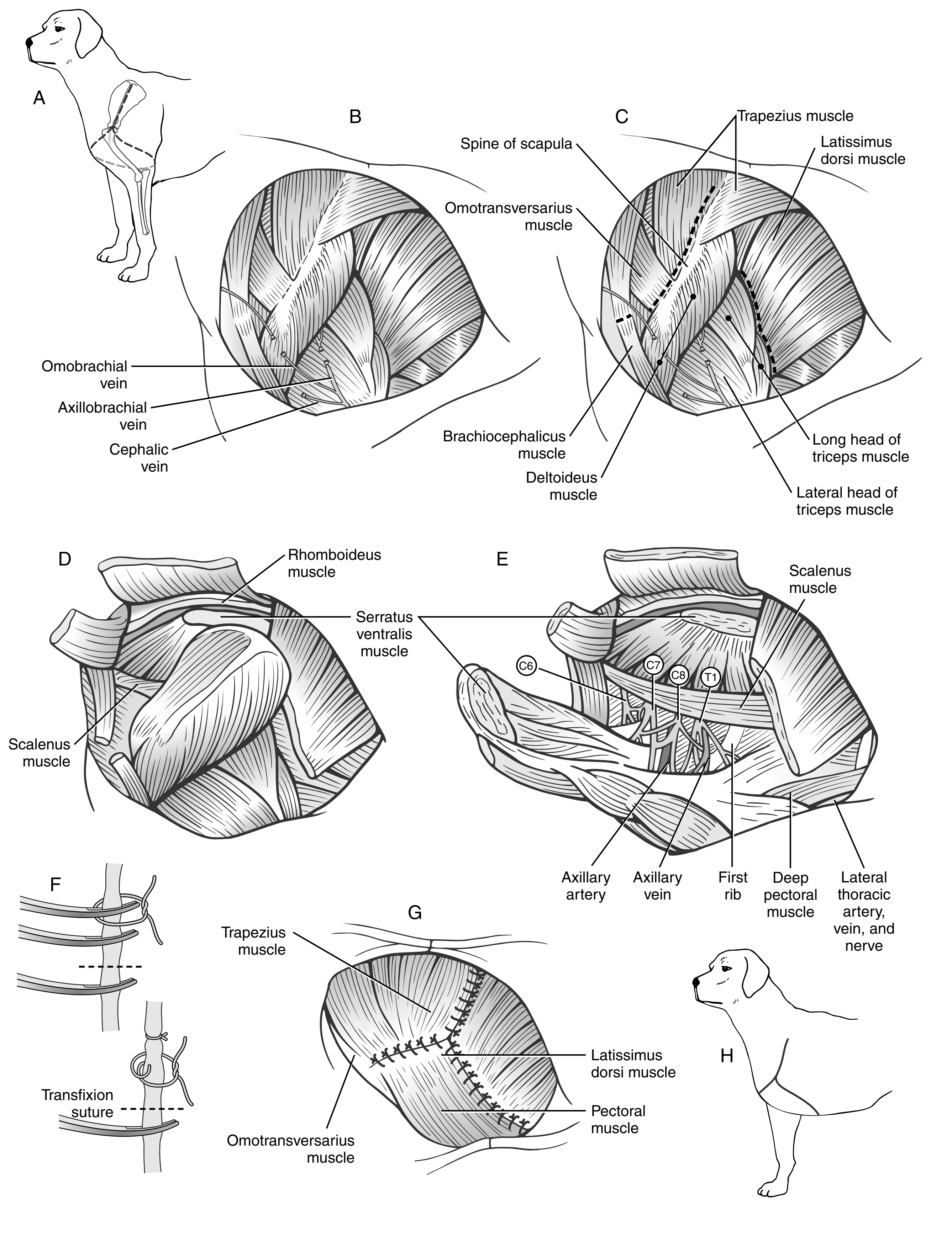
### EXPECTED OUTCOME[1,2,4]

The outcome for return to function and quality of life is good to excellent. Most animals adapt very well to forelimb amputation but will have a noticeable gait deficit on ambulation.

#### References

1. Daly WR: Amputation of the forelimb. In Bojrab MJ (ed): Current Techniques in Small Animal Surgery, 4th ed. Baltimore, Williams & Wilkins, 1998.
2. Bone DL, Aberman HM: Forelimb amputation in the dog using humeral osteotomy. J Am Anim Hosp Assoc 24:5, 525–529, 1988.
3. Muir WW, Hubbell JAE: Handbook of Veterinary Anesthesia. St. Louis, Mosby, 1989.
4. Harvey CE: Forequarter amputation in the dog and cat. J Am Anim Hosp Assoc 10(1):25–28, 1974.

# PLATE 33


A
B
C
Trapezius muscle
Spine of scapula
Latissimus dorsi muscle
Omotransversarius muscle
Omobrachial vein
Axillobrachial vein
Cephalic vein
Brachiocephalicus muscle
Deltoideus muscle
Long head of triceps muscle
Lateral head of triceps muscle
D
E
Rhomboideus muscle
Serratus ventralis muscle
Scalenus muscle
Scalenus muscle
C6
C7
C8
T1
Axillary artery
Axillary vein
First rib
Deep pectoral muscle
Lateral thoracic artery, vein, and nerve
F
Transfixion suture
G
Trapezius muscle
Latissimus dorsi muscle
Pectoral muscle
Omotransversarius muscle
H

## AMPUTATIONS

# CHAPTER 34 Forelimb Salvage via Partial and Complete Scapulectomy

### INDICATIONS[1,2]

Partial and total scapulectomy are limb-sparing procedures most commonly used in the treatment of neoplasia of the proximal scapula or in select cases of degenerative joint disease and pain in the shoulder that are not responsive to conservative management and in which arthrodesis is not an option.

### OBJECTIVES

- To preserve limb function and, in the cases of cancer, to allow for local tumor control

### ANATOMIC CONSIDERATIONS[1]

Partial scapulectomy is most commonly performed by removing the proximal scapula while preserving the scapulohumeral joint. Complete scapulectomy is indicated for tumors involving the distal part of the scapula, or when more than 90% of the scapula is involved. Anatomic landmarks for the procedure include the scapular spine, neck, acromial process, glenoid cavity, supraglenoid process, and associated musculature.

### EQUIPMENT

- Standard surgical pack; electrocautery; hemoclips or ample suture material for vascular ligation; Senn, Army-Navy, and/or Gelpi retractors; a saw or osteotome for osteotomy of the scapula; sterile syringe; 25-gauge needle; 1 to 2 mL of 0.5% bupivacaine, not exceeding 1.5 to 2.0 mg/kg of body weight in the dog and 1 mg/kg of body weight in the cat, for brachial plexus injection[3]

### PREPARATION AND POSITIONING

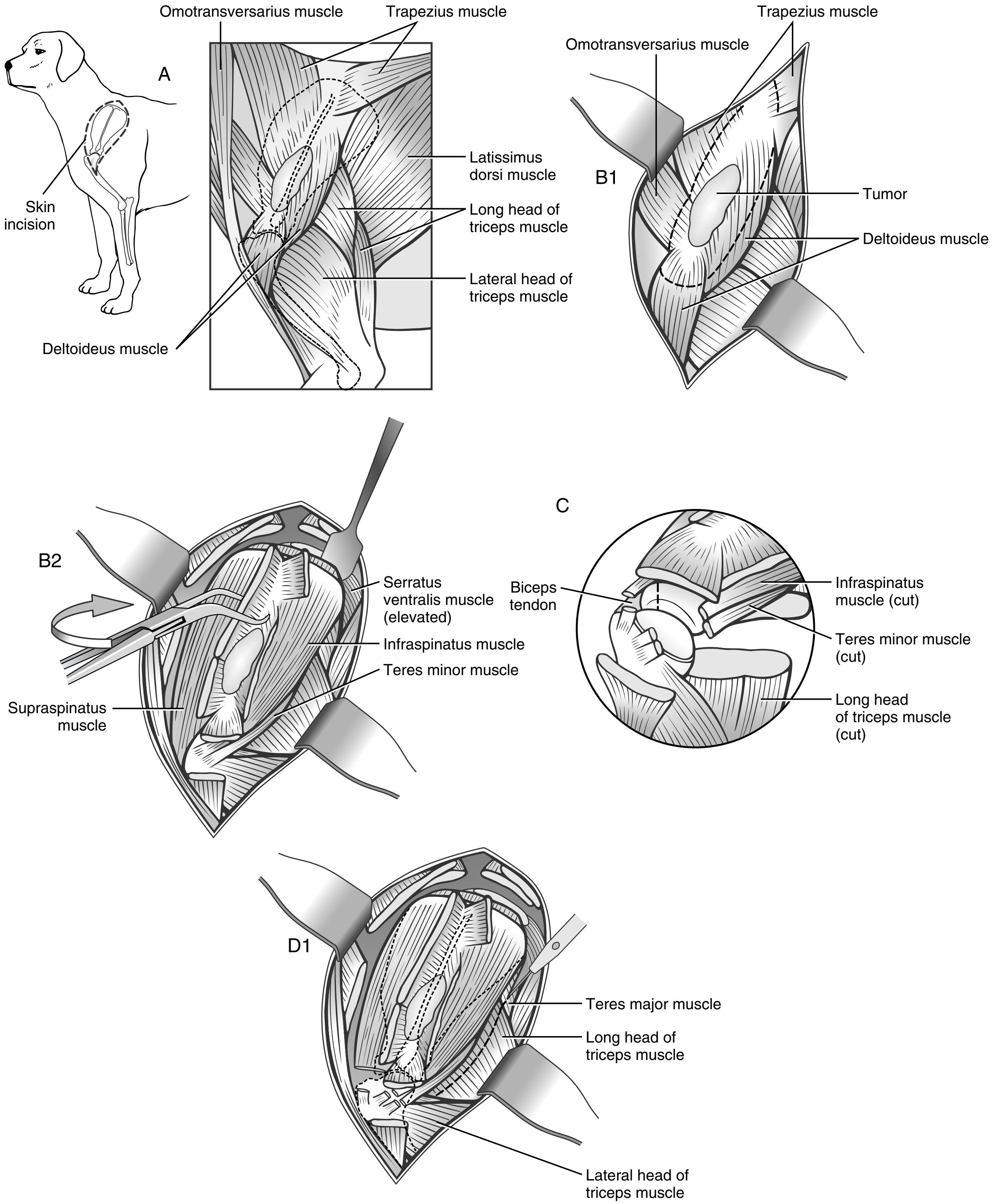
Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Complete Scapulectomy:**[1] Incise the skin and subcutaneous tissue from the dorsal border of the scapula to the proximal third of the humerus, following the dorsal border of the scapula. Incise along the caudal aspect of the scapula, connecting the two incisions at the apices (Plate 34A). Hemorrhage may be controlled with ligatures, hemoclips, and electrocautery. Without disturbing the pseudocapsule of the tumor, reflect the skin and subcutaneous tissue to expose the superficial muscles of the trapezius, omotransversarius, rhomboideus, and deltoideus (Plate 34B1). Using electrocautery, incise these muscles close to their origins on the scapula, without disturbing the tumor. Retract the scapula laterally, and elevate the serratus ventralis muscle from the medial aspect of the scapula, taking care to preserve the brachial plexus and axillary artery and vein (Plate 34B2). Identify the supra- and subscapular nerves coming from the brachioplexus bundle, and inject each nerve prior to transection with 0.2 to 0.4 mL bupivacaine until a bleb forms under the epineurium proximal to the cut. Transect the tendons of the coracobrachialis, teres minor, infraspinatus, supraspinatus, and subscapularis muscles close to their insertions on the humerus (Plate 34C). Sharply incise the joint capsule of the shoulder, and transect the teres major muscle and the long head of the triceps from their insertions from the caudal aspect of the scapula using electrocautery (Plate 34D1). Perform an osteotomy of the supraglenoid tubercle, preserving the attachment of the biceps tendon (see Plate 34D1). The scapula and associated musculature (i.e., infraspinatus, supraspinatus, and subscapularis) may now be removed and submitted for histopathology and margin evaluation.

*Continued*

# PLATE 34


A
Omotransversarius muscle
Trapezius muscle
Latissimus dorsi muscle
Long head of triceps muscle
Lateral head of triceps muscle
Skin incision
Deltoideus muscle
B1
Trapezius muscle
Omotransversarius muscle
Tumor
Deltoideus muscle
B2
Serratus ventralis muscle (elevated)
Infraspinatus muscle
Teres minor muscle
Supraspinatus muscle
C
Biceps tendon
Infraspinatus muscle (cut)
Teres minor muscle (cut)
Long head of triceps muscle (cut)
D1
Teres major muscle
Long head of triceps muscle
Lateral head of triceps muscle

**Closure:** Secure the biceps tendon and supraglenoid tubercle to the caudal aspect of the joint capsule using nonabsorbable monofilament suture in a horizontal mattress pattern. Reattach the triceps muscle to the deltoideus, omotransversarius, and trapezius muscles with an interrupted Lembert or horizontal mattress suture pattern and nonabsorbable suture. Secure the remaining trapezius to the underlying serratus ventralis muscle to further eliminate dead space. The subcutaneous tissue and skin closure is routine.

**Partial Scapulectomy:**[1] A partial scapulectomy is performed in a manner similar to a complete scapulectomy, with the exception that the scapulohumeral joint is left intact, and the osteotomy is at the level of or proximal to the scapular neck. The osteotomy site will vary, depending on the level and size of the tumor, and only the proximal portion of the scapula is removed (Plate 34D2). Attach the transected muscles of the trapezius, omotransversarius, serratus ventralis, and rhomboideus to the distal scapula via holes drilled into the body using nonabsorbable suture in a simple interrupted or horizontal mattress pattern. Alternatively, close the remaining musculature without bone tunnels by suturing transected muscles of the supraspinatus, infraspinatus, deltoideus, and the long head of the triceps to the serratus ventralis, omotransversarius, and trapezius muscles. The subcutaneous tissue and skin closure are routine.

## CAUTIONS

It may be necessary to modify the surgical incision to obtain adequate surgical margins. Preoperative planning is crucial to ensure complete tumor excision. Patients should be thoroughly staged and assessed before this limb salvage procedure surgery is initiated (e.g., with thoracic and abdominal radiographs, presurgical fine needle aspiration or biopsy, blood work, coagulation profile, and electrocardiogram).

## POSTOPERATIVE EVALUATION

The scapula and associated musculature should be submitted for histopathology and margin evaluation. The sutures should be removed in 10 to 14 days. For the first year the patient should be checked every 3 months with a physical examination and thoracic radiographs to evaluate for local recurrence of disease.

## POSTOPERATIVE CARE

Postoperative bandaging of the wound for 3 to 5 days may be desirable to prevent seroma formation. Preemptive multimodal analgesia should be instituted in all patients for the first 48 to 72 hours. Rehabilitation and range-of-motion exercises should be instituted early to prevent joint contraction and loss of function.

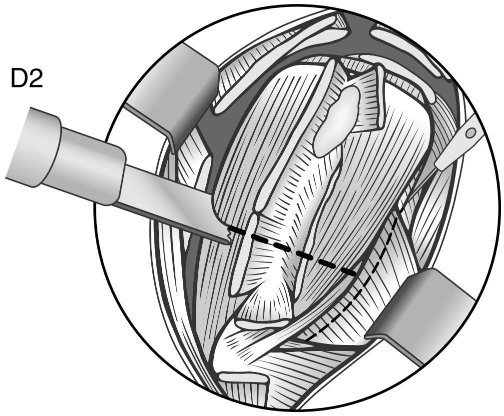
## EXPECTED OUTCOME[1]

Postoperative use of the limb is usually fair to excellent. Dogs that undergo partial scapulectomy are reported to have better function than dogs with total scapulectomy.

### References

1. Kirpensteijn J, Straw RC, Pardo AD, et al: Partial and total scapulectomy in the dog. J Am Anim Hosp Assoc 30(4):313–319, 1994.
2. Trout N, Pavletic M, Kraus K: Partial scapulectomy for management of sarcomas in three dogs and two cats. J Am Vet Med Assoc 207(5):585–587, 1995.
3. Muir WW, Hubbell JAE: Handbook of Veterinary Anesthesia. St. Louis, Mosby, 1989.

## PLATE 34



## AMPUTATIONS

# Chapter 35 Rear Limb Amputation via Coxofemoral Disarticulation

### INDICATIONS
Rear limb amputation is a salvage procedure indicated for the treatment of neoplasia, osteomyelitis, nonunion fractures, severe trauma with vascular compromise and limb necrosis, paralysis caused by sciatic or femoral nerve damage, and congenital limb deformities.

### OBJECTIVES
- To remove the limb and preserve the animal's quality of life

### ANATOMIC CONSIDERATIONS
Rear limb amputation may be performed via two methods: (1) by removing the limb at the midshaft femur; or (2) by removal at the coxofemoral joint. More distal procedures have been described, but these produce a nonfunctional limb that may actually inhibit ambulation and that is aesthetically less pleasing. Coxofemoral disarticulation should be performed in dogs with neoplastic conditions affecting the femur to ensure adequate surgical margins, and the entire limb should be submitted for histopathology to confirm tumor-free margins and tumor identification. Anatomic landmarks for the procedure include the femur, the coxofemoral joint, and associated musculature.

### EQUIPMENT[1]
- Standard surgical pack; electrocautery, hemoclips, or ample suture material for vascular ligation; Senn, Army-Navy, and/or Gelpi retractors; sterile syringe; 25-gauge needle; 1 to 2 mL of 0.5% bupivacaine, not exceeding 1.5 to 2.0 mg/kg of body weight in the dog and 1 mg/kg of body weight in the cat, for brachial plexus injection

### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from dorsal midline to tarsus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE
**Coxofemoral Disarticulation:** Incise the skin and subcutaneous tissue, using a curved incision on the lateral aspect of the leg that begins at the flank fold and extends caudodistally to the distal third of the femur, and then caudodorsally to the tuber ischii (Plate 35A). Make a similar incision on the medial aspect of the leg, connecting at either end. Retract the skin and subcutaneous tissue to expose the muscle bellies of the biceps femoris and the tensor fascia latae. Using electrocautery in the coagulation mode, transect these muscle belly groups at the level of midshaft femur (Plate 35B). Reflect the muscle bellies proximally to expose the sciatic nerve. Block and sever the sciatic nerve, injecting it prior to transection with 0.2 to 0.4 mL bupivacaine until a bleb forms under the epineurium proximal to the cut. Using electrocautery, transect the gluteal muscles at their insertions at the greater and third trochanters (Plate 35C). Transect the semitendinosus and semimembranosus at the level of the proximal femur, and reflect proximally (see Plate 35C). Transect the external rotator and quadratus femoris muscles at their insertions in the trochanteric fossa. Working cranially, transect the rectus femoris muscle close to its origin on the ilium. On the medial aspect of the leg, isolate, ligate, and divide the femoral artery and vein in the femoral triangle via placement of a circumferential and transfixation suture proximally and a hemostat or circumferential suture distad (Plate 35D). Identify, block, and sever the femoral nerve. Transect the pectineus, the cranial belly of the sartorius, the gracilis, and the adductor muscles at the level of the midshaft femur (Plate 35E). Transect the iliopsoas muscle at its insertion on the lesser trochanter, and retract it cranially to fully expose the coxofemoral joint capsule. Incise the joint capsule and sever the round ligament to remove the limb (Plate 35F).

**Closure:** Inverting the muscle bellies, suture the lateral fascial sheaths of the muscle bellies in an interrupted Lembert pattern with 0 to 2-0 monofilament absorbable suture (Plate 35G). Eliminate the dead space with 2-0 to 3-0 absorbable sutures in an interrupted cruciate or simple interrupted pattern in the subcutaneous tissue. Appose the skin edges with interdermal or skin sutures (see Plate 35G).

### CAUTIONS
Preoperative planning will ensure adequate soft tissue coverage and tension-free closure of the surgical wound. Elizabethan collars should be employed in animals that lick or chew at the incision.

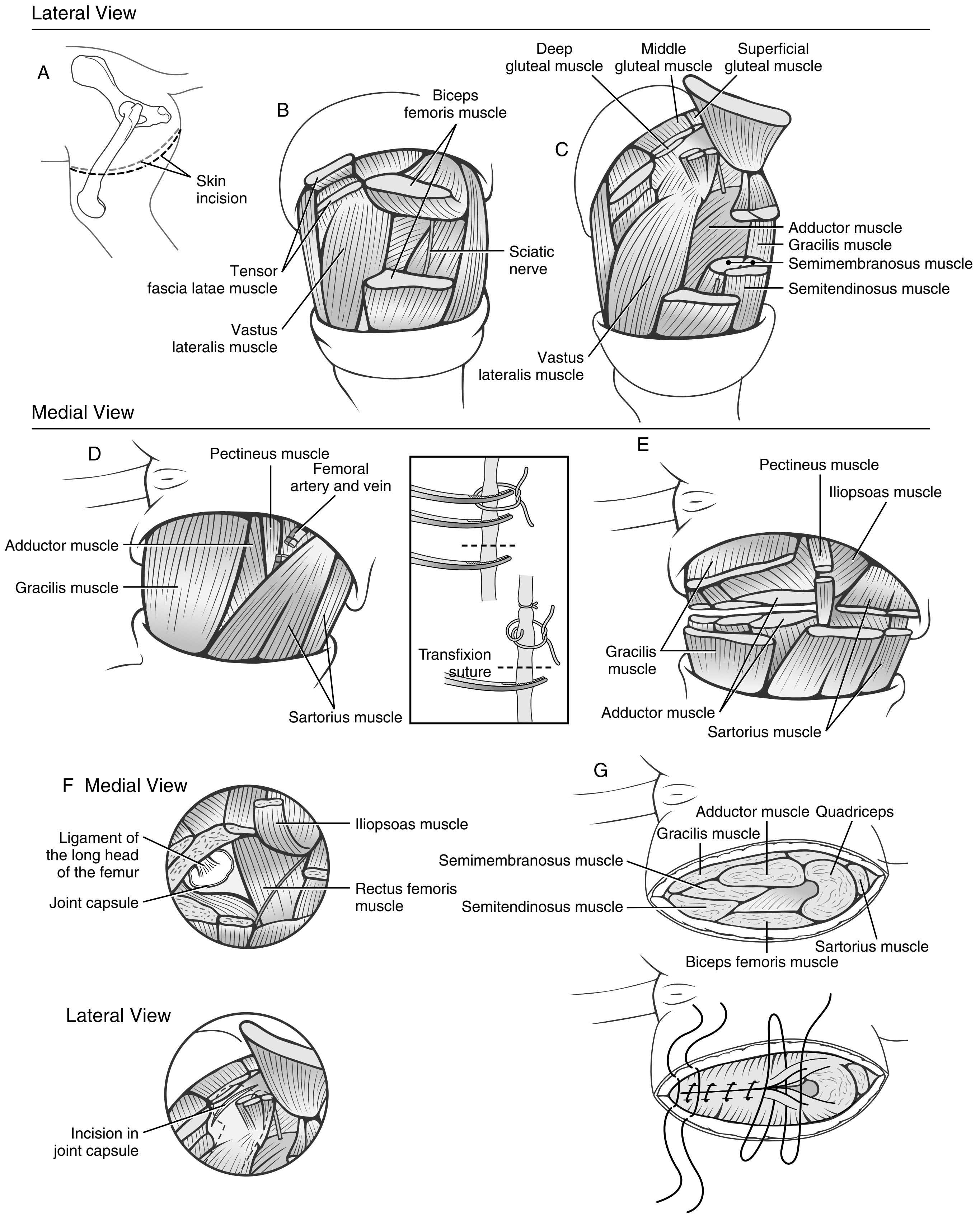
### POSTOPERATIVE EVALUATION
If indicated, the entire limb should be submitted for histopathology. Sutures can be removed in 10 to 14 days.

### POSTOPERATIVE CARE
Preemptive multimodal analgesia should be instituted in all patients for the first 48 to 72 hours. Common parameters to evaluate in the postoperative amputee are heart rate, pulse quality, respiratory rate, capillary refill time, body temperature, electrocardiogram, pulse oximetry, central venous pressure, serial packed cell volume, total protein, serum glucose, and activated clotting times. Activity should be restricted for 2 weeks until sutures are removed. It may be necessary to assist ambulation with slings or carts in some cases, until the animal adjusts to its new center of balance.

### EXPECTED OUTCOME[2,3]
Expectations for a return to function and quality of life are good to excellent. Most animals adapt well to hind limb amputation, but they will have a noticeable gait deficit on ambulation, and about one dog in three has a noticeable change in behavior.

#### References
1. Muir WW, Hubbell JAE: Handbook of Veterinary Anesthesia. St. Louis, Mosby, 1989.
2. Kirpensteijn J, Van Den Bos R, Endenburg N: Adaptation of dogs to the amputation of a limb and their owners' satisfaction with the procedure. Vet Rec 144(5):115–118, 1999.
3. Endicott M: Principles of treatment for osteosarcoma. Clin Tech Small Anim Pract 18(2):110–114, 2003.

# PLATE 35


Lateral View
A
Skin incision
B
Biceps femoris muscle
Tensor fascia latae muscle
Sciatic nerve
Vastus lateralis muscle
C
Deep gluteal muscle
Middle gluteal muscle
Superficial gluteal muscle
Adductor muscle
Gracilis muscle
Semimembranosus muscle
Semitendinosus muscle
Vastus lateralis muscle
Medial View
D
Pectineus muscle
Femoral artery and vein
Adductor muscle
Gracilis muscle
Sartorius muscle
Transfixion suture
E
Pectineus muscle
Iliopsoas muscle
Gracilis muscle
Adductor muscle
Sartorius muscle
F Medial View
Ligament of the long head of the femur
Joint capsule
Iliopsoas muscle
Rectus femoris muscle
Lateral View
Incision in joint capsule
G
Adductor muscle
Quadriceps
Gracilis muscle
Semimembranosus muscle
Semitendinosus muscle
Sartorius muscle
Biceps femoris muscle

## AMPUTATIONS

# CHAPTER 36 Midshaft Femur Amputation

### INDICATIONS

Rear limb amputation is a salvage procedure indicated for the treatment of neoplasia, osteomyelitis, nonunion fractures, severe trauma with vascular compromise and limb necrosis, paralysis caused by sciatic or femoral nerve damage, and congenital limb deformities.

### OBJECTIVES

- To remove the limb and preserve the animal's quality of life

### ANATOMIC CONSIDERATIONS

Rear limb amputation may be performed via two methods: (1) removing the limb at the midshaft femur; or (2) removing it at the coxofemoral joint. More distal procedures have been described, but these produce a nonfunctional limb that may actually inhibit ambulation and that is aesthetically less pleasing. Midshaft femoral amputation is easier to perform than is a coxofemoral disarticulation, and therefore it is the method preferred by most veterinarians. Anatomic landmarks for the procedure include the femur, the coxofemoral joint, and associated musculature.

### EQUIPMENT[1]

- Standard surgical pack; electrocautery, hemoclips, or ample suture material for vascular ligation; Senn, Army-Navy, and/or Gelpi retractors; a Gigli wire or saw for midshaft femoral amputation; sterile syringe; 25-gauge needle; 1 to 2 mL of 0.5% bupivacaine, not exceeding 1.5 to 2.0 mg/kg of body weight in the dog and 1 mg/kg of body weight in the cat, for local nerve blockade

### PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to tarsus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Midshaft Femoral Amputation:**[1] Incise the skin and subcutaneous tissue, using a curved incision on the lateral aspect of the leg that begins at the flank fold and extends caudodistally to the distal third of the femur and then caudodorsally to the tuber ischii (Plate 36A). Make a similar incision on the medial aspect of the leg, connecting at either end. Retract the skin and subcutaneous tissue to expose the muscle bellies of the biceps femoris, the tensor fascia latae, and the quadriceps (Plate 36B1). Using electrocautery in the coagulation mode, transect these muscle belly groups at the level of the distal third of the femur (Plate 36B2). Identify, block, and sever the sciatic nerve, injecting it prior to transection with 0.2 to 0.4 mL bupivacaine until a bleb forms under the epineurium proximal to the cut. At the same level, use electrocautery to transect the semitendinosus, semimembranosus, and adductor muscles (Plate 36C). On the medial aspect of the leg, transect the gracilis and the caudal belly of the sartorius muscles at the level of the midshaft femur (Plate 36D). Isolate, ligate, and divide the femoral artery and vein via placement of a circumferential and transfixation suture proximally, and a hemostat or circumferential suture distad (Plate 36E). Identify, block, and sever the femoral nerve. Transect the remaining pectineus muscle and the cranial belly of the sartorius muscle to fully isolate the femoral diaphysis. Elevate any remaining tissue or muscle from the proximal femur at the osteotomy site, and cut the femur using a saw or Gigli wire to remove the limb (Plate 36F). The level of the osteotomy is located within the proximal third of the femoral shaft to ensure appropriate soft tissue coverage.

**Closure:** Inverting the muscle bellies, suture the lateral fascial sheaths of the muscle bellies in an interrupted Lembert pattern with 0 to 2-0 monofilament absorbable suture. Cover the femoral shaft by suturing the transected muscle bellies of the quadriceps to the adductor. Suture the transected biceps femoris to the gracilis, the semitendinosus, and the semimembranosus muscles. Eliminate the dead space with 2-0 to 3-0 absorbable sutures in an interrupted cruciate or simple interrupted pattern in the subcutaneous tissue. Appose the skin edges with interdermal or skin sutures.

### CAUTIONS

Preoperative planning is imperative to ensure adequate soft tissue coverage and tension-free closure of the surgical wound. Elizabethan collars should be employed in animals that lick or chew at the incision.

### POSTOPERATIVE EVALUATION

If indicated, the entire limb should be submitted for histopathology. Sutures should be removed in 10 to 14 days.

### POSTOPERATIVE CARE

Preemptive multimodal analgesia should be instituted in all patients for the first 48 to 72 hours. Common parameters to evaluate in the postoperative amputee are heart rate, pulse quality, respiratory rate, capillary refill time, body temperature, electrocardiogram, pulse oximetry, central venous pressure, serial packed cell volume, total protein, serum glucose, and activated clotting times. Activity should be restricted for 2 weeks until suture removal. It may be necessary to assist ambulation with slings or carts, until the animal adjusts to its new center of balance.

### EXPECTED OUTCOME[2,3]

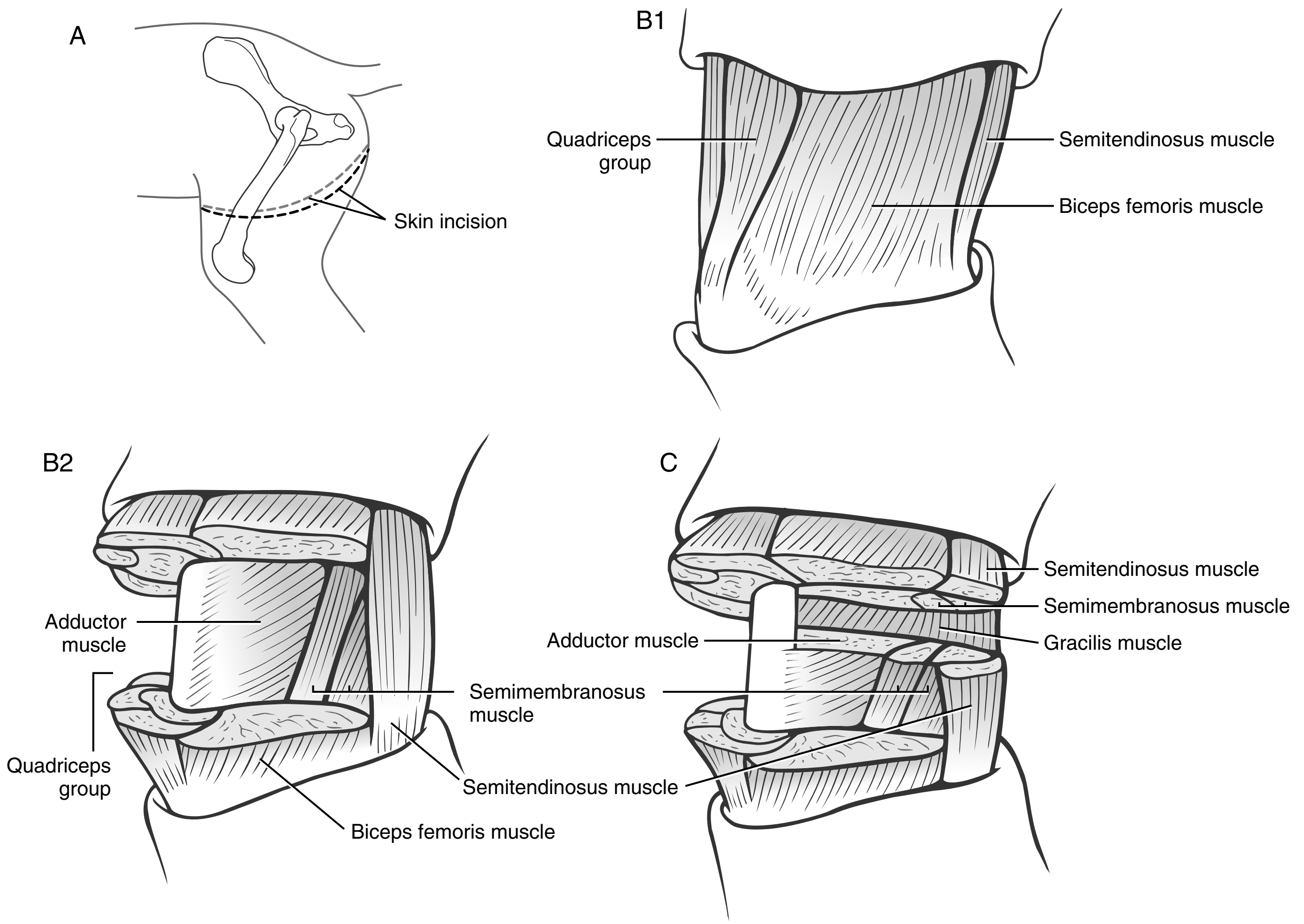
The outcome for return to function and quality of life should be good to excellent. Most animals adapt well to hind limb amputation, although they will have a noticeable gait deficit on ambulation. About one dog in three has a noticeable change in behavior.

#### References

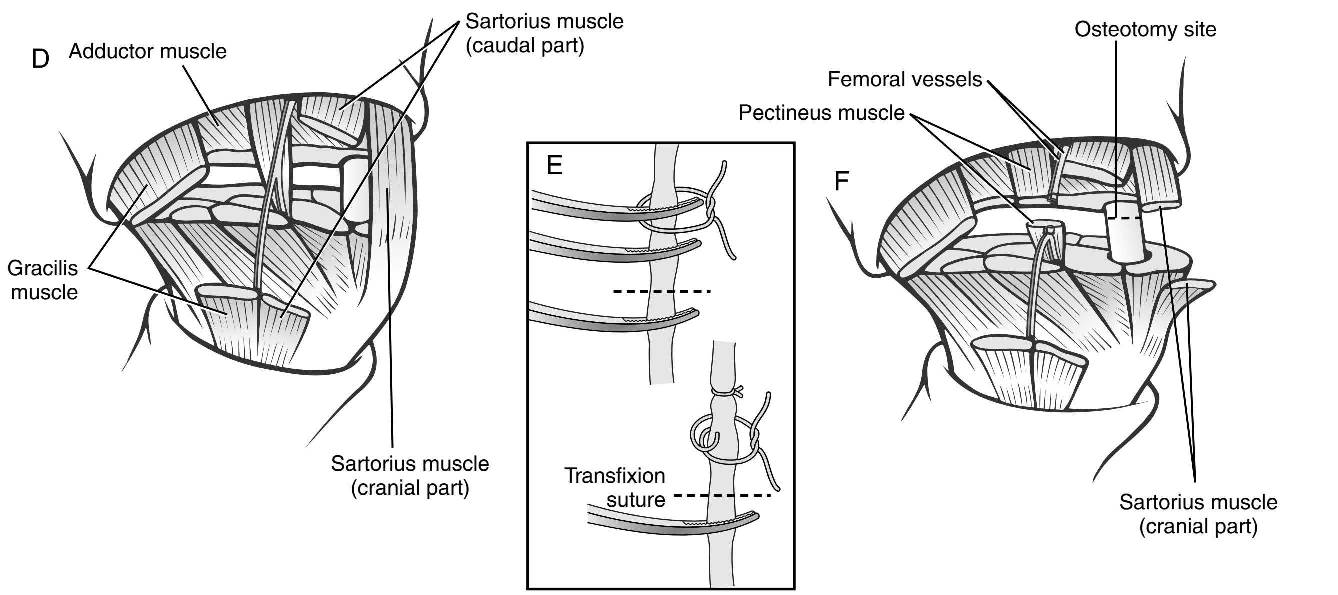
1. Muir WW, Hubbell JAE: Handbook of Veterinary Anesthesia. St. Louis, Mosby, 1989.
2. Kirpensteijn J, Van Den Bos R, Endenburg N: Adaptation of dogs to the amputation of a limb and their owners' satisfaction with the procedure. Vet Rec 144(5):115–118, 1999.
3. Endicott M: Principles of treatment for osteosarcoma. Clin Tech Small Anim Pract 18(2):110–114, 2003.

# PLATE 36

## Lateral View




## Medial View



# AMPUTATIONS

# CHAPTER 37 Digital Amputation

## INDICATIONS[1–3]

Digital amputation is indicated for the treatment of neoplasia, osteomyelitis, nonunion fractures, severe trauma, and severe toe deformities that result in lameness or pain. Dewclaw removal is indicated for cosmesis, and as a preventative measure to avoid future injury. Dewclaws should not be removed in working breeds such as the Briard or Great Pyrenees, in which double dewclaws on each hindfoot are a breed standard and requirement. Dewclaws in puppies less than 1 week of age may be amputated with minimal instrumentation. Once the digits develop, amputation of the dewclaw is more complicated and requires general anesthesia.

## OBJECTIVES

- To remove a digit and preserve the foot function and normal weight-bearing capacity

## ANATOMIC CONSIDERATIONS

The primary weight-bearing digits of the paw are the third and fourth digits. Each digit is composed of three phalangeal bones. Anatomic landmarks for the procedure include the phalanges of digits 1 through 5 and associated tendons and musculature.

## EQUIPMENT

- Standard surgical pack, electrocautery, bone cutters for proximal phalangeal amputation, tourniquet to control hemorrhage (optional)

## PREPARATION AND POSITIONING

Clip and prepare the affected paw from the carpus or tarsus distally. Position the animal in lateral recumbency with the affected limb up. Place a tourniquet on the limb below the elbow or above the tarsus (optional). Drape the limb out from a hanging position to allow maximal manipulation during surgery.

## PROCEDURE

**Digital Amputation of Digits 3 and 4:** Incise the skin and subcutaneous tissue in a reverse Y incision beginning at the mid-metacarpus of the affected digit, excising the digital pad (Plate 37A1). Disarticulate the phalanges at the metacarpophalangeal joint, or create an osteotomy of the proximal phalanx with bone-cutting forceps. Bevel the angle of the osteotomy to ensure adequate soft tissue coverage of the protruding bone (Plate 37A2). Using the electrocautery and suture, identify and ligate any persistent bleeding vessels. Appose the subcutaneous tissue and fascia in a simple interrupted pattern with monofilament absorbable suture. The remaining closure is routine (Plate 37A3).

**Amputation of Digit 1:** Incise the skin and subcutaneous tissue from the midshaft metatarsus around the medial or lateral digit (Plate 37B1). Disarticulate the phalanges at the metacarpophalangeal joint, and identify and ligate or cauterize any persistent bleeding vessels (Plate 37B2). Appose the subcutaneous tissue and fascia in a simple interrupted pattern with monofilament absorbable suture. The remaining closure is routine (Plate 37B3).

**Dewclaw Amputation in a Neonate:** Crush the tissue of the dewclaw using straight or curved hemostatic forceps at the level of the appendage's attachment to the paw (Plate 37C1). Using a scalpel blade, scissors, or digital pressure, remove the digit and suture the wound closed with a simple interrupted or cruciate suture and monofilament absorbable suture (optional) (Plate 37C2). Usually, neither bandaging nor suture removal is necessary.

## CAUTIONS[4]

The surgical incision may need to be modified in order to obtain adequate surgical margins in the cases of neoplasia. Preoperative planning is crucial to ensure complete tumor excision. Patients should be thoroughly staged and assessed before this limb salvage procedure surgery is initiated (e.g., with thoracic radiographs, presurgical fine needle aspiration or biopsy, blood work, coagulation profile, and electrocardiogram). Evidence of bone lysis is present in 83% of cases of malignant tumors and in 17% of the benign or pyogranulomatous masses.

## POSTOPERATIVE EVALUATION

If indicated, the digit should be submitted for histopathology and culture and sensitivity. Sutures should be removed in 10 to 14 days.

## POSTOPERATIVE CARE[5]

The foot should be protected with a soft, padded bandage. Elizabethan collars should be employed until the wound is healed in animals that lick or chew at the bandage or incision. Activity should be restricted for 2 weeks, until suture removal.

## EXPECTED OUTCOME[4,6]

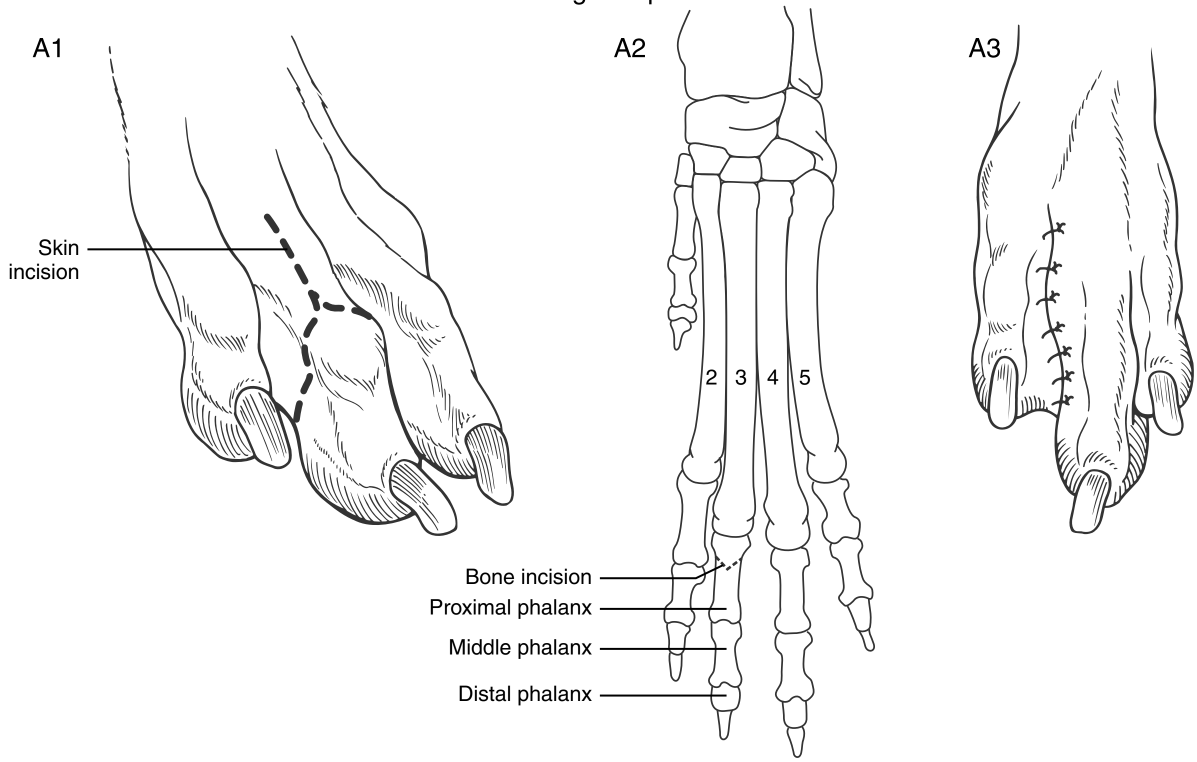
The level of amputation depends on the disease; however, pad preservation is important in ensuring pain-free ambulation. Up to two non–weight-bearing digits may be completely amputated without affecting limb function. Amputation of both digits 3 and 4 may result in lameness, and therefore should be avoided if possible. The prognosis in dogs with digital neoplasia varies depending on the histopathologic type of the tumor, the presence of regional and distant metastasis, and the clinical stage of the disease.

### References

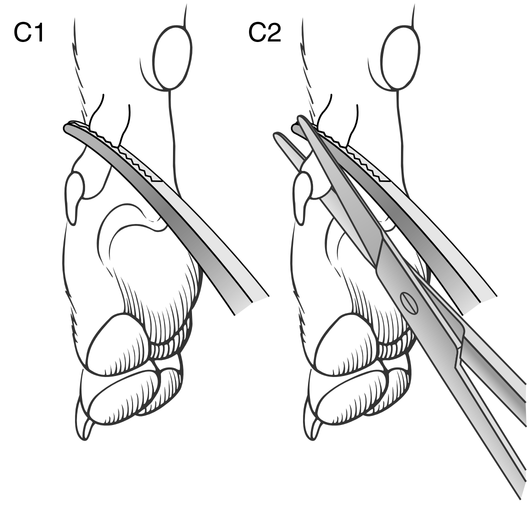
1. Basher A: Foot injuries in dogs and cats. Compend Contin Educ Pract Vet 16(9):1159–1176, 1994.
2. American Kennel Club Staff: Briard. In The Complete Dog Book. New York, Howell House Book, 1998.
3. American Kennel Club Staff: Great Pyrenees. In The Complete Dog Book. New York, Howell House Book, 1998.
4. Marino DJ, Matthiesen DT, Stefanacci JD, Moroff SD: Evaluation of dogs with digit masses: 117 cases (1981–1991). J Am Vet Med Assoc 207(6):726–728.
5. Swaim S: Management and bandaging of soft tissue injuries of dog and cat feet. J Am Anim Hosp Assoc 21(3):329–340, 1985.
6. O'Brien M, Berg J, Engler S: Treatment by digital amputation of subungual squamous cell carcinoma in dogs. J Am Vet Med Assoc 201(5):759–761, 1992.

# PLATE 37

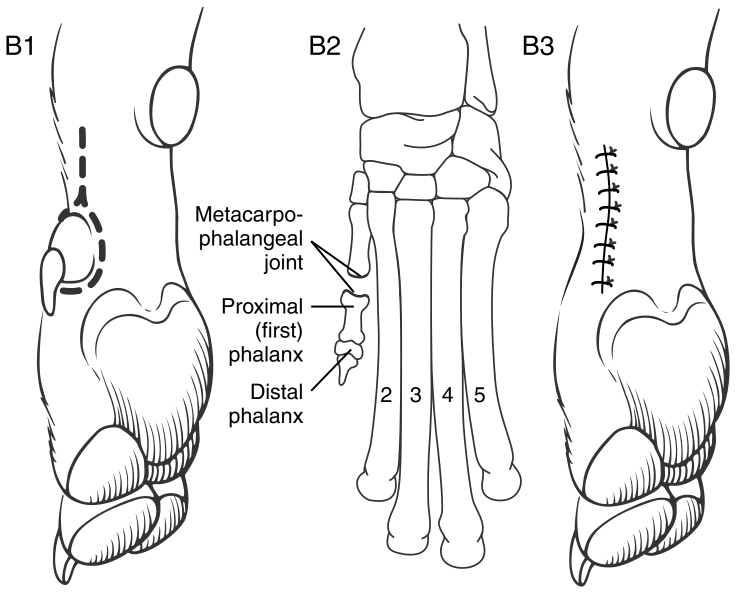
Adult Middle Digit Amputation




Juvenile/Puppy Dewclaw Amputation




Adult Digit 1 Amputation



## ADDITIONAL CORRECTIVE OSTEOTOMIES

# CHAPTER 38 Oblique Osteotomy Stabilized with a Type II External Fixator

### INDICATIONS

Candidates include animals with either angular or rotational deformity of the radius and ulna[1] or tibia and fibula,[2] with minimal length discrepancy when compared with the contralateral limb.

### OBJECTIVES

- To realign joint surfaces, reestablish rotational alignment, and preserve length of the affected bone

### ANATOMIC CONSIDERATIONS

A physical examination is needed to estimate the degree of rotation. By flexing the carpus and the elbow or the hock and stifle of the affected limb, the degree of angulation of the metacarpal or metatarsal bones in relation to the radius and ulna or in relation to the tibia can be measured. The degree of angulation approximates the degree of rotation. The osteotomy should be planned at the site of greatest curvature visible on the radiographic view that shows the most deformity (usually the cranial caudal view) and parallel to the joint surface closest to the deformed area (usually the distal joint surface) (Plate 38A). Landmarks for the pin placement and the vital structures to avoid vary with the affected bone.

### EQUIPMENT

- Surgical pack, Senn retractors, small Hohmann retractors, periosteal elevator, oscillating saw, Jacob pin chuck, low-speed power drill, external fixation equipment, pin cutter, bone curette for harvesting graft

### PREPARATION AND POSITIONING

For the radius, prepare the forelimb circumferentially from above the shoulder to the phalanges. Position the animal in dorsal recumbency, and suspend the affected limb from the ceiling. Drape the limb out in the hanging position. For the tibia, prepare the affected rear limb circumferentially from midline to foot. Position the animal in dorsal recumbency, and suspend the affected limb from the ceiling. Drape the limb out in the hanging position. Prepare the ipsilateral proximal humerus as a cancellous bone graft donor site for either osteotomy.

### PROCEDURE

**Approach:** Position a transfixation pin parallel to the proximal joint surface in the dorsal plane of the proximal portion of the bone. For the radius, start the pin on the lateral surface of the proximal radius or radial head. Position a transfixation pin parallel to the distal joint surface in the dorsal plane of the distal portion of the bone. For the radius, start the pin on the lateral surface of the distal radius, just cranial to the ulna. Make a transverse osteotomy of the ulna or fibula at the same level as the radial or tibial osteotomy. Make an oblique osteotomy of the radius or tibia at the area of greatest curvature (Plate 38B). The osteotomy should parallel the distal joint surface in both the dorsal and transverse planes.[3]

**Reduction:** Lower the table to allow the animal's weight to align the bone. Use the distal transfixation pin to manipulate the distal bone segment to align the joint surfaces and derotate the bone. Medial and lateral angular alignment is correct when the proximal and distal joint surfaces are parallel (Plate 38C). Cranial caudal joint surface relationships should mimic the contralateral intact bone. Rotational alignment is correct if the paw aligns with the radius or tibia when the elbow and carpus or stifle and hock are flexed.

**Stabilization:** Stabilize the bone by adding medial and lateral connecting bars and additional fixation pins to create a type II external fixation frame[3] (see Plate 38C).

### CAUTIONS

It is important to avoid major nerves and vessels and joint surfaces when placing the fixation pins. Angular and rotational alignment should be monitored during the reduction. Intraoperative radiographs are useful to verify proximal and distal pin placement and joint alignment during reduction and stabilization.

### POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement. The joint surfaces should be parallel, and a cranial caudal view of the proximal joint should be visible in the same radiograph as a cranial caudal view of the distal joint. If angular deformity persists, the external fixator should be manipulated by loosening the clamps distal to the osteotomy and realigning the fixation pins on the connecting bar to correct the deformity (Plate 38D).

### POSTOPERATIVE CARE

Gauze sponges should be packed around the pins; the sponges should be secured with a bandage, which also incorporates the paw, to limit postoperative swelling. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Radiographs should be repeated at 6-week intervals to evaluate healing. The fixator may be destabilized by removing selected fixation pins, or one connecting bar of the type II fixator, when early bone bridging is observed. The external fixator should be removed when the osteotomy has healed.

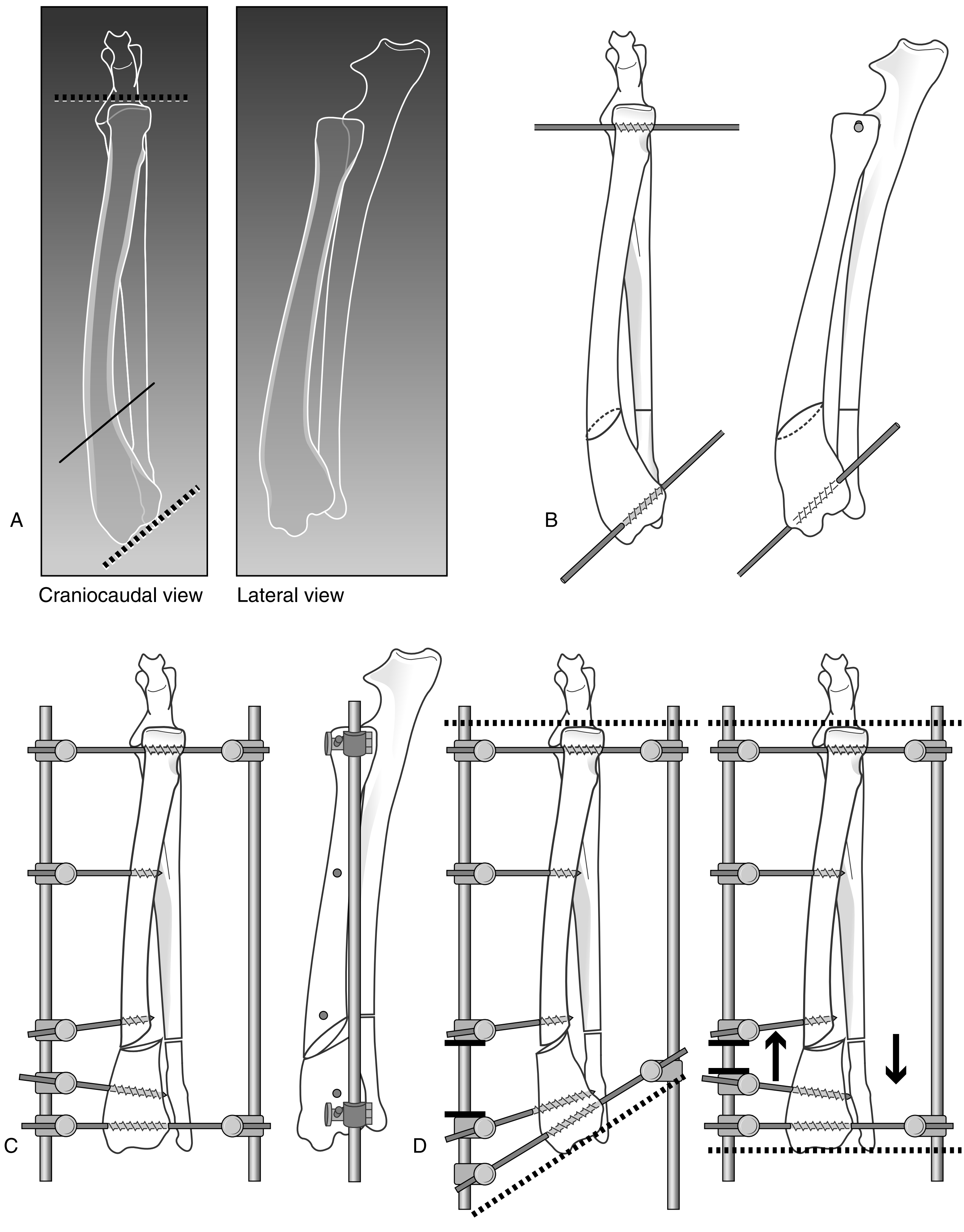
### EXPECTED OUTCOME

In most dogs, bone healing is seen in 6 to 12 weeks. Function may be compromised while the external fixator is in place. Good correction of medial lateral angular deformities can be achieved with this technique; however, minimal correction is anticipated for cranial caudal bowing or restoration of large length discrepancies.[1]

#### References

1. Quinn M, Ehrhart N, Johnson AL: Realignment of the radius in canine antebrachial growth deformities treated with corrective osteotomy and bilateral (Type II) external fixation. Vet Surg 29:558, 2000.
2. Johnson SG, Hulse DA, Vangundy TE, et al: Corrective osteotomy for pes varus in the dachshund. Vet Surg 18:373, 1989.
3. Johnson AL, Hulse DA: Management of specific fractures: Radial and ulnar growth deformities. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

## PLATE 38



## ADDITIONAL CORRECTIVE OSTEOTOMIES

# CHAPTER 39 Transverse Derotational Osteotomy Stabilized with a Plate

### INDICATIONS
Candidates include animals with isolated rotational deformity of a long bone caused by fracture malunion. Concurrent angular deformity may be corrected by performing an oblique osteotomy at the area of greatest curvature and then realigning the joint surfaces.[1]

### OBJECTIVES
- To reestablish rotational alignment

### ANATOMIC CONSIDERATIONS
Rotation should be estimated from radiographic landmarks for the humerus and femur. The rotation for the radius or tibia from a physical examination by flexing the carpus and the elbow or the hock and stifle of the affected limb. The degree of angulation of the metacarpal or metatarsal bones should be measured in relation to the radius and ulna or in relation to the tibia. The degree of angulation approximates the degree of rotation. Generally, the osteotomy can be made at the mid-diaphysis. Landmarks for the approach, and vital structures to avoid, vary with the affected bone.

### EQUIPMENT
- Surgical pack, periosteal elevator, Gelpi retractors, Myerding or Hohmann retractors, Kern bone-holding forceps, self-centering plate-holding forceps, high-speed drill, Kirschner wires, plating equipment, bone curette for harvesting graft

### PREPARATION AND POSITIONING
Prepare the affected limb circumferentially from midline to foot. If a cancellous bone graft harvest is anticipated, prepare a donor site as well. Positioning depends on the affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE
**Approach:** Position a Kirschner wire perpendicular to the bone in the transverse plane of the proximal joint. Position a Kirschner wire perpendicular to the bone in the transverse plane of the distal joint (Plate 39A). The approach depends on the affected bone. Make the transverse osteotomy at the major region of rotation (Plate 39B).

**Reduction:** Rotate the distal segment until the Kirschner wires are in the same plane (see Plate 39B).

**Stabilization:** Apply an appropriately contoured plate to the bone (Plate 39C). The plate should function as a compression plate. Harvest a cancellous bone autograft, and place it at the osteotomy site.

### CAUTIONS
Rotational alignment and reduction should be maintained during implant application. It is important to be sure that the plate is centered on the bone. Irrigation is needed during drilling to reduce bone necrosis. All screws should be tightened after each screw is placed and at the end of the procedure.

### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for bone alignment and implant placement. For radius and tibia, it is important to check the alignment of the metacarpal or metatarsal bones to the radius or tibia to verify rotational correction.

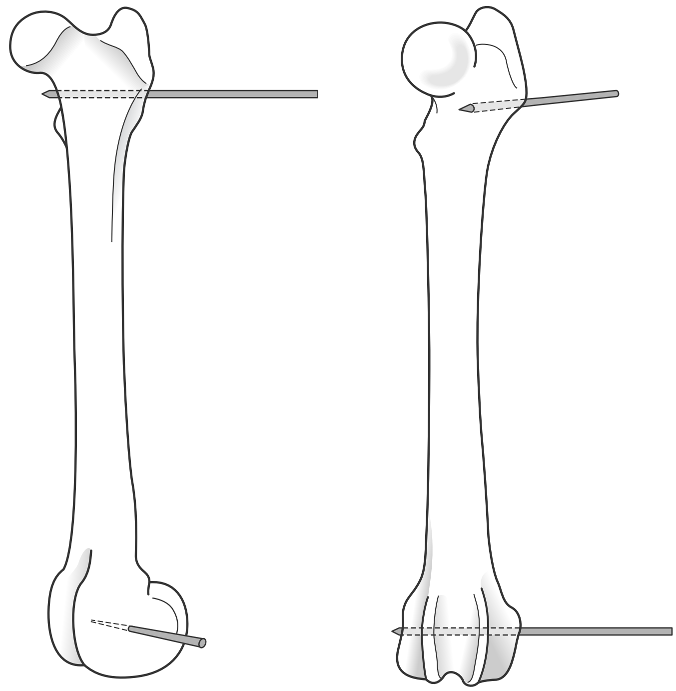
### POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals to evaluate healing. Activity should be increased when bone bridging is observed.

### EXPECTED OUTCOME
In most dogs, bone healing is seen in 12 to 18 weeks. Implant removal may be necessary if soft tissues are irritated.

#### Reference
1. Johnson AL: Osteotomies. In Olmstead ML (ed): Small Animal Orthopedics. St. Louis, Mosby, 1995.

# PLATE 39

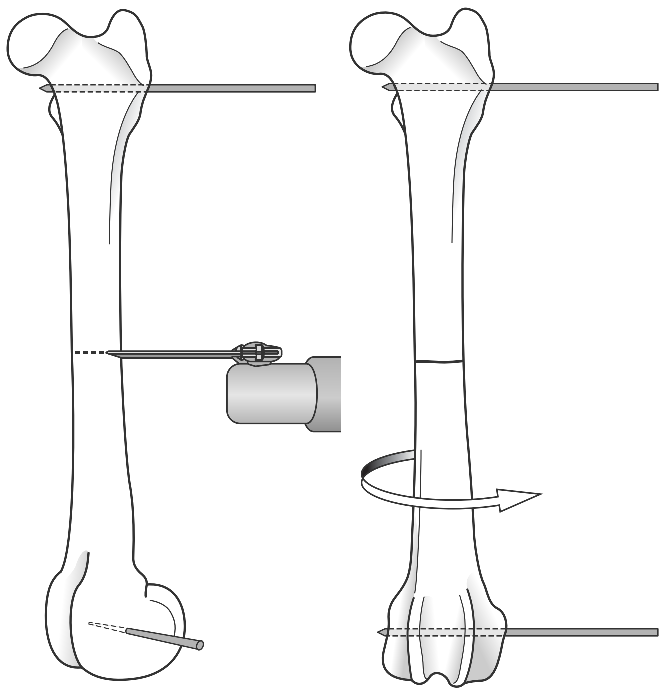
A



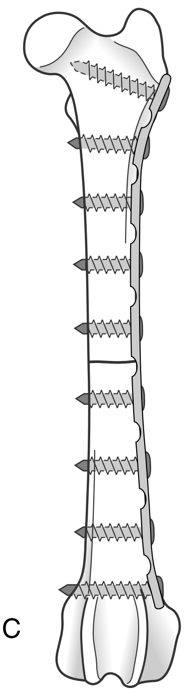
Cranial caudal view of proximal femur

Cranial caudal view of distal femur

B



C



## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# Chapter 40 Stabilizing a Transverse or Short Oblique Diaphyseal Fracture with a Compression Plate

### INDICATIONS

Candidates include animals with transverse or short oblique diaphyseal fractures requiring fixation with implants that will securely hold bone for a long time (12 weeks or more). The procedure is also indicated in large active older dogs, dogs with multiple limb injuries, toy breed dogs with distal radial fractures, and animals for which postoperative comfort is imperative.[1]

### OBJECTIVES

- To anatomically reduce and compress the fracture line using the bone plate as a compression plate

The plate provides rigid fixation and resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

Landmarks for the approach, and vital structures to avoid, vary with the affected bone.

### EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, self-centering plate-holding forceps, high-speed drill, plating equipment, bone curette for harvesting cancellous bone autograft

### PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. If cancellous bone graft harvest is anticipated, prep a donor site as well. Positioning depends on the affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Approach:** The required approach varies with the affected bone.

**Reduction:** Reduce the fracture by lifting the bone ends from the incision and bringing them into contact. With the bone ends in contact, slowly push the bone segments back into the normal position. Alternatively, use a lever to reduce the fracture. With transverse fractures, manual maintenance of reduction is necessary. Alternatively, after the plate is contoured, secure the fracture in reduction with self-centering plate-holding forceps applied to the plate and the bone (Plate 40A).

**Stabilization:** Contour the plate to match the bone surface. Prestress the plate by bending it an additional amount to cause the plate to stand away from the fracture surface by about 2 mm (see Plate 40A). Make sure the plate is long enough to allow at least 6 cortices secured by screws on both sides of the fracture. Compress the fracture line, using the loaded drill guide to insert one or two screws (Plate 40B). Place the remaining screws in a neutral position (Plate 40C). Short, oblique fractures may additionally be compressed with a lag screw positioned through the plate or outside of the plate (Plate 40D).[2,3] If indicated, harvest a cancellous bone autograft and place it at the fracture site. Close the incision routinely.

### CAUTIONS

Reduction should be maintained during implant application. It is important to make sure that the plate is centered on the bone. Irrigatation during drilling is needed to reduce bone necrosis. It is necessary to drill, measure, tap, and insert each screw before moving on to prepare the next screw hole. All screws should be tightened after each screw is placed and at the end of the procedure.

### POSTOPERATIVE EVALUATION

Radiographs are necessary to evaluate for fracture reduction and implant placement.

### POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals to monitor healing. Activity should be increased when bone bridging is observed.

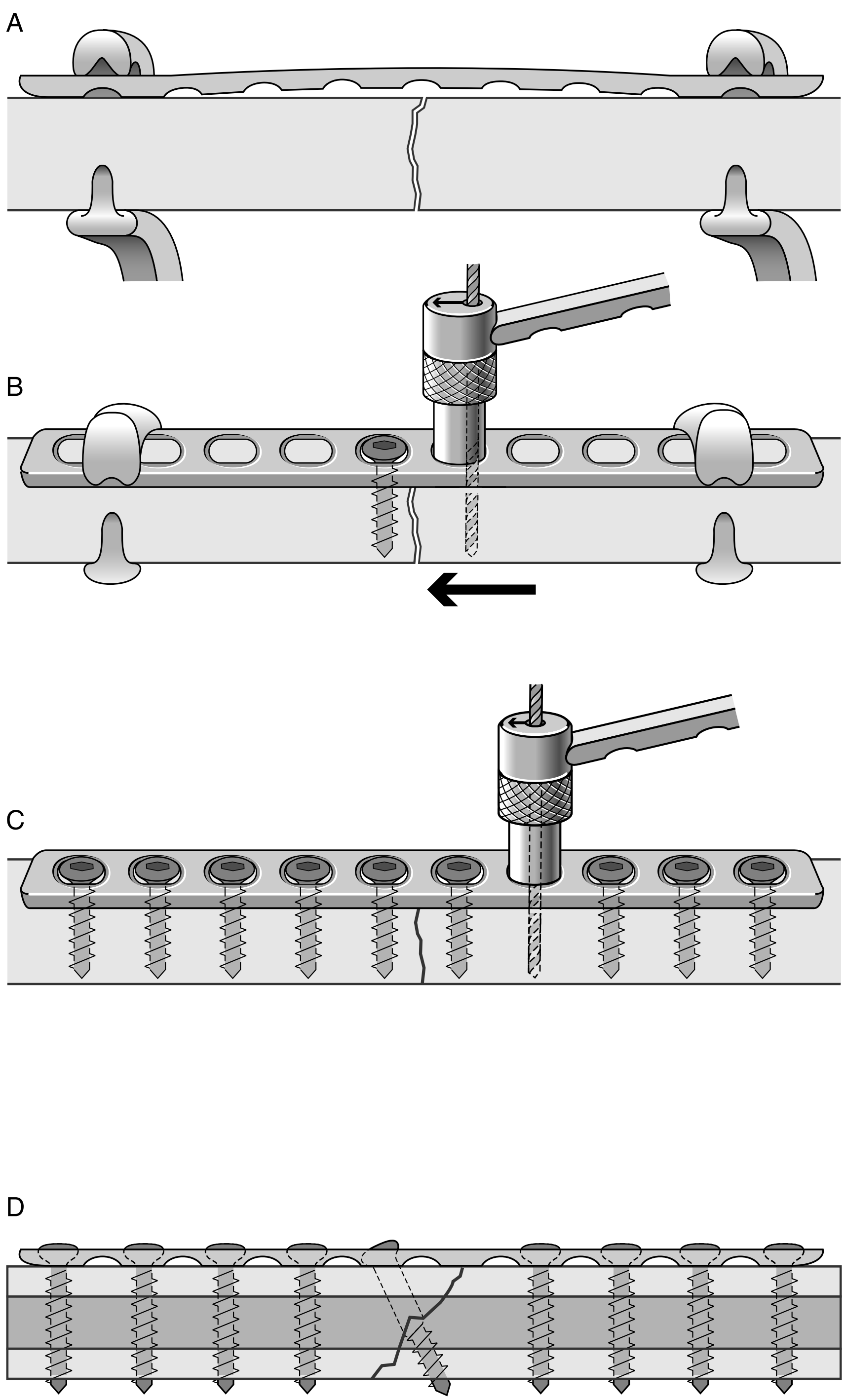
### EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. A good return to function can be expected. Implant removal may be necessary if soft tissues are irritated.

#### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management: Decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Schatzker J, Muestage F, Prieur WD: Implants and their application. In Brinker WO, Olmstead ML, Sumner-Smith G, et al (eds): Manual of Internal Fixation in Small Animals. New York, Springer-Verlag, 1998.
3. Wittner G, Holz U: Plates. In Ruedi TP, Murphy WM (eds): AO Principles of Fracture Management. New York, AO Publishing and Thieme, 2000.

# PLATE 40



## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 41 Stabilizing a Transverse or Short Oblique Diaphyseal Fracture with an Intramedullary Pin and External Fixator

## INDICATIONS
The procedure is indicated for transverse or short oblique diaphyseal fractures in animals with anticipated short healing times (6 to 12 weeks). It is indicated in smaller dogs and cats that are young, that are healthy, and that have single limb injuries.[1] Owners must be willing and able to assume fixator management.

## OBJECTIVES
- To anatomically reduce the fracture line and stabilize the bone

The intramedullary (IM) pin resists bending forces at the fracture, whereas the external fixator resists axial loading and rotational forces at the fracture. IM pins are not indicated in the radius.

## ANATOMIC CONSIDERATIONS
Landmarks for the approach, and the vital structures to avoid, vary with the affected bone.

## EQUIPMENT
- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, Jacob pin chuck, low-speed power drill, IM pins, external fixation equipment, pin cutter, bone curette for harvesting cancellous bone autograft

## PREPARATION AND POSITIONING
Prepare the affected limb circumferentially from midline to foot. If cancellous bone graft harvest is anticipated, prep a donor site as well. Positioning depends on the affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

## PROCEDURE
**Approach:** The approach varies with the affected bone. Incise the skin, and create soft tissue tunnels for fixation pin placement.

**Reduction:** Place an IM pin (of a size selected to equal 50% of the medullary canal at the isthmus) in the proximal segment using a retrograde (humerus or femur) (Plate 41A1) or antegrade (tibia, humerus, or femur) (Plate 41A2) technique.[2] Retract the pin within the medullary canal of the proximal segment. Reduce the fracture by lifting the bone ends from the incision and bringing them into contact. With the bone ends in contact, slowly push the bone segments back into the normal position. Alternatively, use a lever to reduce the fracture. Drive the IM pin distally to maintain reduction (Plate 41A3).

**Stabilization:** Seat the IM pin in the distal segment of the bone. Establish rotational alignment, and place external fixation pins through the proximal and distal metaphyses of the bone. Predrill the bone before placing the threaded fixation pins. Secure the connecting bar to the pins (Plate 41B). If additional stability is needed, add a fixation pin, placed close to the fracture, to both bone segments (Plate 41C). Cut the IM pin below the level of the skin (see Plate 41B), or leave it long and tie it into the fixator (see Plate 41C).[3] Tighten all of the fixation clamps. If indicated, harvest a cancellous bone autograft and place it at the fracture. The incision closure is routine.

## CAUTIONS
It is important to pay attention to the direction of the IM pin and external fixation pins in the soft tissues to avoid nerves and vessels. It is also necessary to ensure that the IM pin does not interfere with a joint surface.

## POSTOPERATIVE EVALUATION
Radiographs should be evaluated for fracture reduction and implant placement.

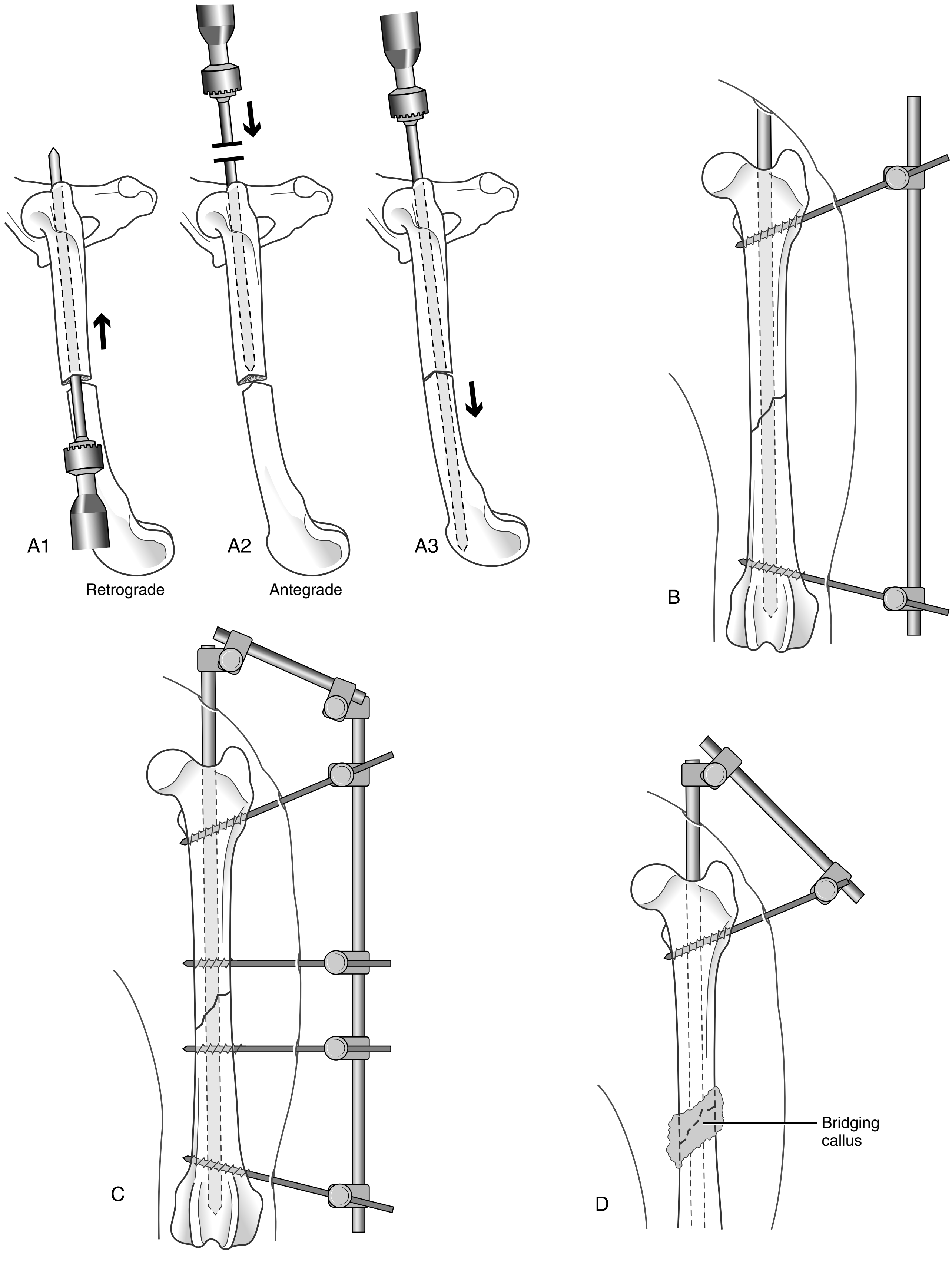
## POSTOPERATIVE CARE
Gauze sponges should be packed around the pins, and the sponges should be secured with a bandage to limit postoperative swelling and to protect the pin tracts. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Radiographs should be repeated at 6-week intervals to monitor healing. The external fixator should be removed when bone bridging is observed. If the tie-in is used, the proximal fixation pin should be left secured to the IM pin (Plate 41D). The IM pin (and proximal fixation pin) should be removed after the fracture has healed.

## EXPECTED OUTCOME
Bone healing is usually seen in 6 to 12 weeks. Animals usually experience a good return to function.

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Johnson AL, Hulse DA: Management of specific fractures, femoral diaphyseal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Aron DN, Dewey C: Experimental and clinical experience with an IM pin external skeletal fixator tie-in configuration. Vet Comp Orthop Traumatol 4:86, 1991.

# PLATE 41



GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 42 Stabilizing a Transverse or Short Oblique Diaphyseal Fracture with a Type Ib External Fixator

## INDICATIONS

The procedure is indicated for transverse or short oblique radial and tibial diaphyseal fractures in animals with anticipated short or moderate healing times (6 to 18 weeks).[1] A modified type Ib external fixator may also be used for humeral fractures. Smooth fixation pins or a combination of threaded and smooth fixation pins can be used for smaller dogs and cats that are young, that are healthy, and that have single limb injuries and an anticipated rapid healing time (6 weeks).[1] Threaded pins should be used in large, active, older dogs and in dogs with multiple limb injuries where postoperative load is increased and anticipated healing times are longer.[1] Owners must be willing and able to assume fixator management.

## OBJECTIVES

- To anatomically reduce the fracture line and stabilize the bone

The external fixator resists bending, axial loading, and rotational forces at the fracture.

## ANATOMIC CONSIDERATIONS

Landmarks for the approach, and the vital structures to avoid, vary with the affected bone.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, Jacob pin chuck, low-speed power drill, external fixation equipment, pin cutter, bone curette for harvesting cancellous bone autograft

## PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. For both the radius and the tibia, position the animal in dorsal recumbency and suspend the affected limb from the ceiling. Drape the limb out in the suspended position. If cancellous bone graft harvest is anticipated, prep a donor site (usually, the ipsilateral proximal humerus) as well.

## PROCEDURE

**Approach:** Perform a limited open reduction to align the bone segments. Pin location and limited open approaches vary with the affected bone. Incise the skin, and create soft tissue tunnels for fixation pin placement.

**Reduction:** For the radius and tibia, lower the table to suspend the animal from the ceiling.[2] Allow the animal's weight to fatigue the muscles. Use a lever to reduce the fracture (Plate 42A).

**Stabilization:** Establish rotational alignment, and place external fixation pins in a cranial-medial to caudal-lateral direction through the proximal and distal metaphyses of the bone. Predrill the bone before placing threaded fixation pins. Secure the connecting bar to the pins. Add fixation pins, placed 1 cm from the fracture, to both bone segments (Plate 42B). Place additional pins to fill out the frame (Plate 42C). Repeat the steps to place a similar frame in a cranial-lateral plane at 90 degrees to the first frame (see Plate 42C). Connect the frames with articulations proximally and distally (Plate 42D).[3] Tighten all of the fixation clamps. If indicated, harvest a cancellous bone autograft and place it at the fracture. The incision closure is routine.

## CAUTIONS

It is important to pay attention to the direction of the fixation pins in the soft tissues to avoid nerves and vessels. It is also necessary to avoid the joint surfaces when placing the fixation pins. Articulations must not interfere with elbow flexion.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

Gauze sponges should be packed around the pins, and the sponges should be secured with a bandage that incorporates the paw to limit postoperative swelling. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Radiographs should be repeated at 6-week intervals to monitor healing. The fixator should be destabilized by removing the cranial frame (converting to a type Ia cranial medial frame) when early bone bridging is observed. The rest of the external fixator should be removed when the fracture is healed.

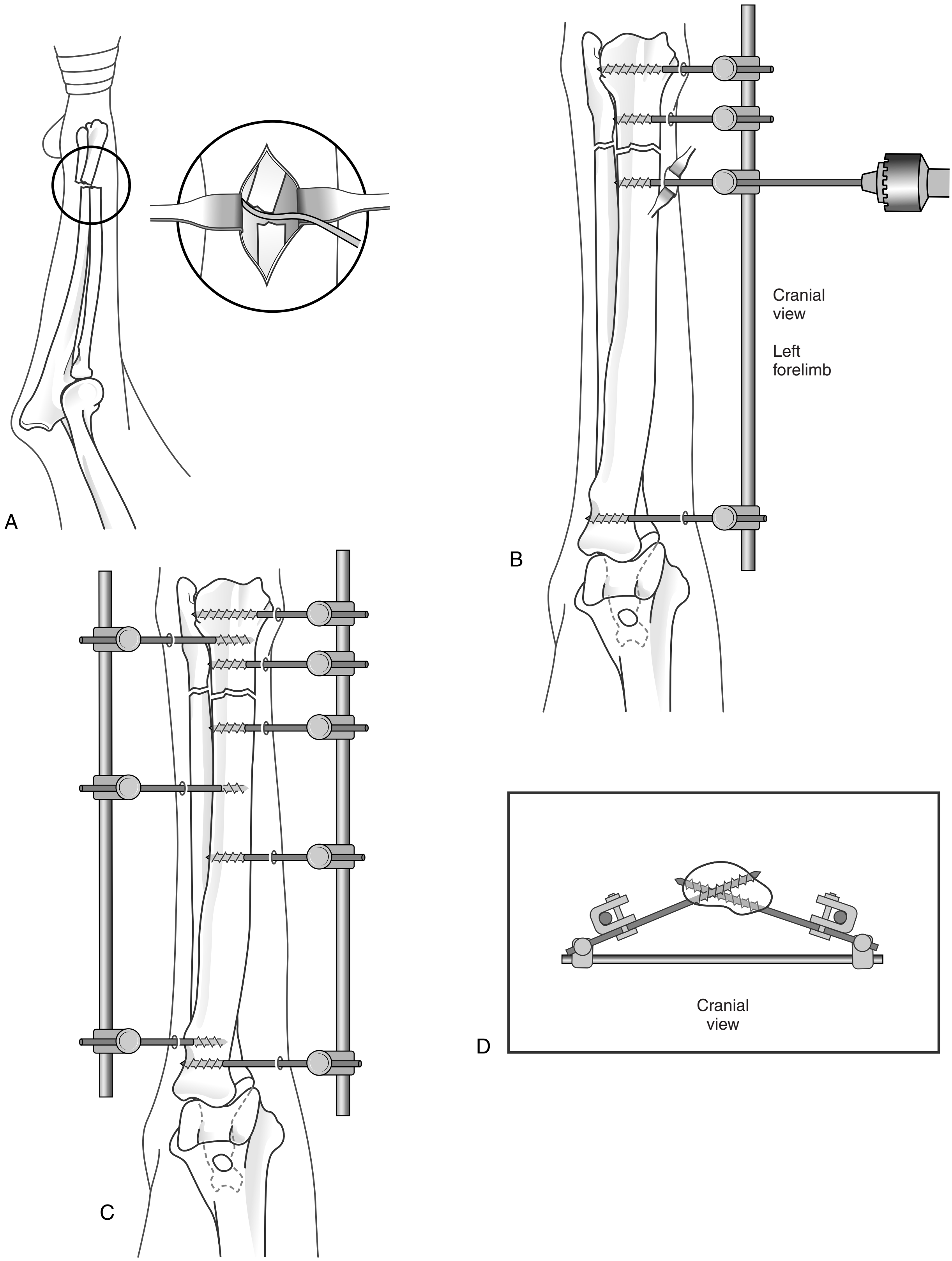
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. The animal will have limited function while the external fixator is in place, but a good return to function is expected.

### References


1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
3. Lauer SK, Aron DN, Evans MD: Finite element method evaluation: Articulations and diagonals in an 8-pin type 1b external skeletal fixator. Vet Surg 29:28, 2000.

# PLATE 42



GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# Chapter 43 Stabilizing a Long Oblique Diaphyseal Fracture with Lag Screws and a Neutralization Plate

## INDICATIONS

The procedure is indicated for long oblique diaphyseal fractures in animals requiring fixation with implants that will securely hold bone for a longer period (e.g., 12 weeks or longer). It is also indicated in large, active, older dogs; in dogs with multiple limb injuries; and in animals for which postoperative comfort is imperative.[1]

## OBJECTIVES

- To anatomically reduce and compress the fracture line with lag screws

Application of a bone plate neutralizes the load on the fracture. The plate and screw combination provides rigid fixation and resists axial loading, bending, and rotational forces at the fracture.

## ANATOMIC CONSIDERATIONS

Landmarks for the approach, and the vital structures to avoid, vary with the affected bone.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, pointed reduction forceps, self-centering plate-holding forceps, high-speed drill, plating equipment, bone curette for harvesting cancellous bone autograft

## PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. If cancellous bone graft harvest is anticipated, prep a donor site as well. Positioning depends on the affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

## PROCEDURE

**Approach:** The approach varies, depending on the affected bone.

**Reduction:** Reduce the fracture by distracting the bone segments, and approximate the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain reduction with the pointed reduction forceps (Plate 43A).

**Stabilization:** When the fracture line is perpendicular to the plate surface of the bone, place two or three lag screws across the fracture line. Drill the near cortex with a drill bit equal to the diameter of the screw threads (Plate 43B1). Place a drill insert sleeve, and drill the far cortex with the appropriate drill bit for the screw (Plate 43B2). Slightly countersink the near cortex (Plate 43B3), measure (Plate 43B4), tap (Plate 43B5), and place the screw (Plate 43B6).[2] Contour a plate to match the bone surface. The plate should be long enough to span the bone and allow a minimum of six cortices secured by screws on both sides of the fracture (Plate 43C). Secure the plate with screws placed in a neutral position.[2] Alternatively, when the fracture line is parallel to the plate surface of the bone, secure the reduced segments with cerclage wire. Place the plate and insert the screws which are crossing the fracture as lag screws (Plate 43D). Remove the cerclage wire before tightening the screws. If indicated, harvest a cancellous bone autograft and place it at the fracture. The incision closure is routine.

## CAUTIONS

Reduction should be maintained with reduction forceps during lag screw application. It is important to ensure that the plate is centered on the bone so the plate holes at the ends of the plate are over bone. Irrigation during drilling is needed to reduce bone necrosis. It is necessary to drill, measure, tap, and insert each screw before moving on to prepare the next screw hole. All screws should be tightened after each screw is placed and again at the end of the procedure.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for fracture reduction and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals to monitor healing. Activity should be increased when bone bridging is observed.

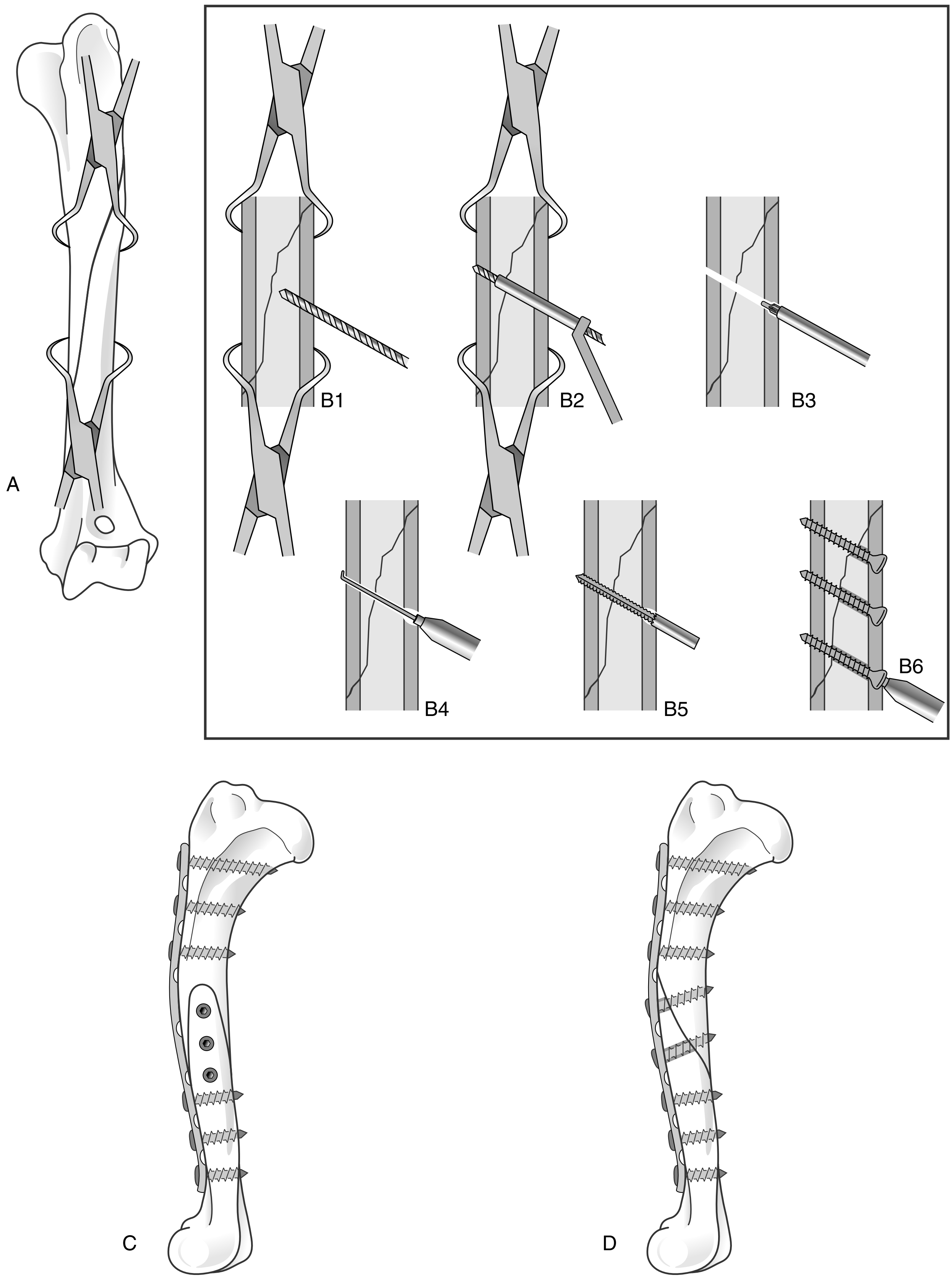
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. Animals usually experience a good return to function. Implant removal may be necessary if soft tissues are irritated.

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Schatzker J, Muestage F, Prieur WD: Implants and their application. In Brinker WO, Olmstead ML, Sumner-Smith G, et al (eds): Manual of Internal Fixation in Small Animals. New York, Springer-Verlag, 1998.

# PLATE 43



## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 44 Stabilizing a Long Oblique Diaphyseal Fracture with an Intramedullary Pin and Multiple Cerclage Wires

### INDICATIONS

The procedure is indicated for long oblique diaphyseal fractures in animals with anticipated short healing times (6 to 12 weeks). It is also indicated in smaller dogs and cats that are young, that are healthy, and that have single limb injuries.[1] It is especially useful for immature dogs and cats. Intramedullary (IM) pins are not indicated in the radius.

### OBJECTIVES

- To anatomically reduce the fracture line and stabilize the bone

The IM pin resists bending forces at the fracture, whereas the cerclage wire compresses the fracture to resist axial loading and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

Landmarks for the approach, and the vital structures to avoid, vary with the affected bone.

### EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, pointed reduction forceps, Jacob pin chuck, IM pins, orthopedic wire (spool or eye cerclage), wire passer, wire tightener (pliers, needle-holder, or loop cerclage wire tightener), wire cutter, pin cutter, bone curette for harvesting cancellous bone autograft

### PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. If cancellous bone graft harvest is anticipated, prep a donor site as well. Positioning depends on affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Approach:** The approach varies, depending on the affected bone.

**Reduction:** Place an IM pin (sized to equal 60% to 70% of the medullary canal at the isthmus) in the proximal segment using an antegrade (tibia, humerus, or femur) or retrograde (humerus or femur) technique.[2] Retract the pin within the medullary canal of the proximal segment. Reduce the fracture by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain reduction with the pointed reduction forceps (Plate 44A).

**Stabilization:** Seat the IM pin in the distal segment of the bone (see Plate 44A). Plan to place two or three (or more, depending on the length of the fracture) cerclage wires around the reduced fracture at intervals of 0.5 cm to 1 cm. Pass a wire passer around the bone. Feed the plain end of the wire through the wire passer, and pull the wire around the bone (Plate 44B). For loop cerclage, tighten the wire by passing the plain end of the wire through the eye of the wire (Plate 44C1). Insert the wire into the wire tightener, and crank the wire tight (Plate 44C2). Bend the wire over the eye. Retract the wire tightener, and finish bending the wire (Plate 44C3). Cut the wire (Plate 44C4).[3] For plain orthopedic wire, begin twisting the wire ends by hand (Plate 44D1). Place the wire twisting pliers or needle-holders onto the twist, and tighten the wire by pulling and twisting (Plate 44D2). When the wire is tight, cut the wire 3 mm from the start of the twist (Plate 44D3). Alternatively, cut the wire 5 mm to 7 mm from the twist, and bend it over in the direction of the twist (Plate 44D4).[3] Cut the IM pin below the level of the skin (Plate 44E). If indicated, harvest a cancellous bone autograft and place it at the fracture. The incision closure is routine.

### CAUTIONS

All wires must be tight. It is important to pay attention to the direction of the IM pin in the soft tissues to avoid nerves and vessels. The IM pin must not interfere with a joint surface.

### POSTOPERATIVE EVALUATION

Radiographs should be taken to evaluate for fracture reduction and implant placement.

### POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals to monitor healing. The IM pin should be removed after the fracture has healed.

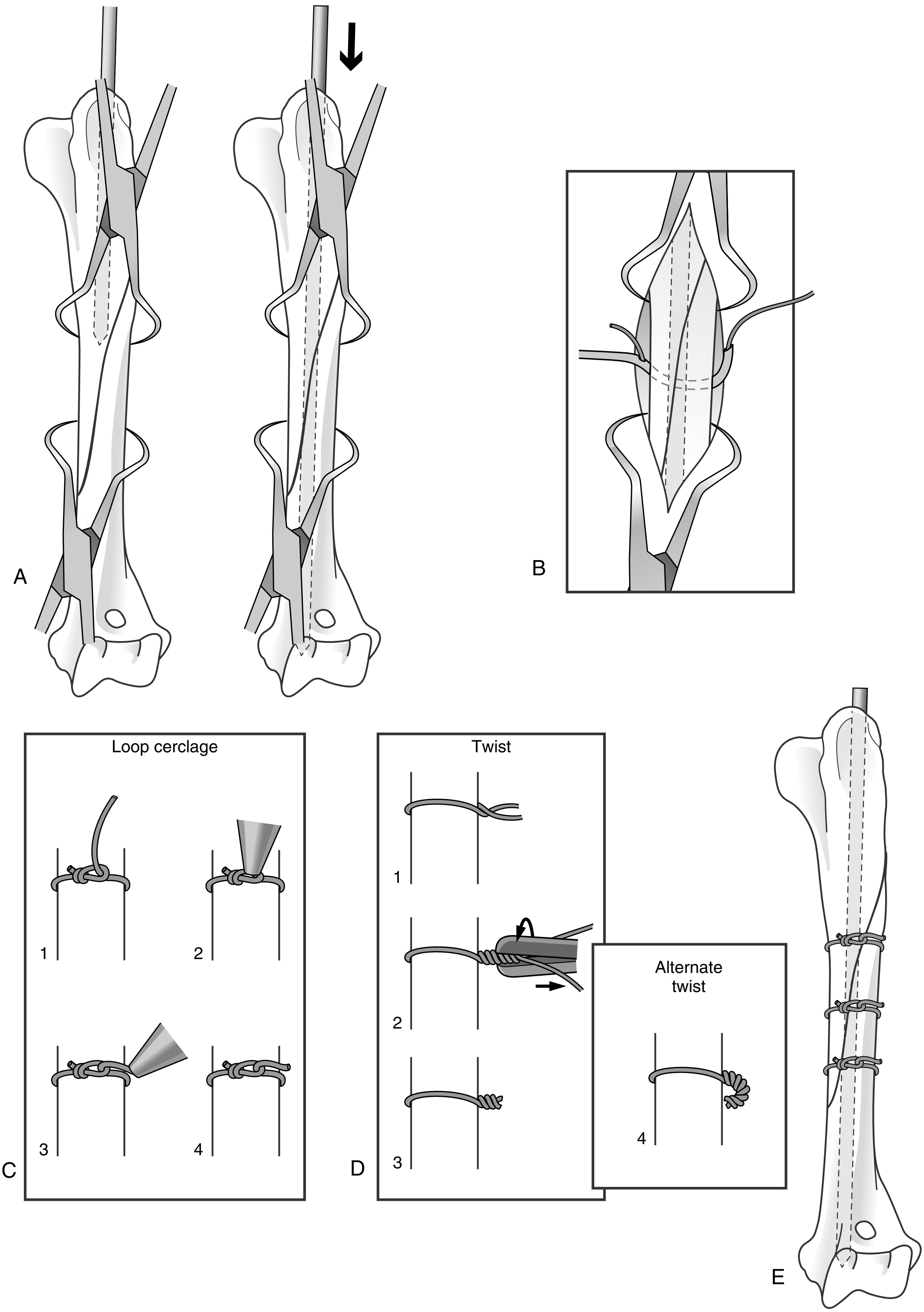
### EXPECTED OUTCOME

Bone healing is usually seen in 6 to 12 weeks. Animals usually experience a good return to function.

#### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Johnson AL, Hulse DA: Management of specific fractures, femoral diaphyseal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Schatzker J, Muestage F, Prieur WD: Implants and their application. In Brinker WO, Olmstead ML, Sumner-Smith G, et al (eds): Manual of Internal Fixation in Small Animals. New York, Springer-Verlag, 1998.

# PLATE 44



## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 45 Stabilizing a Comminuted Diaphyseal Fracture with an Intramedullary Pin and a Bridging Plate

### INDICATIONS

The procedure is indicated for comminuted nonreducible (more than one or two large fragments) humeral, femoral, and tibial diaphyseal fractures in large, active, older dogs; and in dogs with multiple limb injuries in which postoperative load is increased and anticipated healing times are longer.[1] A plate and intramedullary (IM) pin can be used to stabilize comminuted radial fractures, with the plate stabilizing the radius and the pin supporting the ulna.

### OBJECTIVES

- To restore normal bone length and alignment

The IM pin restores axial alignment and protects the plate from bending forces at the fracture, whereas the plate resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

Landmarks for the approach, and the vital structures to avoid, vary with the affected bone.

### EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, self-centering plate-holding forceps, Jacob pin chuck, IM pins, plating equipment, high-speed drill, bone curette for harvesting cancellous bone autograft

### PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. If cancellous bone graft harvest is anticipated, prep a donor site as well. Positioning depends on the affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Approach:** The approach varies, depending on the affected bone. Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments.[2]

**Reduction and Stabilization:** Place an IM pin (sized to equal 40% to 50% of the medullary canal width at the isthmus) in the proximal segment using an antegrade (tibia, humerus, or femur) or retrograde (humerus or femur) technique. Drive the pin to the fracture site, and blunt the pin tip. Lift and align the distal segment, and insert the IM pin. Distract the bone to length by advancing the pin while holding the proximal segment with bone-holding forceps (Plate 45A). Contour a plate so that the bend matches a radiographic image of the contralateral intact bone (Plate 45B). Torque the plate to match the proximal and distal ends of the fractured bone. Restore rotational alignment, and secure the plate to the appropriate bone surface with self-centering plate-holding forceps (Plate 45C). The plate should span the length of the bone, and the screws should secure a minimum of six cortices on either side of the fracture. Place bicortical screws in the metaphyses and unicortical screws in the diaphysis where the IM pin interferes with screw placement. Cut the pin below the skin.[3,4] Harvest cancellous bone graft and place it at the fracture site (Plate 45D).

### CAUTIONS

The plate should be centered on the bone so that the plate holes at the ends of the plate are over bone. Irrigation is needed during drilling to reduce bone necrosis. All screws should be tightened after each screw is placed and at the end of the procedure. The IM pin must not interfere with nerves, vessels, or any joint surface.

### POSTOPERATIVE EVALUATION

Radiographs should be taken to evaluate for fracture reduction and implant placement.

### POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals to monitor healing. Activity should be increased when bone bridging is observed. The IM pin should be removed when early fracture bridging is evident.

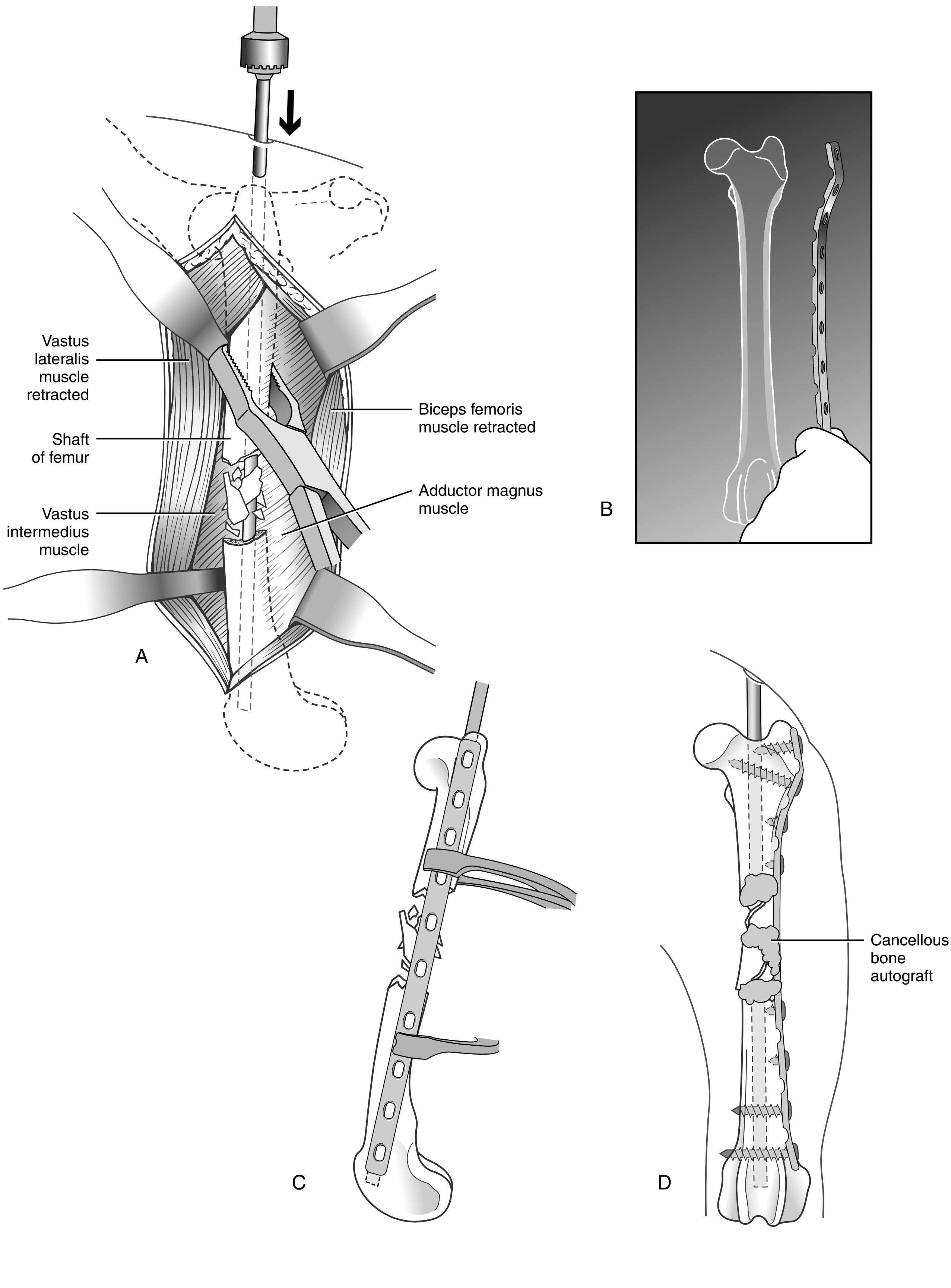
### EXPECTED OUTCOME

The IM pin may cause morbidity and lameness. Bone healing is usually seen in 12 to 18 weeks. Animals usually experience a good return to function. Plate removal may be necessary if soft tissues are irritated.

#### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
3. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, bone plates and screws. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
4. Johnson AL, Smith CW, Schaeffer DJ: Fragment reconstruction and bone plate fixation compared with bridging plate fixation for treating highly comminuted femoral fractures in dogs: 35 cases (1987–1997). J Am Vet Med Assoc 213:1157, 1998.

# PLATE 45


Vastus lateralis muscle retracted
Shaft of femur
Vastus intermedius muscle
Biceps femoris muscle retracted
Adductor magnus muscle
A
B
C
D
Cancellous bone autograft

## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 46 Stabilizing a Comminuted Diaphyseal Fracture with a Type II External Fixator

### INDICATIONS

The procedure is indicated for animals with comminuted nonreducible (more than one or two large fragments) radial and tibial diaphyseal fractures. Smooth fixation pins, or a combination of threaded fixation plus and smooth fixation pins, can be used for animals with rapid healing times (i.e., 6 to 12 weeks). Threaded pins should be used in large, active, older dogs and in dogs with multiple limb injuries in which postoperative load is increased and anticipated healing times are longer.[1]

### OBJECTIVES

- To restore normal bone length and alignment

A type II external fixator is applied to bridge the fracture. The fixator resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

Landmarks for the pin placement, and the vital structures to avoid, vary with the affected bone.

### EQUIPMENT

- Surgical pack, Senn retractors, small Hohmann retractors, low-speed power drill, Jacob pin chuck, external fixator equipment

### PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. For both the radius and the tibia, position the animal in dorsal recumbency, and suspend the affected limb from the ceiling. Drape the limb out in the hanging position.

### PROCEDURE

**Approach:** Perform a closed reduction to preserve the integrity of the fracture hematoma and the surrounding soft tissues.[2] If necessary, use a limited open reduction to line up major bone segments.[3] Pin location and limited open approaches vary depending on the affected bone. Incise the skin and create soft tissue tunnels for pin placement.

**Reduction:** Lower the table to allow the animal's weight to align the fractured bone (Plate 46A).

**Stabilization:** Place a centrally threaded fixation pin through the distal metaphyses. Make sure the pin parallels the distal joint surface and is in the medial to lateral plane. Predrill the hole with a drill bit 0.1 mm smaller than the selected pin.[4] Insert the pin with a hand chuck or low RPM power. Repeat the procedure for the proximal metaphysis (Plate 46B). Align the segments, checking for angular and rotational alignment, and secure the pins to medial and lateral connecting bars. Fill out the frame with either transfixation pins or unilateral fixation pins, depending on the anatomy of the bone and surrounding soft tissues (Plate 46C). Use a guiding device or additional connecting bar and guide clamp to ensure accurate placement of transfixation pins (see Plate 46C).[5,6] Be sure that there are at least two pins, or preferably three pins, above and below the fracture (Plate 46D). Tighten all of the clamps.

### CAUTIONS

It is important to avoid the joint surfaces and the fracture lines with the fixation pins. Intraoperative radiographs are helpful in evaluating bone alignment and pin location.

### POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant location. If the fractured bone is reduced in a varus or valgus position (i.e., the proximal and distal joint surfaces are not parallel), then the distal clamps should be loosened and the distal segment should be repositioned to eliminate the angular deformity. If rotational malalignment is present, some correction may be obtained by repositioning the distal clamps onto the opposite side of the bar.

### POSTOPERATIVE CARE

Gauze sponges should be packed around the pins, and the sponges should be secured with a bandage that incorporates the paw, to limit postoperative swelling. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Radiographs should be repeated at 6-week intervals to monitor healing. The fixator should be destabilized by removing selected fixation pins (or the lateral connecting bar) when early bone bridging is observed. If the lateral bar is removed, the associated transfixation pins should be left long enough to exit the skin on the lateral surface of the limb. The pins should be covered to prevent injury to the owner. The external fixator should be removed when the fracture is healed.

### EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. The animal may experience limited function while the external fixator is in place but will eventually have a good return to function.

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
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5. Johnson AL, Seitz SE, Smith CW, et al: Closed reduction and type II external fixation of severely comminuted fractures of the radius and tibia in dogs: 23 cases (1990–1994). J Am Vet Med Assoc 209:1445, 1996.
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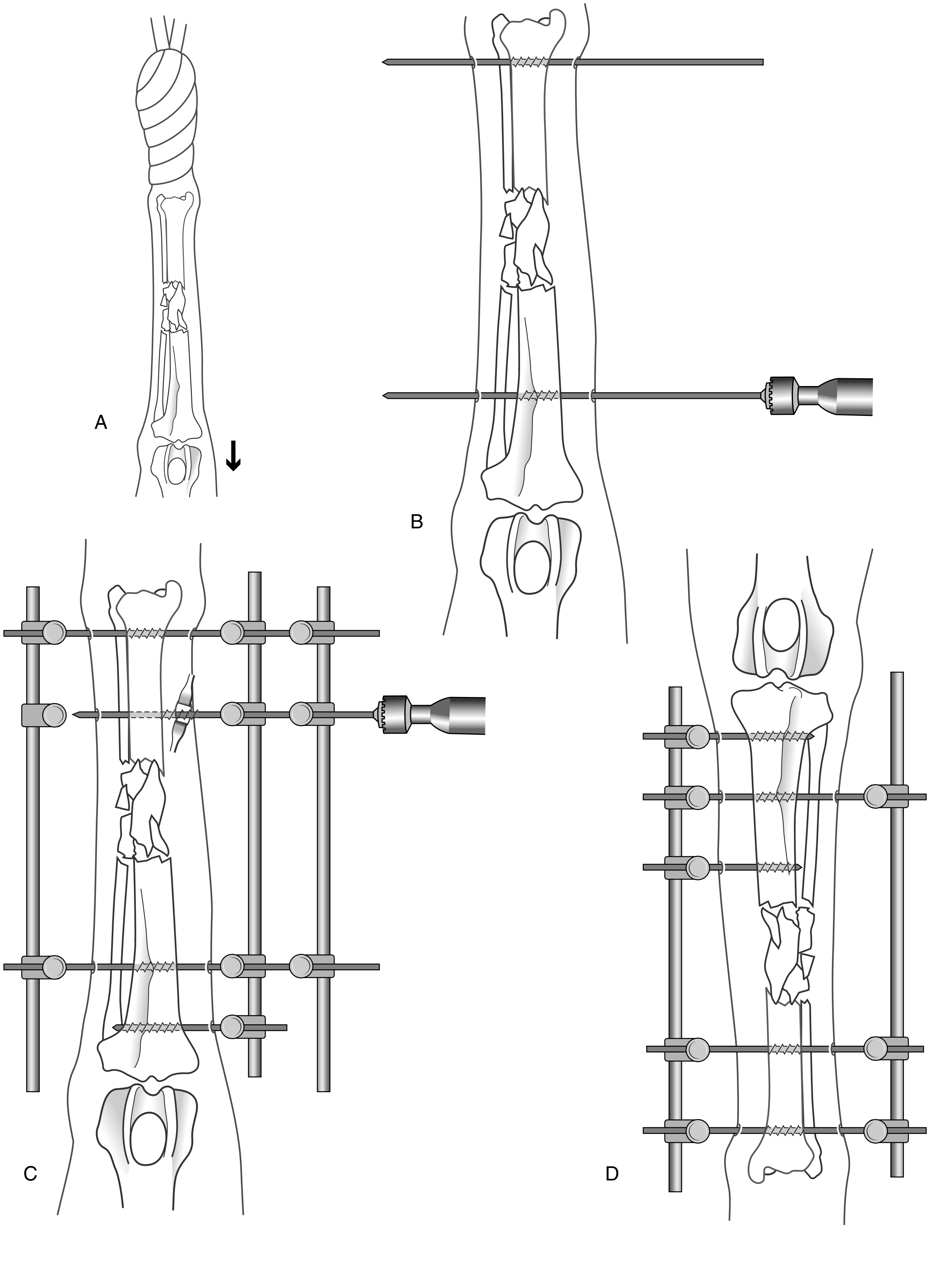
# PLATE 46



## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 47 Stabilizing a Comminuted Diaphyseal Fracture with an Interlocking Nail

### INDICATIONS

The procedure is indicated in comminuted nonreducible (more than one or two large fragments) humeral, femoral, and tibial diaphyseal fractures. It is indicated in dogs that have anticipated healing times that are short or intermediate, and when postoperative comfort is important.[1] Interlocking nails are contraindicated for the radius.

### OBJECTIVES

- To restore normal bone length and alignment

The interlocking nail restores axial alignment and resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

Landmarks for the approach, and the vital structures to avoid, vary with the affected bone. Pin insertion sites vary with the affected bone.

### EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, Kern bone-holding forceps, interlocking nail equipment, bone screws, high-speed drill, bone curette for harvesting cancellous bone autograft

### PREPARATION AND POSITIONING

Prepare the affected limb circumferentially from midline to foot. If a cancellous bone graft harvest is anticipated, prep a donor site as well. Positioning depends on the affected bone. Drape the limb out from a hanging position to allow maximal manipulation during surgery.

### PROCEDURE

**Approach:** The approach varies, depending on the affected bone. Use an “open but do not disturb the fragments” technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments.[2]

**Reduction and Stabilization:** Establish the insertion hole in the proximal bone segment, using a reamer of the appropriate size to prepare for the nail. The nail diameter and length are estimated from preoperative radiographs of the contralateral bone (Plate 47A). Attach the nail to the extension piece and nail driver, and insert it into the proximal bone segment so that it exits at the fracture surface. Align the distal segment, and drive the nail distally within the medullary canal. Stabilize the proximal bone segment with a bone-holding forceps, and continue to drive the nail distally to distract the distal bone segment to length (Plate 47B). Ensure that the proximal portion of the nail is seated within the proximal segment. Remove the nail driver, and attach the jig. Drill, measure, and tap the distal screw hole, using the jig and associated guides to maintain screw alignment with the hole in the nail. Insert the screw (Plate 47C). Check rotational alignment, and insert the remaining screws. Remove the extension piece.[3] Harvest cancellous bone graft and place it at the fracture site (Plate 47D). Close the incision routinely.

### CAUTIONS

It is important to ensure that the nail does not penetrate the distal joint. The first screw should be placed in the distal hole of the nail to help secure nail and jig alignment. The rotational alignment must be correct before proximal screws are inserted. Irrigation must be done during drilling to reduce bone necrosis.

### POSTOPERATIVE EVALUATION

Radiographs should be taken to evaluate for fracture reduction and implant placement.

### POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals to monitor healing. Activity should be increased when bone bridging is observed.

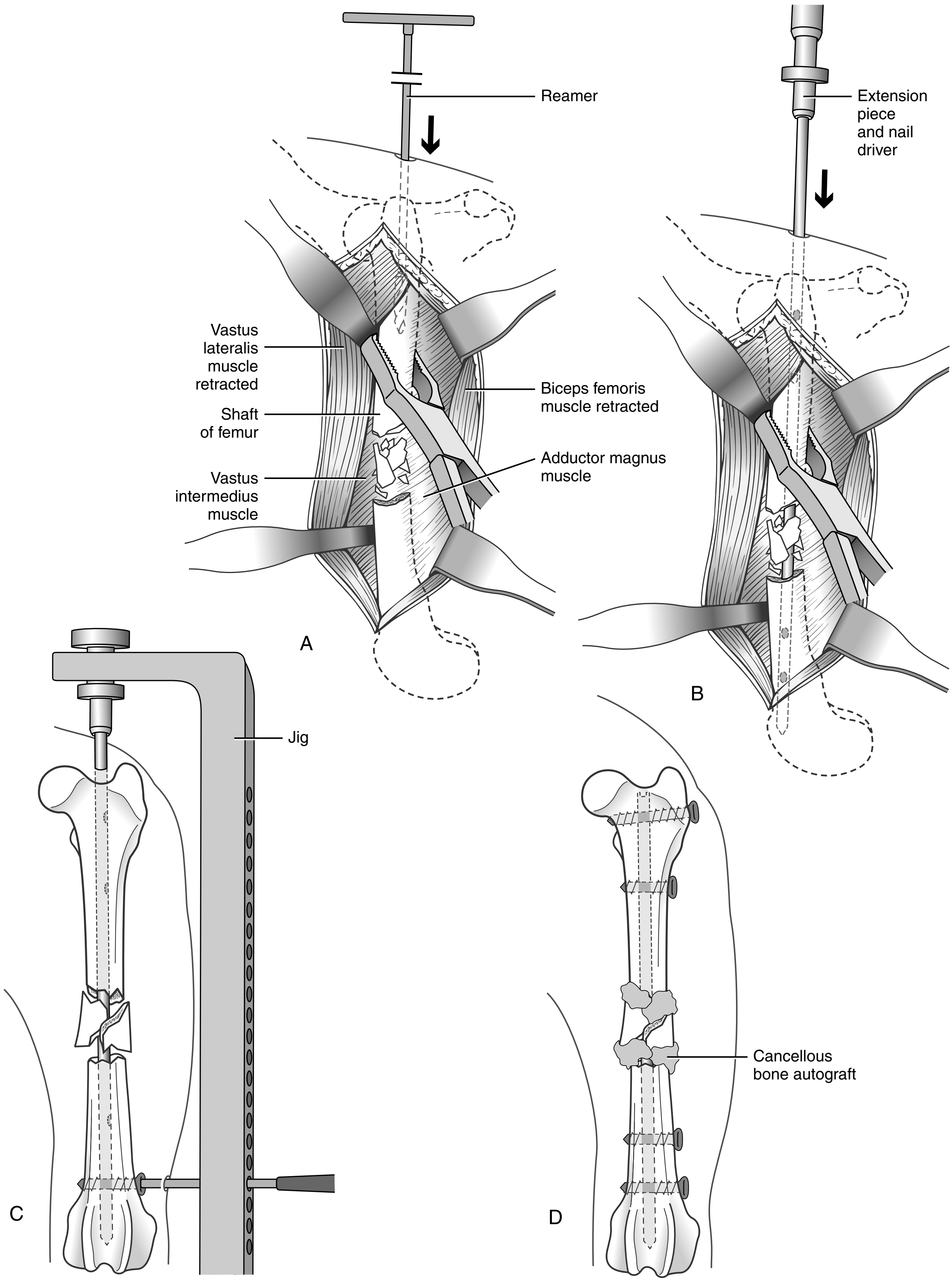
### EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. Animals should experience a good return to function. Removal of the interlocking nail may be necessary if soft tissues are irritated.

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
3. Dueland RT, Johnson KA, Roe SC, et al: Interlocking nail treatment of diaphyseal long-bone fractures in dogs. J Am Vet Med Assoc 214:59, 1999.

# PLATE 47


Reamer
Vastus lateralis muscle retracted
Shaft of femur
Vastus intermedius muscle
Biceps femoris muscle retracted
Adductor magnus muscle
A
Extension piece and nail driver
B
Jig
C
Cancellous bone autograft
D

## GENERAL PRINCIPLES FOR DIAPHYSEAL FRACTURES

# CHAPTER 48 Cancellous Bone Autograft

### INDICATIONS
Autogenous cancellous bone grafts are used to promote rapid bone formation. Candidates include animals with cortical defects after fracture repair and adult and elderly animals with fractures, delayed unions, nonunions, osteotomies, joint arthrodesis, or cystic defects. Autogenous cancellous bone also promotes bone formation in infected fractures.[1]

### OBJECTIVES
- To promote bone formation and bone cell survival by harvesting cancellous bone at the end of the procedure and transferring directly to the recipient site

### ANATOMIC CONSIDERATIONS
Optimal sites for cancellous bone harvest are the proximal humeral metaphysis, the wing of the ilium, and the proximal tibial metaphysis. All three sites have minimal soft tissue coverage and are easily accessible. The proximal humerus and iliac wing yield the largest amounts of cancellous bone.

### EQUIPMENT
- Surgical pack, Gelpi retractors, Senn retractors, Army-Navy retractors, drill bit or intramedullary pin, osteotome and mallet, rongeur, bone curette, stainless steel cup, syringe

### PREPARATION AND POSITIONING
Select, prepare, and drape the graft donor site so that it is easily accessible when the recipient site is draped.

### PROCEDURE
**Proximal Humerus:** Incise the skin and subcutaneous tissues over the craniolateral aspect of the proximal humerus. Retract the acromial head of the deltoid muscle caudally, and expose the flat aspect of the craniolateral metaphysis just distal to the greater tubercle. Make a round hole in the bone cortex using an intramedullary pin or drill bit. Insert a bone curette, and harvest cancellous bone (Plate 48A). Place the cancellous bone in a stainless steel cup. Use a syringe to collect blood from the donor site to add to the graft (Plate 48B). The blood will clot and form a moldable composite with the graft, facilitating handling. Flush and loosely pack the recipient site with graft material. Close subcutaneous tissues around the graft to hold it in position.

**Proximal Tibia:** Incise the skin and subcutaneous tissue over the medial surface of the proximal tibia. Harvest cancellous bone as previously described (Plate 48C). Closure is routine.

**Iliac Wing:** Incise the skin over the craniodorsal iliac spine. Incise subcutaneous tissues, and expose the dorsal surface of the iliac wing. Elevate the musculature from the lateral surface and medial surfaces of the craniodorsal portion of the iliac wing. Obtain a corticocancellous graft by using an osteotome to remove a cortical wedge from the iliac wing. Harvest cancellous bone from between the inner and outer cortical bone of the iliac body with a bone curette (Plate 48D). Macerate the wedge with rongeurs, and place it into the recipient site. Closure is routine.

### CAUTIONS
Avoid open physes in immature animals. Avoid penetrating the articular surface or other cortical surfaces with the curette. Create round holes in the long bone cortex to minimize stress concentration and possible fracture. If the recipient site is infected, or is the site of a tumor, harvest the graft first to avoid contamination of the donor site. Alternatively, use a separate surgical team and instrumentation to harvest the graft.

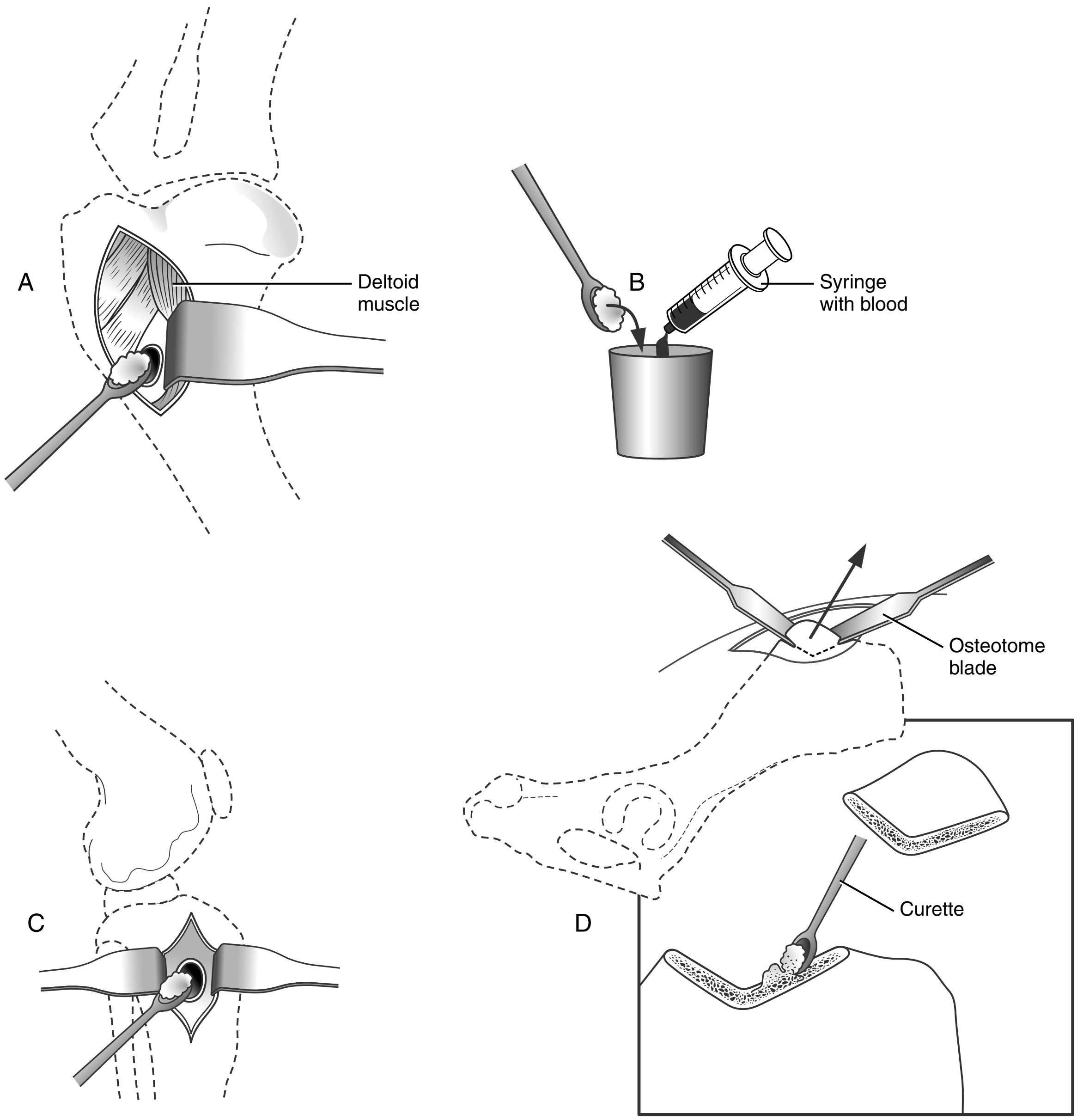
### POSTOPERATIVE EVALUATION
Wound healing at the donor site should be evaluated when the recipient site procedure is evaluated.

### POSTOPERATIVE CARE
Routine procedures for caring for a surgical wound should be followed.

### EXPECTED OUTCOME
Bone formation should be seen at the recipient site by 12 weeks after surgery. Complications at the donor site include seroma formation; infection; and, rarely, fracture. Complications at the recipient site (e.g., failure of grafts to stimulate bone formation) are difficult to recognize.

### Reference
1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, bone grafts. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 48


A
Deltoid muscle
B
Syringe with blood
C
D
Osteotome blade
Curette

# MANDIBLE

# Chapter 49 Mandibular Symphyseal Fractures

## INDICATIONS

Candidates include animals with mandibular symphyseal fractures.

## OBJECTIVES

- To reduce and stabilize the symphyseal fracture and restore dental alignment and occlusion

## ANATOMIC CONSIDERATIONS

Realignment of dental occlusion is important for return to function.

## EQUIPMENT

- Scalpel blade, 18- to 20-gauge (for dogs) or 20- to 22-gauge (for cats) orthopedic wire, hypodermic needles sized to accommodate the orthopedic wire, wire tightener, wire cutter

## PREPARATION AND POSITIONING

Prepare the ventral aspect of the mandible for aseptic surgery. Rinse the mouth with an antiseptic. Position the animal in dorsal recumbency. It is not necessary to drape the mandible for an isolated symphyseal fracture.

## PROCEDURE

**Approach:** Make a small incision in the skin overlying the ventral aspect of the symphysis.

**Reduction:** Reduce and hold the symphysis with digital pressure applied to the mandibular canine teeth (Plate 49A).

**Stabilization:** Insert the hypodermic needle through the skin incision and along one lateral mandibular surface (under the subcutaneous tissues). Exit the needle in the oral cavity caudal to the canine tooth, and thread an 18- or 20-gauge wire through the needle (Plate 49B). Remove the needle and reposition it on the opposite side of the mandible. Curve the wire across and behind the canine teeth, and reinsert it through the hypodermic needle to exit from the skin incision at the original insertion point (Plate 49C). Remove the needle. While holding the fracture in reduction, tighten the wire (Plate 49D). Leave the ends of the wire exposed through the skin incision, and bend them to decrease the possibility of injury to the owner (Plate 49E).[1]

## CAUTIONS

The incisor alignment should be observed when tightening the wire, and dental occlusion should be checked after the wire is tightened.

## POSTOPERATIVE EVALUATION

Radiographs should be taken to evaluate symphyseal reduction and implant placement.

## POSTOPERATIVE CARE

It is important to clean the wire daily where it is exposed ventrally. Hard food, chew toys, and tug of war games should be eliminated until the fracture has healed.

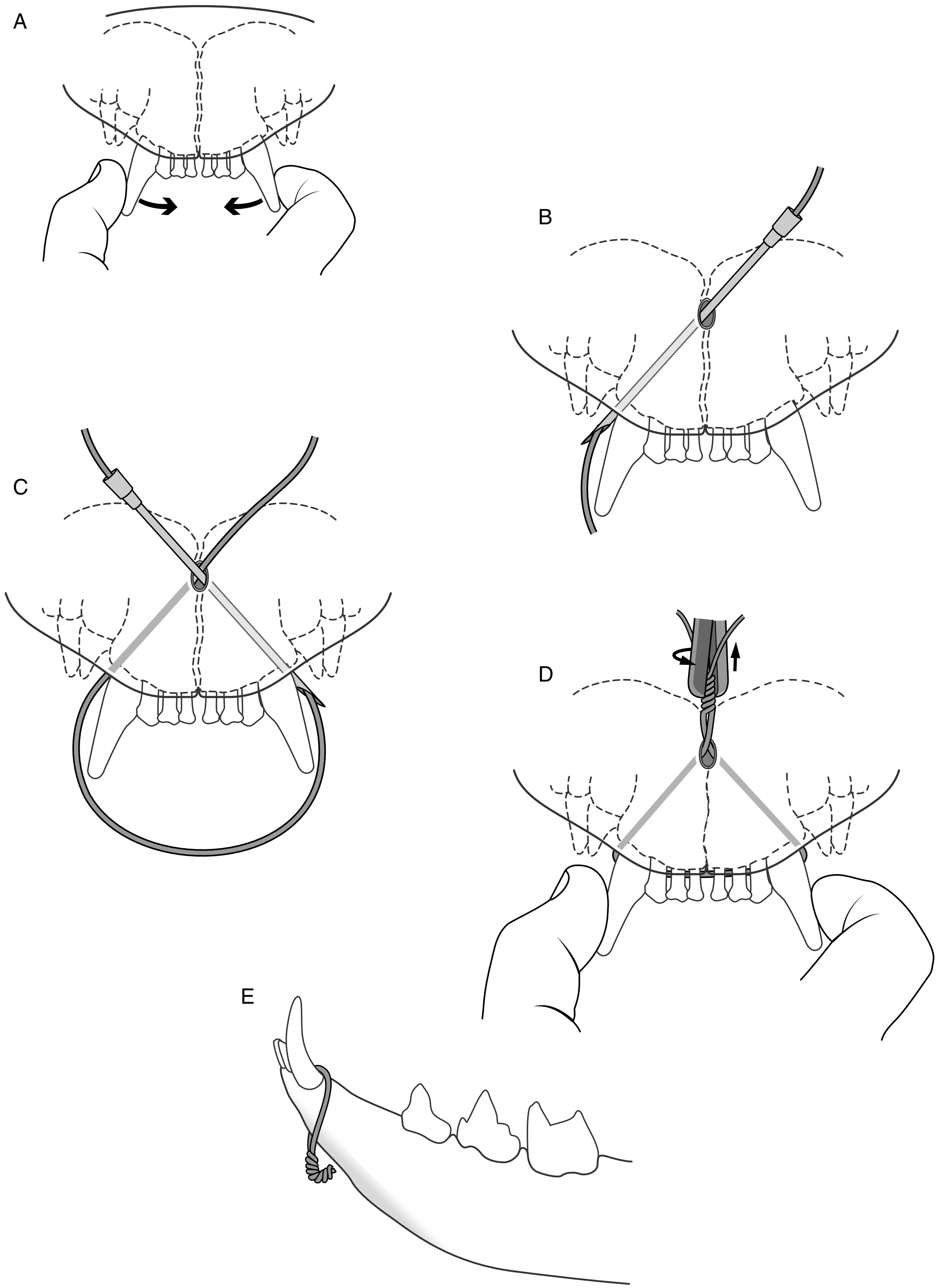
## EXPECTED OUTCOME

Symphyseal union is usually seen in 6 to 12 weeks. Radiographic evidence of bone bridging or callus formation is usually not evident. Once the fracture has stabilized, the wire can be removed by cutting it with wire scissors where it is exposed behind the canine teeth and extracting it by the twist.

### Reference

1. Johnson AL, Hulse DA: Management of specific fractures: Maxillary and mandibular fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 49



## MANDIBLE

# Chapter 50 Transverse and Oblique Mandibular Body Fractures

### INDICATIONS

Candidates include animals with single fracture lines of the mandibular body that can be anatomically reconstructed.

### OBJECTIVES

- To restore dental occlusion by anatomic reconstruction of the fracture

Stable internal fixation allows a rapid return to function and minimizes aftercare.

### ANATOMIC CONSIDERATIONS

The mandibular body is easily palpated and surgically approached through the skin and subcutaneous tissue. The mandibular alveolar nerve, which is sensory to the teeth of the mandible, passes through the mandibular canal along with the mandibular alveolar artery. These structures are often damaged during mandibular fractures, although clinical signs are seldom evident. Tooth roots must be avoided when placing implants.

### EQUIPMENT

- Surgical pack, Gelpi retractors, Senn retractors, small Hohmann retractors, periosteal elevator, baby Kern bone-holding forceps, small pointed reduction forceps, high-speed Kirschner wire driver or Jacob pin chuck, Kirschner wires, orthopedic wire, wire-tighteners, wire cutters

### PREPARATION AND POSITIONING

Prepare the ventral aspect of the mandible for surgery. Rinse the mouth with an antiseptic. Position the animal in dorsal recumbency, and secure the maxilla to the table by placing adhesive tape from one table edge across the maxilla to the opposite table edge. Drape the mandible out to allow maximal manipulation during surgery by placing one of the drapes into the mouth to cover the maxilla. A cancellous bone graft is usually not necessary.

### PROCEDURE

**Approach:** Incise the skin on the ventral midline between the mandibles. Extend the incision from the symphysis to 1 cm to 2 cm caudal to the angular process of the mandibles. Move this incision in either direction to expose both mandibles. If only one mandible is involved, incise directly over that mandible. Incise the subcutaneous tissue to expose the ventral portions of the mandibles. Elevate soft tissues from both sides of the mandibles to expose the fracture(s). Preserve the digastricus muscle attachments (Plate 50A1).[1]

**Reduction:** Reduce the fracture by securing each bone segment with Kern bone-holding forceps and then manipulating them into anatomic alignment. Maintain reduction manually (with transverse fractures) or with pointed reduction forceps (for oblique fractures). Because there is little musculature around the mandibular body, reduction is usually easily accomplished. Anatomic reduction of the mandibular cortex will realign the teeth.

**Stabilization:** For transverse fractures, drill a hole with the Kirschner wire. Start on the lateral aspect of the cranial mandibular segment, 0.5 cm to 1 cm from the fracture line and close to the oral edge of the mandible. Aim the wire to exit on the medial side of the mandible, slightly closer to the fracture line (see Plate 50A1). Drill a similar hole on the caudal segment at the same level in the bone so the wire will be placed perpendicular to the fracture. Feed a 12- to 18-inch strand of orthopedic wire through each pair of holes, starting and finishing on the lateral aspect of the mandible. Hold the fracture in reduction, and twist the wire (Plate 50A2). To ensure the wire contacts the medial cortex, place a forceps between the twist and the lateral mandible, and lever the wire away from the bone. Finish tightening the wire, cut the excess, and bend the remaining twist into the bone (Plate 50A3). The interfragmentary wires applied perpendicular to the fracture line will result in compression at the fracture. Transverse fractures are best stabilized with two wires (Plate 50B1); occasionally, however, one wire in the rostral mandible is sufficient (Plate 50B2). Interdental wiring may complement the interfragmentary wire (Plate 50B3). For oblique fractures, follow the previous steps, taking care to orient the wire perpendicular to the fracture. Stabilize caudal-to-rostral oblique fracture with two wires placed at right angles to each other (Plate 50C). Stabilize medial-to-lateral oblique fracture with two wires placed perpendicular to each other in two planes (Plate 50D).[2] In both cases, the second wire prevents overriding of the fracture as the wires are tightened.

Evaluate the oral cavity for open wounds. If large wounds are present, close the mucosa partially to decrease their size. Do not completely close contaminated wounds; to do so would prevent postoperative drainage. Place a Penrose drain if infection is present or likely to be present. Suture the subcutaneous tissue over the mandibles. Suture the skin incision.

### CAUTIONS

Tooth roots should be avoided when drilling through the bone. It is important to check that interfragmentary wires lie flat against the bone surface.

### POSTOPERATIVE EVALUATION

Dental occlusion should be evaluated. Radiographs should be taken to evaluate bone alignment and implant placement.

### POSTOPERATIVE CARE

Oral exercise should be limited, soft foods should be provided, and no chew toys should be allowed. Radiographs should be repeated at 6-week intervals until bone bridging occurs.

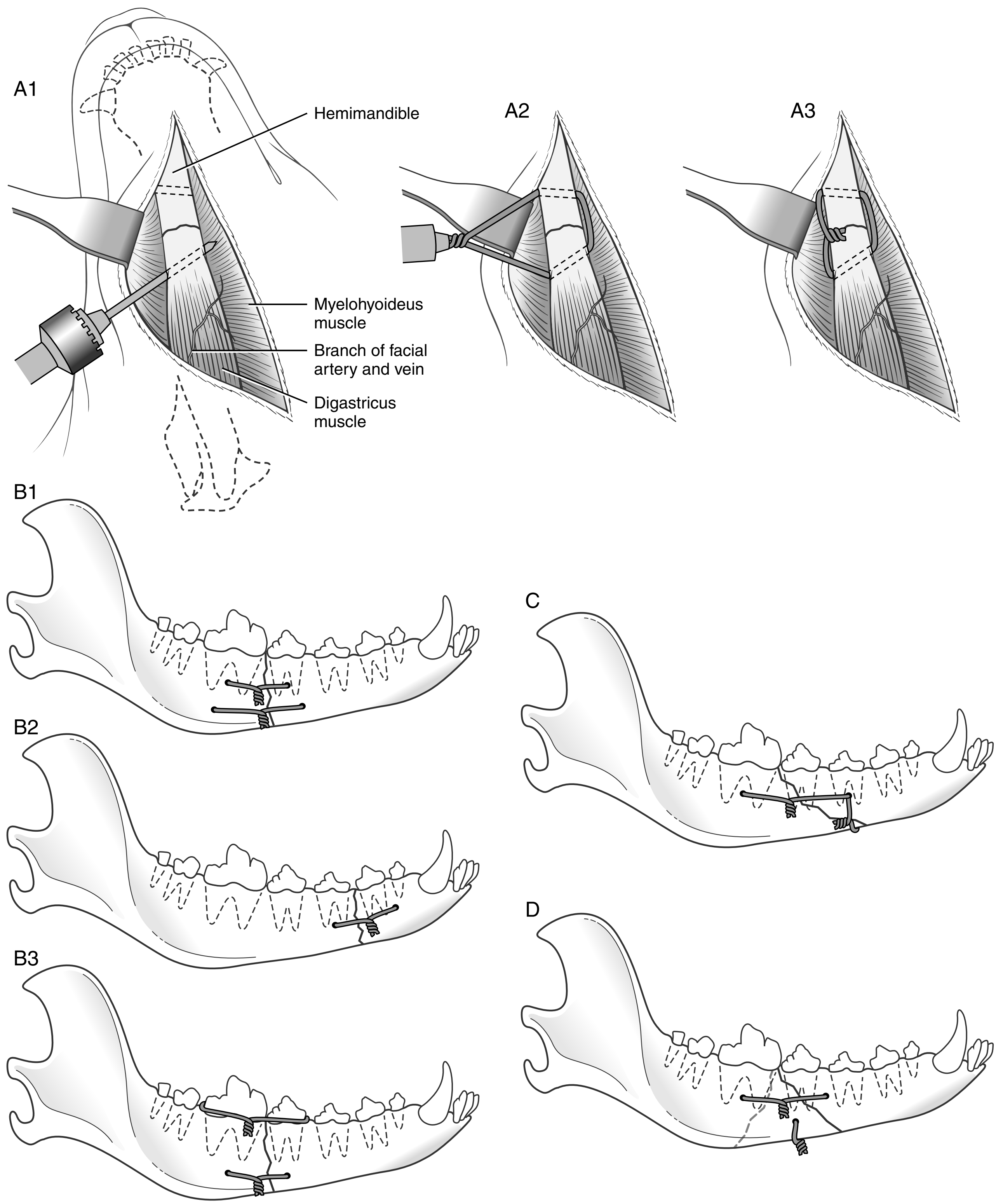
### EXPECTED OUTCOME

Bone healing is usually seen in 6 to 12 weeks. Animals generally experience an excellent return to function if dental occlusion is normal. Intraoral wires are removed after fracture healing, but interfragmentary wires remain in place unless they cause a problem. Damaged teeth may require endodontic care or extraction.

#### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Rudy RL, Boudrieau RJ: Maxillofacial and mandibular fractures. Sem Vet Med Surg Small Anim 7:3, 1992.

# PLATE 50


A1
Hemimandible
A2
A3
Myelohyoideus muscle
Branch of facial artery and vein
Digastricus muscle
B1
B2
B3
C
D

## MANDIBLE

# CHAPTER 51 Comminuted Mandibular Body Fractures

## INDICATIONS

Candidates include animals with comminuted fractures of the mandibular body that cannot be anatomically reconstructed.

## OBJECTIVES

- To align major mandibular segments and restore dental occlusion

## ANATOMIC CONSIDERATIONS

The mandibular body is easily palpated through the skin and subcutaneous tissue. The mandibular alveolar nerve, which is sensory to the teeth of the mandible, passes through the mandibular canal along with the mandibular alveolar artery. These structures are commonly damaged with mandibular fractures, although clinical signs are seldom evident. Tooth roots must be avoided when placing fixation pins. Normal occlusion is assessed by observing the unobstructed interdigitation of the mandibular canine teeth between the maxillary incisors and canine teeth and the mandibular fourth premolar positioned between the maxillary third and fourth premolars.

## EQUIPMENT

- Surgical pack, low-speed power drill, Jacob pin chuck, positive profile threaded external fixation pins, external fixator equipment, methyl methacrylate acrylic

## PREPARATION AND POSITIONING

To gain an unobstructed view of dental occlusion, place an endotracheal tube via a pharyngotomy incision. Insert an index finger into the oral cavity, and locate the pharyngeal area immediately cranial to the hyoid bones. Incise skin, subcutaneous tissues, and mucous membrane to create a passage for the endotracheal tube. Place a forceps through the surgically created passage to grasp the endotracheal tube (with connector removed), and reroute it (Plate 51A).[1] Prepare the ventral aspect of the mandible for aseptic surgery. Rinse the mouth with an antiseptic. Position the animal in dorsal recumbency, and secure the maxilla to the table by placing adhesive tape from one table edge across the maxilla to the opposite table edge. Drape the mandible out to allow maximal manipulation during surgery by placing one of the drapes into the mouth to cover the maxilla and the rest of the drapes secured around the mandible. A cancellous bone graft is not generally used with closed reduction.

## PROCEDURE

**Approach:** There is no surgical approach to the fracture site for closed reduction of comminuted fractures, only the approaches for the fixation pin insertion. Incise the skin at each pin insertion site. Dissect the overlaying soft tissues to gain access to the bone surface.

**Reduction:** After the fixation pins are placed, use them as a handle to realign the major bone segments so the dental occlusion is restored. Maintain the reduction manually or by securing two fixation pins on each side of the mandible with clamps and connecting bars (biphasic splint) (Plate 51B). Remove the clamps and bars after the acrylic is placed.

**Stabilization:** Insert at least two and, if possible, three fixation pins into each major bone segment by predrilling a pilot hole and placing the pins with a pin chuck. Bend or notch the free ends of the pins to enhance acrylic purchase. Mix methyl methacrylate acrylic until it becomes doughy (3 to 4 minutes). Mold the acrylic to form a connecting column incorporating all of the pins at a distance of 1 cm to 2 cm from the skin. Place saline moistened sponges around the fixation pins to dissipate the heat generated by the methyl methacrylate. Check the fracture reduction and hold it in position until the acrylic hardens (8 to 10 minutes) (Plate 51C).[1]

Evaluate the oral cavity for open wounds. If large wounds are present, close the mucosa partially to decrease their size. In order to allow postoperative drainage, do not close contaminated wounds completely.

## CAUTIONS

Tooth roots should be avoided when drilling through the bone.

## POSTOPERATIVE EVALUATION

Dental occlusion should be evaluated. Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

The skin and the apparatus should be cleaned daily to avoid food accumulation and skin excoriation. Oral exercise and soft foods should be limited, and no chew toys should be allowed. Radiographs should be repeated at 6-week intervals until bone bridging occurs. After the fracture has healed, the external fixator should be removed by cutting each pin to remove the acrylic frame and then removing individual pins.

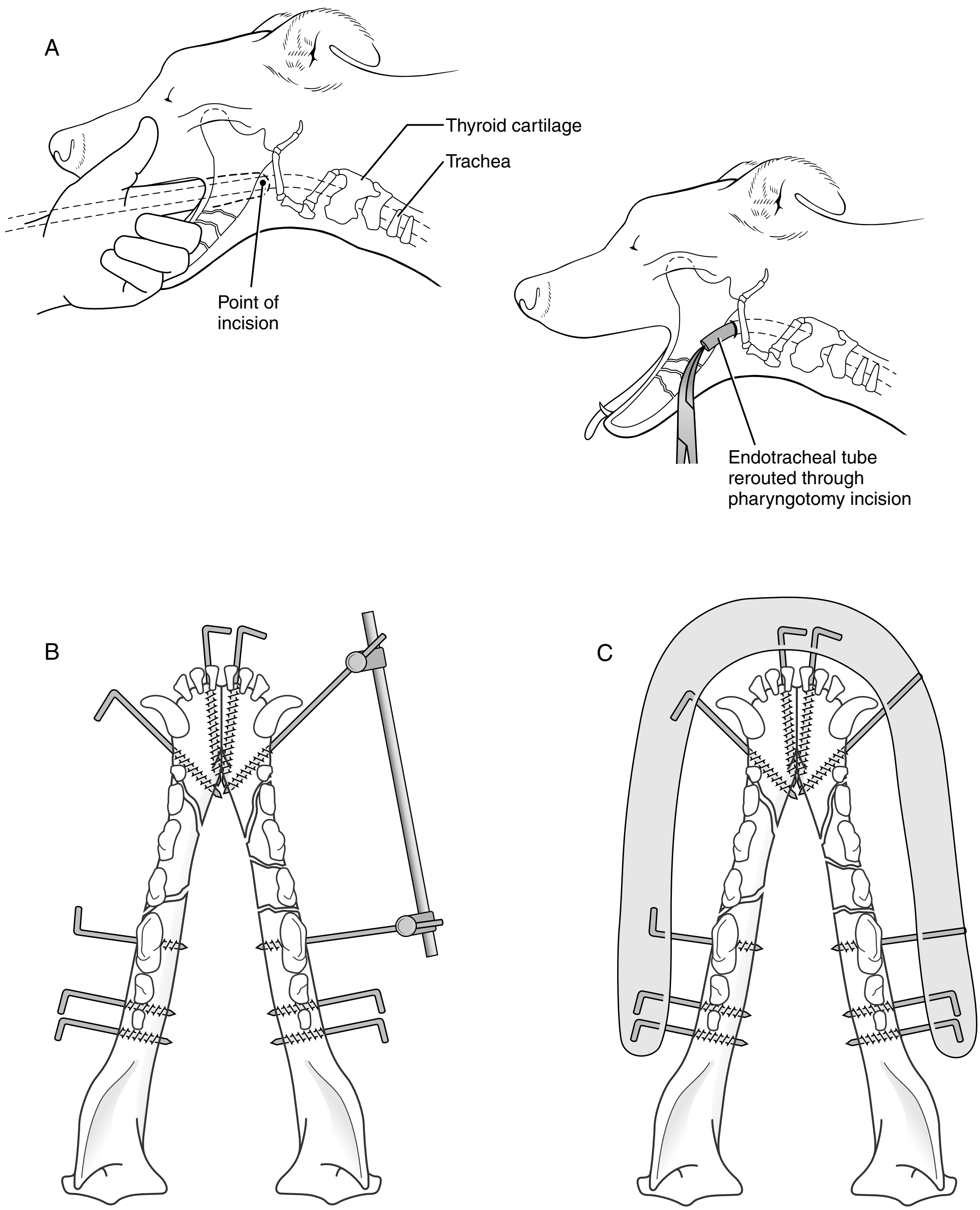
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. Large gaps may benefit from cancellous bone autograft if healing appears delayed. Excellent return to function is expected if dental occlusion is restored.

### Reference

1. Egger EL: Skull and mandibular fractures. In Slatter D (ed): Textbook of Small Animal Surgery, 2nd ed. Philadelphia, WB Saunders, 1993.

# PLATE 51


A
Thyroid cartilage
Trachea
Point of incision
Endotracheal tube rerouted through pharyngotomy incision
B
C

## SCAPULA

# CHAPTER 52 Transverse Scapular Body Fractures

### INDICATIONS

Candidates include animals with folding or displaced scapular body fractures.

### OBJECTIVES

- To restore normal anatomic contour to the shoulder area and internally splint the fracture

### ANATOMIC CONSIDERATIONS

Palpable landmarks are the spine and the acromial process of the scapula; and the cranial, dorsal, and caudal borders of the scapula. The body and spine of the scapula are easily approached with dissection and elevation of muscle. The suprascapular nerve runs over the scapular notch and under the acromion process.[1]

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, plating equipment, high-speed drill

### PREPARATION AND POSITIONING

Prepare the scapular region from dorsal midline to carpus. Position the animal in lateral recumbency with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is usually not necessary.

### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue the length of the spine distally to the shoulder joint. Transect the omotransversarius muscle from the spine, and reflect it cranially. Incise trapezius and scapular parts of the deltoideus muscles from the spine, and reflect them caudally. Incise the supraspinatus and infraspinatus muscular attachments to the spine, and elevate these muscles from the scapular body (Plate 52A).[2]

**Reduction:** Use a periosteal elevator or small Hohmann retractor as a lever to reduce the transverse fracture. Alternatively, secure the spine on the proximal segment and the distal segment with pointed reduction forceps, and lift the bone segments out of the soft tissues until the fracture ends are apposed. While maintaining contact, slowly replace the fragments into the reduced position. Maintain reduction manually (see Plate 52A).

**Stabilization:** Lay an appropriately contoured veterinary cuttable plate(s) across the fracture on the cranial portion of the body of the scapula, and secure with screws placed through the distal and proximal plate holes (Plate 52B). Direct the screws into the thick bone at the junction of the spine and body of the scapula (Plate 52C). Place additional screws in plate holes close to the fracture. Fill additional plate holes with screws. Alternate plate holes may be filled (see Plate 52B). When additional support is needed, the veterinary cuttable plates can be stacked, an additional plate can be positioned on the caudal border of the scapula (Plate 52D), or both.

### CAUTIONS

It is important to avoid placing screws in the thin bone of the body of the scapula.

### POSTOPERATIVE EVALUATION

Radiographs should be evaluated for reduction and implant position.

### POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture has healed. Radiographs should be repeated at 6-week intervals until the fracture is healed.

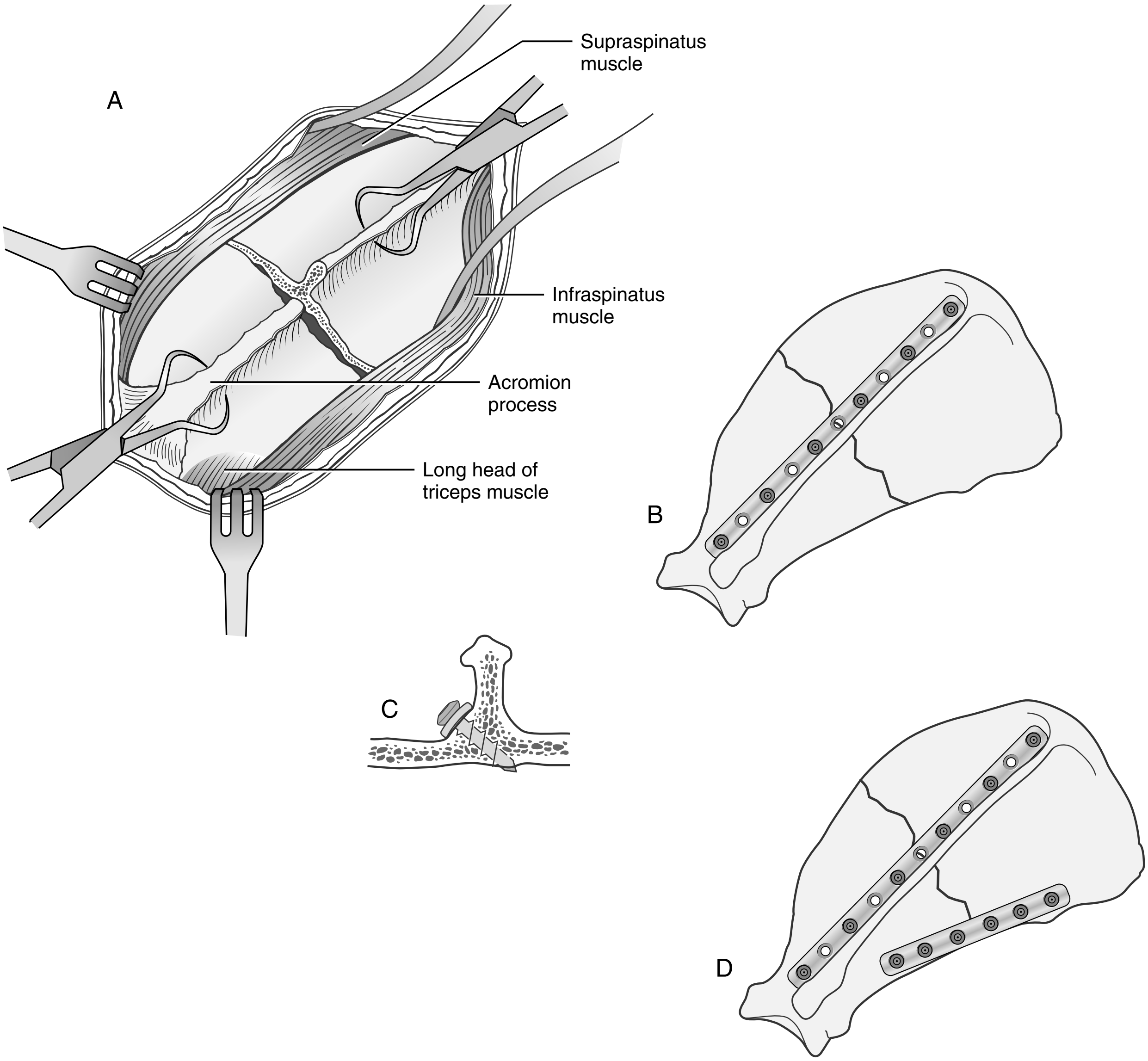
### EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. Excellent return to function is expected.

#### References

1. Jerram RM, Herron MR: Scapular fractures in dogs. Comp Cont Educ Small Animal 20:1254, 1998.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.

# PLATE 52


A
Supraspinatus muscle
Infraspinatus muscle
Acromion process
Long head of triceps muscle
B
C
D

## SCAPULA

# Chapter 53 Supraglenoid Tuberosity Fractures

### INDICATIONS
Candidates include animals with avulsion fractures of the supraglenoid tuberosity.

### OBJECTIVES
- To restore the articular surface and compress the fracture with a lag screw or tension band wire

### ANATOMIC CONSIDERATIONS
The biceps brachii muscle originates from the supraglenoid tuberosity. The supraglenoid tuberosity is part of the articular surface of the scapula. The suprascapular nerve runs over the scapular notch and under the acromion process.

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, osteotome and mallet or oscillating saw, pointed reduction forceps, Kirschner wires, orthopedic wire, high-speed drill and wire driver, bone screws and instruments for inserting bone screws, metal washer or spiked Teflon washer, wire twister, wire cutter

### PREPARATION AND POSITIONING
Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not necessary.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue from the middle portion of the scapular spine distally to the shoulder joint. Incise the attachments of the omotransversarius, trapezius, and scapular head of the deltoideus muscles to the scapula to expose the acromion process. Osteotomize the acromion process, and reflect it distally with the acromial head of the deltoideus muscle. Reflect the supraspinatus muscle away from the scapular spine and neck. Identify and protect the suprascapular nerve. Incise the joint capsule to observe the articular surface during reduction. For additional exposure, osteotomize the greater tubercle and reflect the supraspinatus muscle proximally (Plate 53A).[1]

**Reduction:** Extend the shoulder and reduce the fragment. Maintain reduction with pointed reduction forceps (Plate 53B).

**Stabilization:** To place a lag screw, drill an appropriate-sized glide hole in the fragment. Place a corresponding drill sleeve in the glide hole and drill, measure, and then tap the thread hole to accept the appropriate screw (see Plate 53B). A cancellous screw is preferred if size permits. A washer may be used if the bone is soft. To place a tension band wire, start two Kirschner wires in the fragment, and drive them across the fracture line to lodge in the main bone segment. Place a transverse drill hole in the main bone segment, pass a figure-eight wire through the hole and around the Kirschner wires, and tighten the figure-eight wire. Bend the Kirschner wires and rotate the ends over the biceps tendon (Plate 53C).[2,3] For chronic cases, where fracture reduction is impossible, attach the biceps tendon to the proximal humerus with a bone screw and spiked Teflon washer.[3] Reattach the greater tubercle with lag screws (Plate 53D). Repair the acromion osteotomy with a tension band wire (Plate 53E).

### CAUTIONS
Articular reduction should be maintained during implant application. It is important to avoid injuring or entrapping the suprascapular nerve.

### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for articular surface reduction and implant placement.

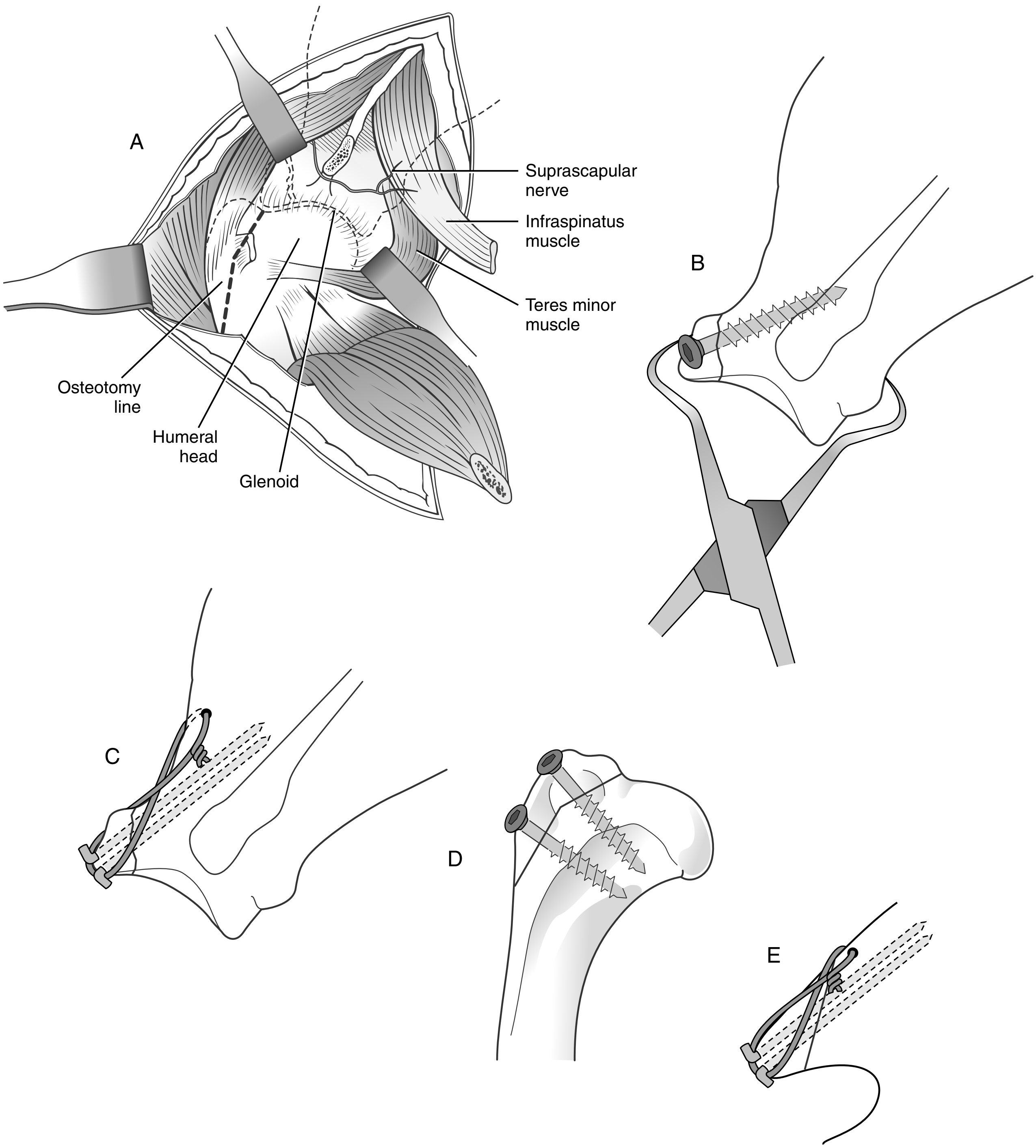
### POSTOPERATIVE CARE
The forelimb should be in a sling for 2 weeks to prevent weight bearing and to protect the fracture repair.[3] The animal should be confined, with activity limited to leash walking, until the fracture has healed. Radiographs should be repeated at 6-week intervals until the fracture(s) is healed. The animal should be slowly returned to normal activity after the fracture is healed.

### EXPECTED OUTCOME
Bone healing is usually seen in 6 to 12 weeks. A good return to function is expected, although some degree of lameness may persist.[2] Degenerative joint disease may result from articular trauma, with the severity depending on accuracy and maintenance of reduction. Implant removal may be necessary if soft tissues are irritated.

### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnston SA: Articular fractures of the scapula in the dog: A clinical retrospective study of 26 cases. J Am Anim Hosp Assoc 29:157, 1993.
3. Piermattei DL, Flo GL: Fractures of the scapula. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 53


A
Suprascapular nerve
Infraspinatus muscle
Teres minor muscle
Osteotomy line
Humeral head
Glenoid
B
C
D
E

## SCAPULA

# CHAPTER 54 Intra-articular and Scapular Neck Fractures

### INDICATIONS
Candidates include animals with T fractures of the scapular neck, or with scapular neck fractures without an intra-articular component.

### OBJECTIVES
- To achieve anatomic articular surface reduction and rigid immobilization of the fracture

### ANATOMIC CONSIDERATIONS
Osteotomy of the acromion process allows reflection of a portion of the deltoideus muscle and visualization of the joint. The suprascapular nerve and artery course over the scapular notch and under the acromial process, and should be avoided. The axillary artery and nerve are located immediately caudal to the joint, but these are not usually visualized with routine approaches.[1]

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, osteotome and mallet or oscillating saw, plating equipment, high-speed drill and wire driver, Kirschner wires, orthopedic wire, wire twisters, wire cutters

### PREPARATION AND POSITIONING
Prepare the forelimb from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is generally not needed.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue from the middle portion of the scapular spine distally to the shoulder joint. Incise the attachments of the omotransversarius, trapezius, and scapular head of the deltoideus muscles to the scapula to expose the acromion process. Osteotomize the acromion process, and reflect it distally with the acromial head of the deltoideus muscle. Reflect the supraspinatus and infraspinatus muscles away from the scapular spine and neck. Identify and protect the suprascapular nerve. If needed for complete joint exposure, tenotomize the infraspinatus muscle. Incise the joint capsule to observe the articular surface during reduction (Plate 54A). For additional exposure, osteotomize the greater tubercle of the humerus and reflect the supraspinatus muscle.[1] (See surgical procedure for supraglenoid tuberosity fracture, Chapter 53.)

**Reduction:** Reduce the intra-articular fracture anatomically, and maintain reduction with pointed reduction forceps (Plate 54B). After lag screw fixation of the intra-articular fracture, reduce the neck fracture by carefully levering it into position. Maintain reduction manually.

**Stabilization:** Reflect the cranial fragment, and drill a glide hole from the center of the fracture surface to exit proximally to the supraglenoid tuberosity prior to reducing the fracture. Reduce the fracture, and secure the reduction with pointed reduction forceps. Place an appropriate-sized drill sleeve in the glide hole and drill, measure, and then tap the thread hole to accept the appropriate screw (see Plate 54B). Reduce the neck fracture, and stabilize it with a small L plate (Plate 54C) or a veterinary cuttable plate or plates (Plate 54D). Close the joint capsule, and re-appose the infraspinatus tendon with a tendon suture. Repair the acromion osteotomy with a tension band wire (Plate 54E).[2,3]

### CAUTIONS
Articular reduction should be maintained during implant application. It is important to avoid injuring or entrapping the suprascapular nerve.

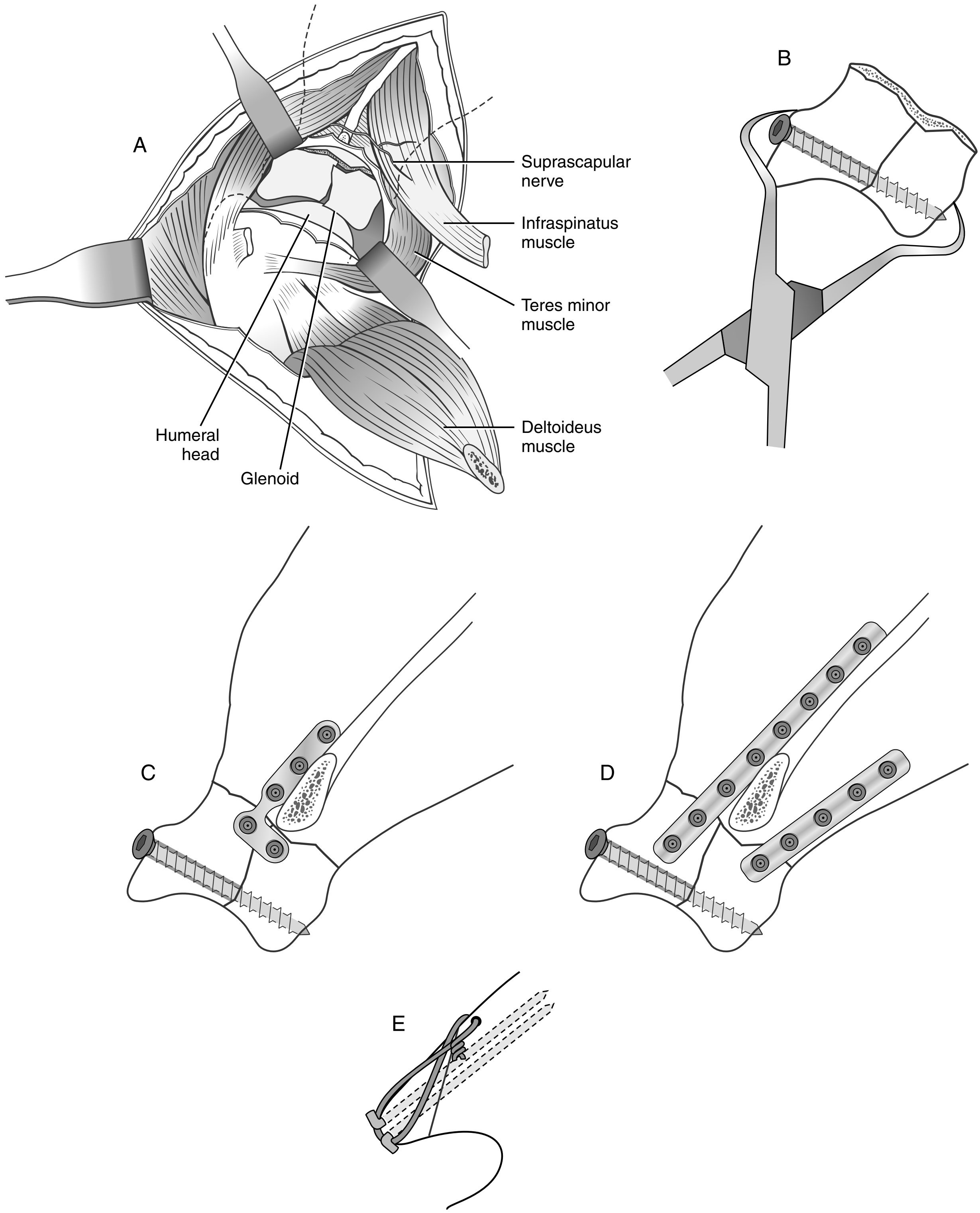
### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for reduction and implant position.

### POSTOPERATIVE CARE
The forelimb should be in a sling for 2 weeks to prevent weight bearing and to protect the fracture repair.[3] Physical therapy should be performed, flexing and extending the shoulder daily after the sling is removed, until adequate range of motion returns. The animal should be confined, with activity limited to leash walking, until the fracture has healed. Radiographs should be repeated at 6-week intervals until the fracture is healed. The animal should slowly be returned to normal activity after the fracture is healed.

### EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks. Animals should experience a fair return to function, although some degree of lameness may persist.[2] Decreased shoulder range of motion occurs but has a minimal effect on function. Atrophy of the shoulder muscles occurs if the suprascapular nerve is damaged. Degenerative joint disease may result from articular trauma, with the severity depending on accuracy and maintenance of reduction. Implant removal may be necessary if soft tissues are irritated.

#### References
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnston SA: Articular fractures of the scapula in the dog: A clinical retrospective study of 26 cases. J Am Anim Hosp Assoc 29:157, 1993.
3. Piermattei DL, Flo GL: Fractures of the scapula. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 54


A
Suprascapular nerve
Infraspinatus muscle
Teres minor muscle
Deltoideus muscle
Humeral head
Glenoid
B
C
D
E

## HUMERUS

# CHAPTER 55 Proximal Humeral Physeal Fractures

### INDICATIONS
Candidates include animals with Salter I and Salter III fractures of the proximal humeral physes.

### OBJECTIVES
- To achieve fracture stabilization and anatomic reduction of the proximal humeral epiphysis and articular surface

### ANATOMIC CONSIDERATIONS
Proximally, the greater tubercle and acromion process of the scapula are palpable. The cephalic vein courses within the subcutaneous tissue along the craniolateral surface of the limb. The configuration of the physis and the cancellous bone surface provide some rotational stability to the fracture.

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kern bone-holding forceps, Kirschner wires or small Steinmann pins for large dogs, pin chuck or high-speed wire driver, wire or pin cutter

### PREPARATION AND POSITIONING
Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not necessary.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue over the craniolateral region of the proximal humerus 2 to 3 cm proximal to the greater tubercle and extending to a point near the midshaft of the humerus. Elevate and reflect the brachiocephalicus muscle from the cranial surface of the bone. Elevate the deltoideus muscle, and retract it caudally to expose the insertions of the teres minor and infraspinatus muscles.[1] Incise through the insertions of these two muscles, and retract them caudally to expose the lateral surface of the proximal humerus (Plate 55A).

**Reduction:** Secure the greater tubercle with a pointed reduction forceps, and secure the proximal humeral diaphysis with a Kern bone-holding forceps. Reduce the epiphyseal segment or segments by manipulating the forceps while gently levering the bone into position. Maintain reduction with pointed reduction forceps (Plate 55B).

**Stabilization:** Starting proximally at the greater tubercle, drive two Kirschner wires or Steinmann pins distally and caudally to cross the fracture line and seat in the caudal metaphysis (see Plate 55B). Stabilize Salter III fractures of the proximal physis by first securing the humeral head to the proximal humerus with two Kirschner wires (Plate 55C) and then reducing the greater tubercle and securing it to the humerus with two Kirschner wires or Steinmann pins (Plate 55D). Reattach the incised tendons, and close the incision routinely.

### CAUTIONS
It is important to avoid damaging the physeal cartilage during reduction and to avoid penetrating the articular cartilage with the Kirschner wires. The articular surface should be evaluated to ensure anatomic alignment.

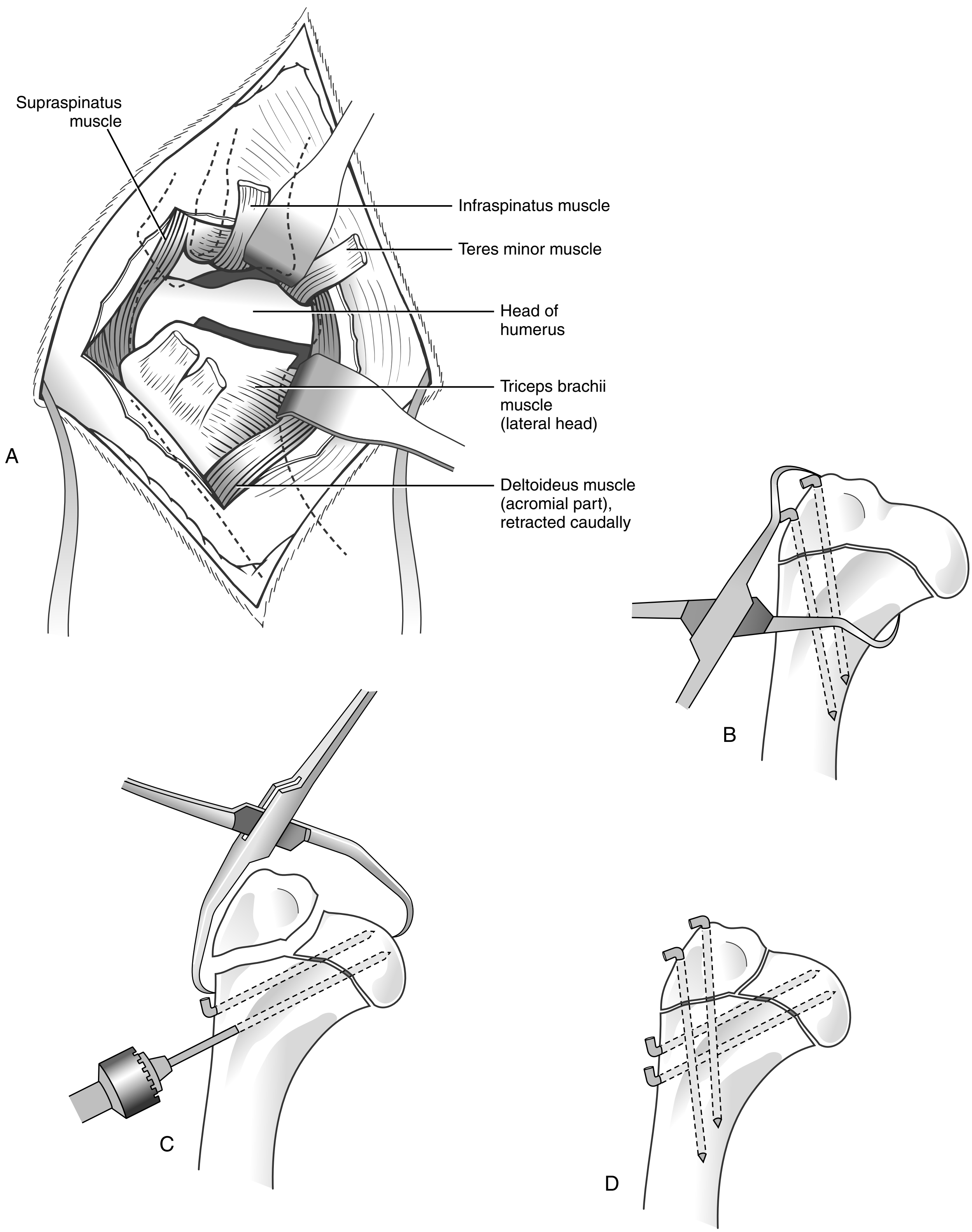
### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for reduction and implant placement.

### POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. Radiographs should be evaluated in 4 weeks. Implant removal may be indicated if soft tissue irritation occurs.

### EXPECTED OUTCOME
Rapid bone healing is usually seen, but premature closure of the physis may occur.

#### Reference
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.

# PLATE 55


Supraspinatus muscle
Infraspinatus muscle
Teres minor muscle
Head of humerus
Triceps brachii muscle (lateral head)
Deltoideus muscle (acromial part), retracted caudally
A
B
C
D

## HUMERUS

# CHAPTER 56 Fractures of the Lateral Portion of the Humeral Condyle

### INDICATIONS

Candidates include animals with Salter IV fracture of the lateral portion of the humeral condyle, or mature animals with condylar fractures.

### OBJECTIVES

- To achieve anatomic alignment of the articular surface and rigid fixation of the fracture to allow for rapid return to elbow function, and to minimize development of degenerative joint disease

### ANATOMIC CONSIDERATIONS

The lateral portion of the humeral condyle projects laterally from the humerus and articulates with the radial head. Fractures occur when the animal jumps or falls, and forces are transmitted up the radius to the lateral condyle. The triceps muscle courses in a cranial proximal direction from its insertion on the olecranon and crosses the humerus rather than paralleling it. The radial nerve lies beneath the lateral head of the triceps near the distal third of the humerus and must be identified and protected.

### EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kirschner wires, bone screws and instruments for insertion of bone screws, washers, high-speed drill and wire driver, wire cutter

### PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not necessary.

### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue beginning over the distal third of the humerus, curving cranial to the lateral epicondyle and extending 4 cm to 5 cm distal to the joint. Incise the deep fascia along the cranial border of the lateral triceps muscle, and continue this incision across the joint over the extensors. Incise the intermuscular septum between the extensor carpi radialis and the common digital extensor muscle, and continue the incision proximally through the periosteal origin of the extensor carpi radialis muscle. Retract the muscle cranially to expose the joint capsule and underlying lateral condyle. Incise the joint capsule with an L-shaped incision to visualize the lateral portion of the humeral condyle (Plate 56A).[1]

**Reduction:** Reduce the fracture by pushing proximally on the medial condyle and distracting the lateral fragment distally. Maintain reduction with pointed reduction forceps across the condyles and across the metaphyseal portion of the fracture.

**Stabilization:** Reflect the lateral condyle fragment laterally, and drill a glide hole from the center of the fracture surface to exit cranially and distally to the lateral epicondyle prior to reducing the fracture (Plate 56B). Reduce the fracture, and secure the reduction with pointed reduction forceps. Place a Kirschner wire perpendicular to the fracture surface and parallel to the glide hole. Place an appropriate-sized drill sleeve in the glide hole and drill, measure, and then tap the thread hole to accept the appropriate screw (Plate 56C). Use a washer with the screw to prevent subsidence of the screw head in soft bone. Place a Kirschner wire across the lateral epicondyloid crest to provide additional stability for short oblique or tranverse fractures (Plate 56D).[2] Stabilize long oblique metaphyseal fractures with an additional lag screw (Plate 56E).

### CAUTIONS

The radial nerve should be protected. A washer should be used in immature dogs. The joint should be inspected to ensure anatomic alignment of the articular surface.

### POSTOPERATIVE EVALUATION

Radiographs should be evaluated for fracture reduction and implant position.

### POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture is healed. Physical therapy should be performed daily, flexing and extending the elbow, until adequate range of motion returns. Radiographs should be evaluated in 4 to 6 weeks and then at 6-week intervals until the fracture is healed.

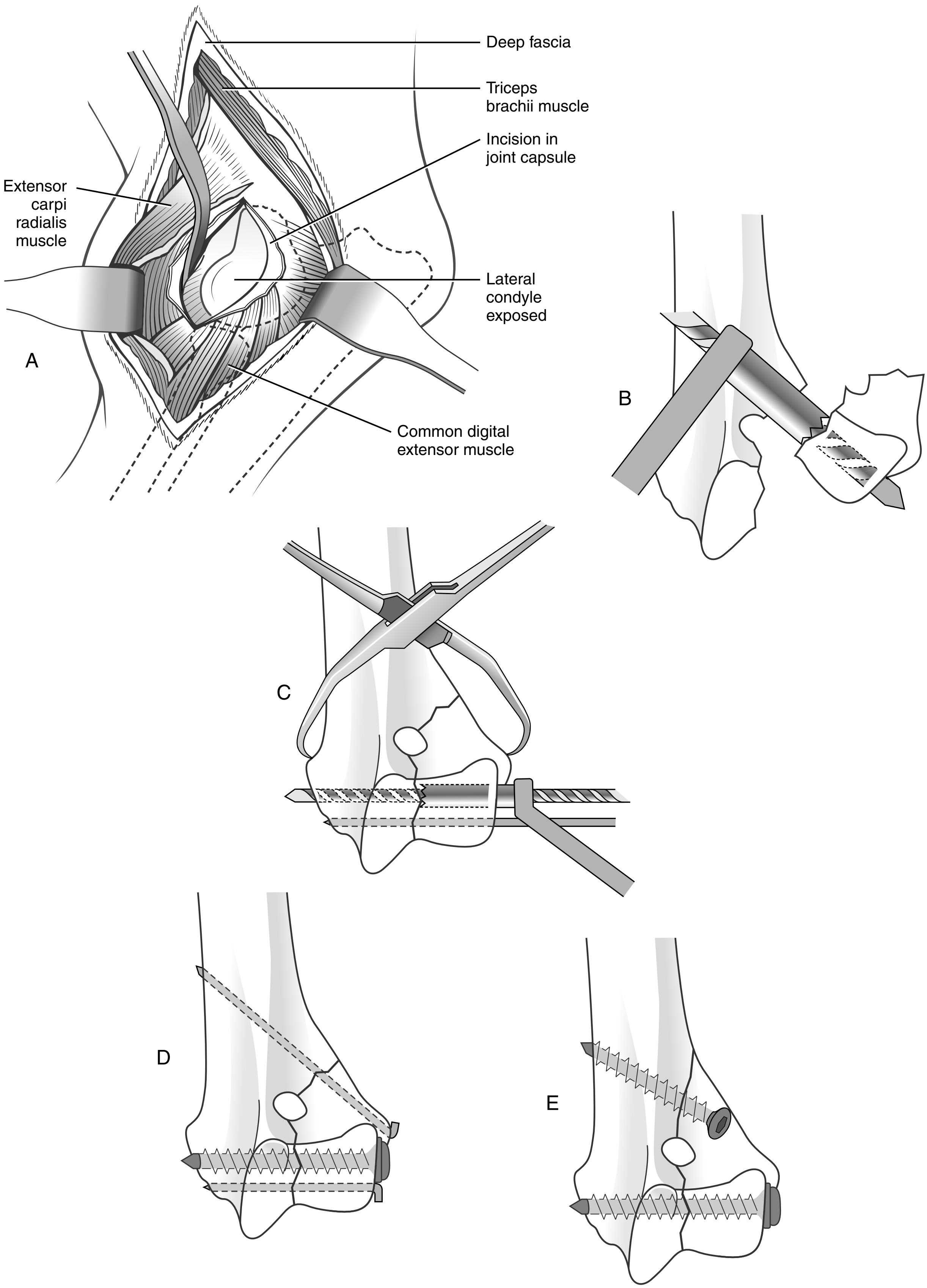
### EXPECTED OUTCOME

Rapid healing is usually seen in immature dogs, but premature closure of the physis may occur; generally this does not cause a clinical problem. Slow healing may be seen in mature dogs, especially spaniels. Animals may experience a decreased elbow range of motion. Degenerative joint disease may occur, with the severity depending on accuracy and maintenance of reduction. Implant removal may be necessary if soft tissues are irritated. Refracture may occur in some mature dogs after implant removal.

#### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures, humeral fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 56


Deep fascia
Triceps brachii muscle
Incision in joint capsule
Extensor carpi radialis muscle
Lateral condyle exposed
A
Common digital extensor muscle
B
C
D
E

HUMERUS

# CHAPTER 57 T or Y Fractures of the Distal Humerus

## INDICATIONS
Candidates include animals with T or Y fractures of the distal humerus.

## OBJECTIVES
- To achieve anatomic alignment of the articular surface and rigid fixation of the fracture to allow for rapid return to elbow function, and to minimize development of degenerative joint disease

## ANATOMIC CONSIDERATIONS
The radial nerve lies beneath the lateral head of the triceps near the distal third of the humerus. The median, ulnar, and musculocutaneous nerves course along the cranial edge of the medial head of the triceps muscle. The brachial artery and vein accompany the nerves on the medial aspect of the humerus. The medial side of the humerus is flat and straight, making it amenable to plate placement. Fitting a plate to the lateral side of the humerus requires bending and twisting of the plate to fit the surface. The medial condyle is an extension of the humeral shaft, allowing an intramedullary (IM) pin to travel from the medial condyle to the greater tubercle.

## EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kern bone-holding forceps, high-speed power drill, IM pins and Jacob pin chuck, plating equipment, pin cutter

## PREPARATION AND POSITIONING
Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in dorsal recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. The proximal humerus serves as a cancellous bone graft donor site.

## PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue beginning over the distal third of the humerus, curving cranial to the lateral epicondyle and extending 4 cm to 5 cm distal to the joint. Incise the deep fascia along the cranial border of the lateral triceps muscle, and continue this incision across the joint over the extensors. Incise the intermuscular septum between the extensor carpi radialis and the common digital extensor muscle, and continue the incision proximally through the periosteal origin of the extensor carpi radialis muscle. Retract the muscle cranially to expose the joint capsule and underlying lateral condyle. Incise the joint capsule with an L-shaped incision to visualize the lateral humeral condyle and the articular surface (Plate 57A1). To expose the medial aspect of the fracture, incise the skin and subcutaneous tissue over the medial surface of the distal humerus. Bluntly dissect the subfascial fat, and retract the nerves and vessels to expose the humerus (Plate 57A2).[1]

**Reduction:** Reduce the articular fracture, and maintain reduction with pointed reduction forceps across the condyles. Inspect the joint surface to ensure anatomic alignment (Plate 57B). After the lag screw is placed, reduce the humeral metaphyseal fracture. Place an IM pin up the medial portion of the condyle and across the fracture line to help maintain reduction (Plate 57C).

**Stabilization:** Stabilize the articular fracture with a lag screw. Drill a glide hole in the lateral condylar fragment. Place an appropriate-sized drill sleeve in the glide hole and drill, measure, and then tap the thread hole to accept the appropriate screw (see Plate 57B). Secure the condyle to the humeral shaft with a plate/rod combination. Start an IM pin into the medial condyle just below the medial epicondyle. Alternatively, retrograde the IM pin from the fracture site to exit below the medial epicondyle. Drive the pin proximally across the fracture and up the humeral diaphysis to lodge at the greater tubercle. Place a plate across the lateral fracture line (see Plate 57C). Cut the pin short at the distal humerus. Alternatively, stabilize the medial and lateral fractures by applying one plate to the medial surface of the humerus and a second plate to the caudolateral epicondyloid crest (Plate 57D). The plates should function as compression plates if the fractures are transverse.[2]

## CAUTIONS
The radial nerve should be protected on the lateral approach and the neurovascular structures on the medial approach. The joint should be inspected to ensure anatomic alignment of the articular surface. The elbow should be taken through range of motion to check for screws penetrating the olecranon fossa.

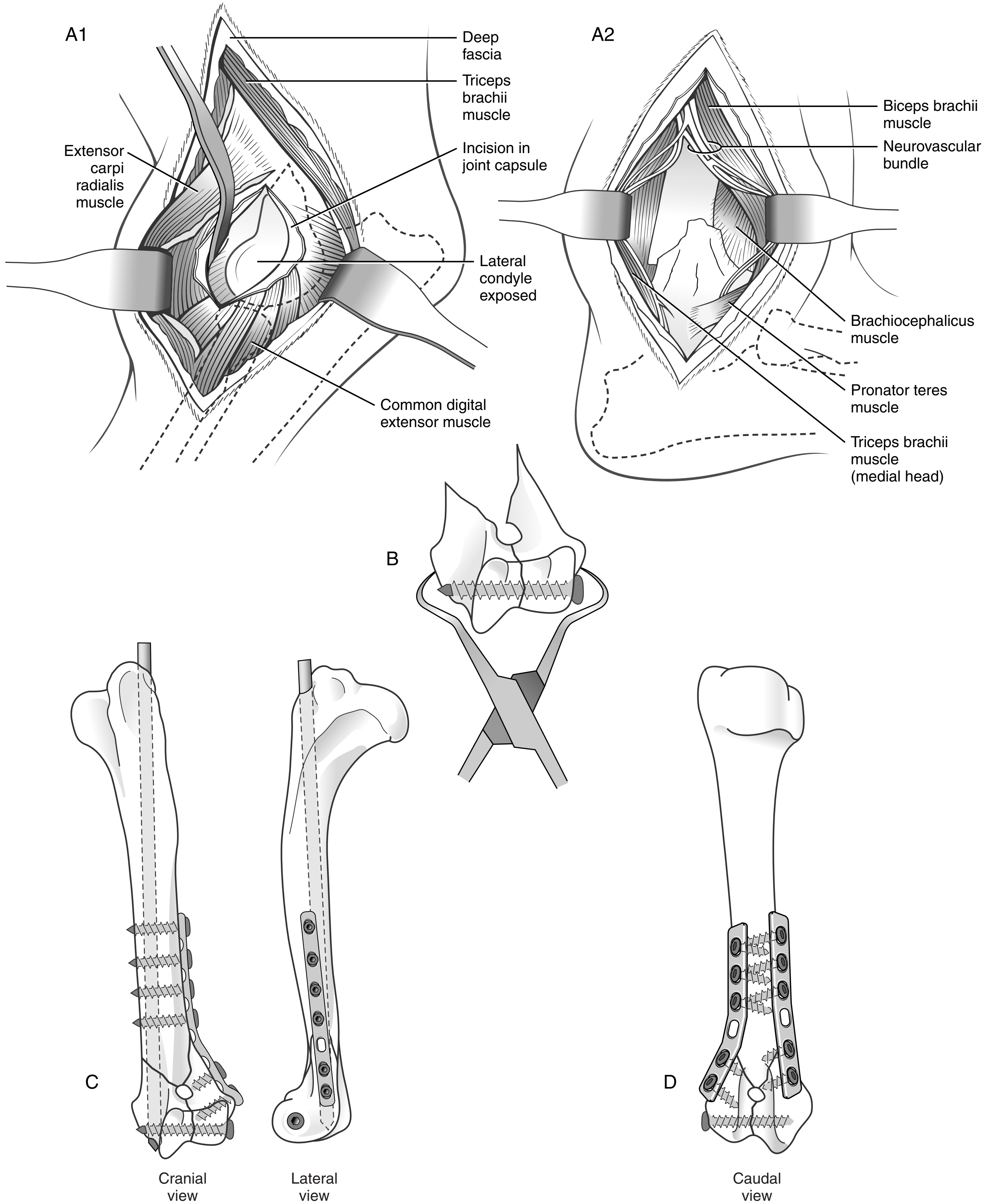
## POSTOPERATIVE EVALUATION
Radiographs should be evaluated for reduction and implant position.

## POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking, until the fracture is healed. Physical therapy should be performed daily, flexing and extending the elbow, until adequate range of motion returns. Radiographs should be repeated at 6-week intervals until the fracture is healed.

## EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks. Slow healing may be seen in mature dogs, especially spaniels. Animals may experience decreased elbow range of motion. Degenerative joint disease may occur, with severity depending on accuracy and maintenance of reduction.[3,4] The IM pin may interfere with elbow function; it should be removed after the fracture has bridged with bone. Plate and screw removal may be necessary if soft tissues are irritated. Refracture may occur in some mature dogs after implant removal.

### References
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures: Humeral fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Vannini R, Smeak DD, Olmstead ML: Evaluation of surgical repair of 135 distal humeral fractures in dogs and cats. J Am Anim Hosp Assoc 24:537, 1988.
4. Anderson TJ, Carmicheal S, Miller A: Intercondylar humeral fracture in the dog: A review of 20 cases. J Small Anim Pract 31:437, 1990.

# PLATE 57


A1
Deep fascia
Triceps brachii muscle
Extensor carpi radialis muscle
Incision in joint capsule
Lateral condyle exposed
Common digital extensor muscle
A2
Biceps brachii muscle
Neurovascular bundle
Brachiocephalicus muscle
Pronator teres muscle
Triceps brachii muscle (medial head)
B
C
D
Cranial view
Lateral view
Caudal view

## HUMERUS

# CHAPTER 58 Application of an Intramedullary Pin or Interlocking Nail to the Humerus

## INDICATIONS

Candidates include animals with single or comminuted humeral diaphyseal fractures.

## OBJECTIVES

- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment for nonreducible comminuted fractures

The intramedullary (IM) pin is used in animals with high fracture-assessment scores. The IM pin neutralizes bending forces at the fracture and is combined with cerclage wire for long oblique fractures and with external fixation for transverse or short oblique fractures to neutralize rotational and axial compressive forces. The interlocking nail (ILN) neutralizes bending, rotational, and axial compressive forces at the fracture; it can be used for animals with medium and low fracture-assessment scores.

## ANATOMIC CONSIDERATIONS

The radial nerve lies superficial to the brachialis muscle and deep to the lateral head of the triceps; it must be identified and protected during the surgical approach, fracture reduction, and stabilization. The humerus has a cranial curvature that positions the long axis of the marrow cavity cranial to the shoulder joint, allowing normograde or retrograde placement of an IM pin and normograde placement of the ILN. The narrowest part of the medullary canal, the isthmus, is located within the distal third of bone, just proximal to the supratrochlear foramen. The medial portion of the humeral condyle is the extension of the medullary canal. In cats, the median nerve and brachial artery run through the supracondylar foramen.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, pointed reduction forceps, Kern bone-holding forceps, Jacob pin chuck, IM pins, cerclage wire, wire tightener, wire cutter, low-speed drill, external fixator equipment, pin cutter, ILN equipment including high-speed drill, bone curette for harvesting cancellous graft

## PREPARATION AND POSITIONING

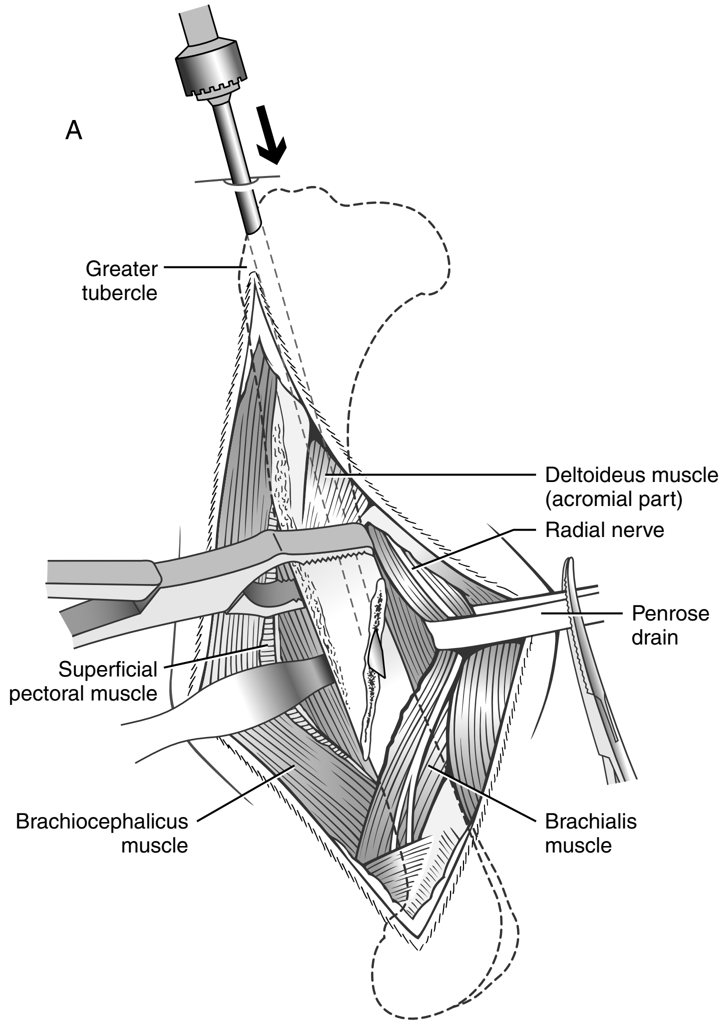
Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal humerus or ilial wing for surgery if harvesting cancellous bone.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissues laterally from the cranial border of the greater tubercle to the lateral epicondyle. Incise the brachial fascia along the border of the brachiocephalicus muscle and the lateral head of the triceps. Visualize and isolate the radial nerve. Incise through the periosteal insertion of the superficial pectoral and brachiocephalicus muscles at their insertion on the humeral shaft. Reflect these two muscles cranially, and the brachialis muscle caudally, to expose the proximal and central humeral shaft.[1] To gain further exposure of the distal humeral shaft, encircle the brachialis muscle and the radial nerve with a Penrose drain; retract them caudally to expose the proximal and mid-diaphysis and cranially to expose the distal diaphysis. Insert the IM pin into the proximal humerus in either a normograde or retrograde manner (Plate 58A).[2] Insert the ILN in a normograde manner, starting at the greater tubercle.[3] Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures.[4] Incise the skin, and create soft tissue tunnels to the bone for fixator pin placement.

*Continued*

# PLATE 58


A
Greater tubercle
Deltoideus muscle (acromial part)
Radial nerve
Penrose drain
Superficial pectoral muscle
Brachiocephalicus muscle
Brachialis muscle

**Reduction:** Place an IM pin (sized to equal 70% to 80% of the medullary canal at the isthmus) in the proximal segment. Direct the pin toward the caudomedial cortex so it will seat in the medial portion of the condyle when the fracture is reduced and the pin is driven distally.[2] Retract the pin within the medullary canal of the proximal segment (see Plate 58A). Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain the reduction manually (for transverse fractures) or with pointed reduction forceps (for oblique fractures). Reduce comminuted nonreducible fractures by distracting the distal end with the IM pin or ILN and aligning the major segments of the bone. Be sure to restore length and normal rotational alignment to the bone.

**Stabilization:** Apply an IM pin and type Ia external fixator to the lateral surface of the humerus (Plate 58B). In each segment, place a fixation pin in the metaphysis and a fixation pin close to the fracture. The external fixator can be connected or "tied-in" to the IM pin in order to strengthen the fixation.[5] Apply an IM pin and cerclage wire to a long oblique fracture (Plate 58C). Apply an ILN and four screws to the humerus for treatment of comminuted nonreducible fractures (Plate 58D).

## CAUTIONS

The radial nerve should be identified and protected during the procedure. It is important to avoid the distal joint surface with the IM pin or ILN. The range of motion of the elbow should be palpated to detect pin interference in the joint. Rotational alignment should be monitored during the realignment of comminuted fractures.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture has healed. External fixator management includes daily pin care and pin packing as needed. Radiographs should be evaluated in 6 weeks. Fixation pins should be removed after radiographic signs of bone bridging are observed. If a tie-in is used, the top fixation pin and its connection to the IM pin should be retained. Radiographs should be repeated at 6-week intervals until the fracture is healed. The IM pin should be removed when the fracture is healed.

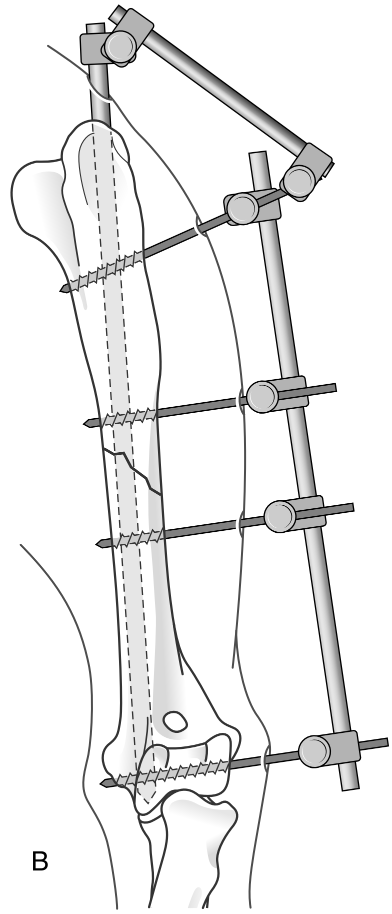
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks (depending on fracture and signalment of the animal).

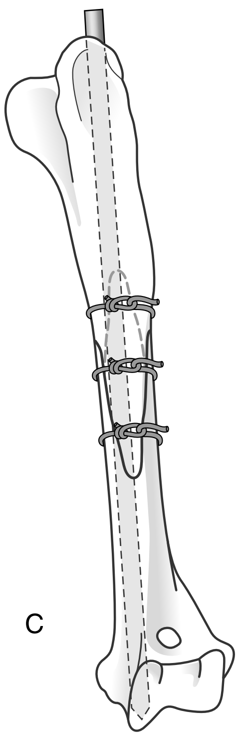
### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures, humeral fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Dueland RT, Johnson KA, Roe SC, et al: Interlocking nail treatment of diaphyseal long bone fractures in dogs. J AM Vet Med Assoc 214:59, 1999.
4. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
5. Aron DN, Dewey C: Experimental and clinical experience with an IM pin external skeletal fixator tie-in configuration. Vet Comp Orthop Traumatol 4:86, 1991.

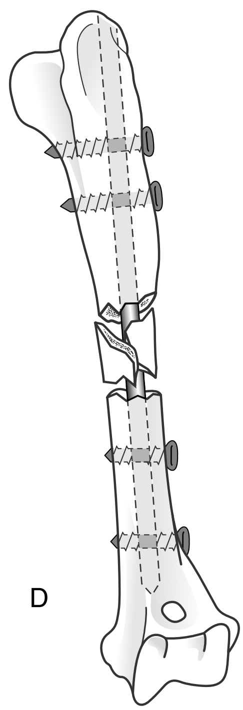
# PLATE 58



B



C



D

## HUMERUS

# Chapter 59 Application of a Plate to the Humerus

### INDICATIONS

Candidates include animals with single or comminuted humeral diaphyseal fractures.

### OBJECTIVES

- To achieve anatomic reduction and compression of single fracture lines, or restoration of normal bone alignment, in nonreducible comminuted fractures

The plate is used as a compression plate for transverse or short oblique fractures; it is combined with lag screws to compress long oblique fractures, neutralizing bending, rotational, and axial compressive forces. The plate is used as a bridging plate for nonreducible comminuted fractures and may be combined with an intramedullary (IM) pin to reduce strain on the plate and to extend fatigue life of the fixation.[1]

### ANATOMIC CONSIDERATIONS

The plate may be placed on the cranial, lateral, or medial surface of the humerus. The cranial and medial surfaces of the humerus are relatively flat and amenable to plate placement. Fitting a plate to the lateral side of the humerus requires bending and twisting of the plate to fit the surface. The radial nerve lies superficial to the brachialis muscle and deep to the lateral head of the triceps; it must be identified and protected during the surgical approach, fracture reduction, and stabilization. In cats, the median nerve and brachial artery run through the supracondylar foramen. During the medial approach to the humerus, care must be taken to isolate and protect the median, musculocutaneous, and ulnar nerves; and the brachial artery and vein.[2] The humerus has a cranial curvature that positions the long axis of the marrow cavity cranial to the shoulder joint, allowing normograde or retrograde placement of an IM pin. The medial portion of the condyle is an extension of the humeral shaft, allowing an IM pin to travel from the medial condyle to the greater tubercle.

### EQUIPMENT

- Surgical pack, Senn retractors periosteal elevator, Gelpi retractors or Hohmann retractors, Penrose drain, pointed reduction forceps, Kern bone-holding forceps, self-centering plate-holding forceps, Jacob pin chuck, IM pins, high-speed drill, plating equipment, bone curette for harvesting graft

### PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up for the craniolateral approach. Position the animal in dorsal recumbency for the medial approach to the humerus. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal humerus or ilial wing for surgery to harvest cancellous bone.

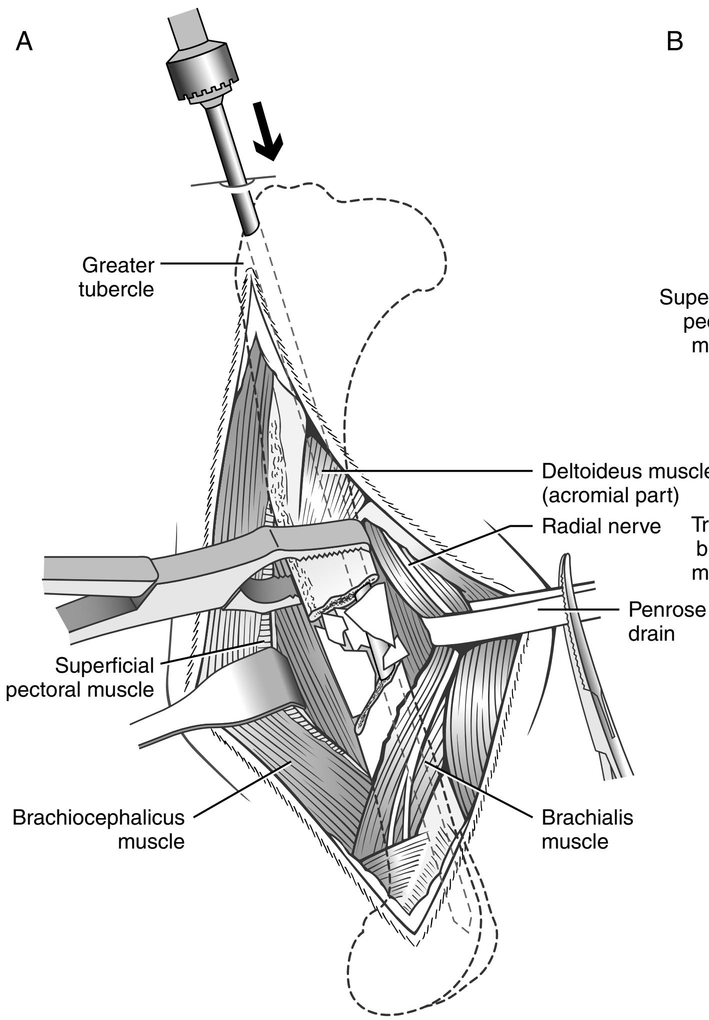
### PROCEDURE

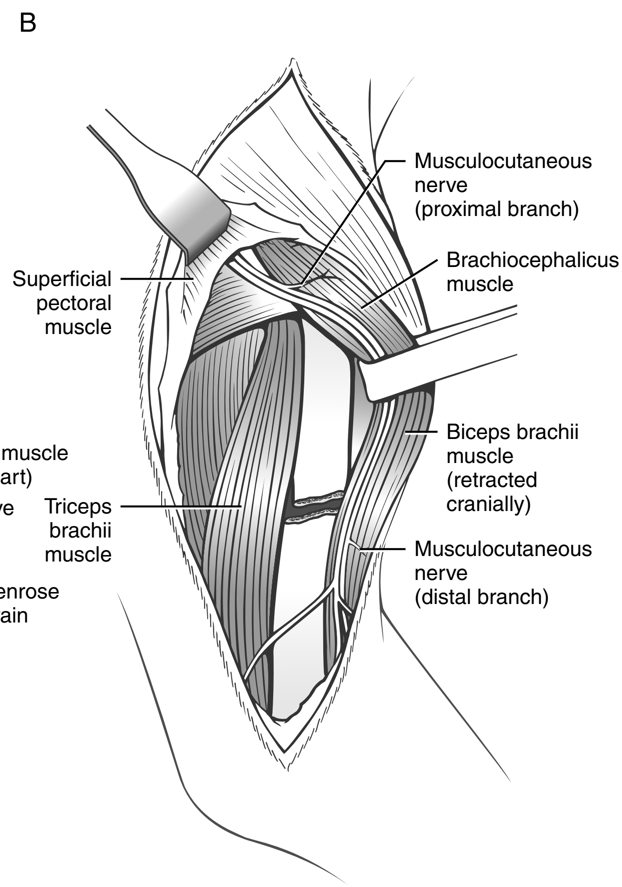
**Approach:** Incise the skin and subcutaneous tissues laterally from the cranial border of the greater tubercle to the lateral epicondyle. Incise the brachial fascia along the border of the brachiocephalicus muscle and the lateral head of the triceps. Visualize and protect the radial nerve. Incise through the periosteal insertion of the superficial pectoral and brachiocephalicus muscles at their insertions on the humeral shaft. Reflect these two muscles cranially, and the brachialis muscle caudally, to expose the proximal and central, cranial, or lateral humeral shaft (Plate 59A).[2] To gain further exposure of the distal lateral humeral shaft, encircle the brachialis muscle and the radial nerve with a Penrose drain and retract them caudally (to expose the proximal and mid-diaphysis) and cranially (to expose the distal diaphysis).

To expose the medial aspect of the fracture, incise the skin and subcutaneous tissue over the medial surface of the humerus from the greater tubercle to below the medial epicondyle. Incise the deep brachial fascia along the caudal border of the brachiocephalicus muscle and the distal portion of the insertion of the superficial pectoral muscle. Retract the biceps brachii muscle and the nerves and vessels caudally (to expose the proximal portion of the humerus) and cranially (to expose the middle and distal portion of the humerus) (Plate 59B).[2] Use an “open but do not disturb the fragments” technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures.[3]

*Continued*

# PLATE 59


A
Greater tubercle
Deltoideus muscle (acromial part)
Radial nerve
Penrose drain
Superficial pectoral muscle
Brachiocephalicus muscle
Brachialis muscle


B
Musculocutaneous nerve (proximal branch)
Brachiocephalicus muscle
Superficial pectoral muscle
Biceps brachii muscle (retracted cranially)
Triceps brachii muscle
Musculocutaneous nerve (distal branch)

**Reduction:** Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain the reduction manually (for transverse fractures) or with pointed reduction forceps (for oblique fractures). Reduce comminuted, nonreducible fractures by distracting the distal or proximal segments with an IM pin (sized to equal 40% to 50% of the medullary canal at the isthmus) and aligning the major segments of the bone (see Plate 59A). Insert the IM pin into the proximal humerus in either a normograde or retrograde manner. For distal fractures, start an IM pin into the medial condyle just below the medial epicondyle. Alternatively, retrograde the IM pin from the fracture site to exit below the medial epicondyle. Drive the pin proximally across the fracture and up the humeral diaphysis to lodge at the greater tubercle. Be sure to restore length and normal rotational alignment to the bone.[4]

**Stabilization:** Apply an appropriately contoured plate to the cranial, lateral, or medial surface of the humerus. The plate can function as a compression plate (Plate 59C) when used to compress transverse or short oblique fractures; a neutralization plate to support a reconstructed fracture (Plate 59D); or as a bridging plate, spanning a nonreducible comminuted fracture (Plate 59E).[5]

## CAUTIONS

All neurovascular structures should be identified and protected during the procedure. It is important to avoid the distal joint surface and olecranon fossa with the IM pin and bone screws. The range of motion of the elbow should be palpated to detect implant interference in the joint. Rotational alignment should be monitored during the realignment of comminuted fractures.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Physical therapy may be necessary to restore elbow range of motion. Radiographs should be evaluated in 6 weeks. The IM pin should be removed after radiographic signs of bone bridging are observed. Radiographs should be repeated at 6-week intervals until the fracture is healed. Plate removal may be necessary after the fracture heals to relieve soft tissue irritation.

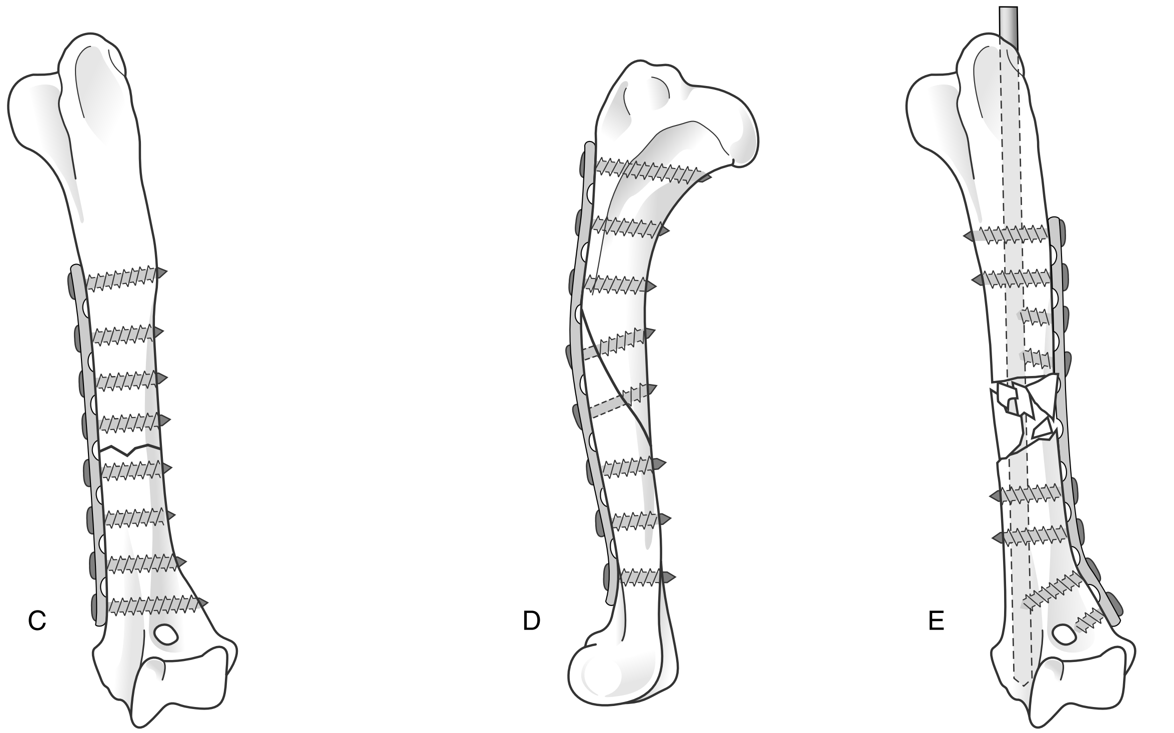
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks (depending on fracture and signalment of the animal).

### References

1. Hulse D, Hyman W, Nori M, et al: Reduction in plate strain by addition of an intramedullary pin. Vet Surg 26:451, 1997.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
4. Johnson AL, Hulse DA: Management of specific fractures, humeral fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
5. Kasa F, Kasa G, Koestlin R, et al: Fractures of the humerus. In Brinker WO, Piermattei D, Flo GL (eds): Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

## PLATE 59



## HUMERUS

# Chapter 60 Application of an External Fixator to the Humerus

### INDICATIONS

Candidates include animals with single or comminuted humeral diaphyseal fractures.

### OBJECTIVES

- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment in comminuted fractures

The stiffness of the fixator can be increased in animals with low fracture-assessment scores by adding fixation pins, using biplanar frames, and incorporating an intramedullary (IM) pin.[1] The fracture and fixator combination, the IM pin and fixator combination, or the biplanar fixator alone resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

The radial nerve lies superficial to the brachialis muscle and deep to the lateral head of the triceps; it must be identified and protected during the surgical approach, fracture reduction, and fixation pin placement. The humerus has a cranial curvature that positions the long axis of the marrow cavity cranial to the shoulder joint, allowing normograde or retrograde placement of an IM pin. The narrowest part of the medullary canal, the isthmus, is located within the distal third of bone, just proximal to the supratrochlear foramen. The medial portion of the humeral condyle is the extension of the medullary canal. In cats, the median nerve and brachial artery run through the supracondylar foramen. The proximity of the thorax prohibits use of bilateral frames in the proximal humerus.

### EQUIPMENT

- Surgical pack, Senn retractors, small Hohmann retractors, Gelpi retractors, periosteal elevator, Kern bone-holding forceps, pointed reduction forceps, Jacob pin chuck, IM pins, low-speed power drill, external fixation equipment, pin cutter, bone curette for harvesting graft

### PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from dorsal midline to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal humerus or ilial wing for harvesting cancellous bone.

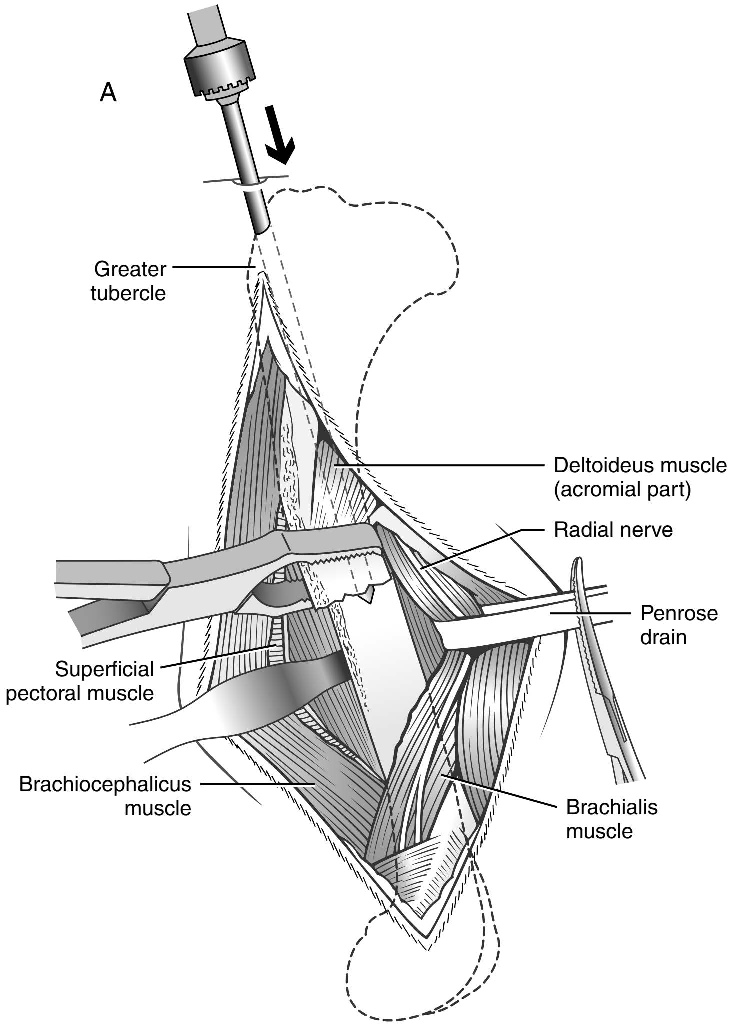
### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissues laterally from the cranial border of the greater tubercle to the lateral epicondyle. Incise the brachial fascia along the border of the brachiocephalicus muscle and the lateral head of the triceps. Visualize and isolate the radial nerve. Incise through the periosteal insertion of the superficial pectoral and brachiocephalicus muscles at their insertions on the humeral shaft. Reflect these two muscles cranially, and the brachialis muscle caudally, to expose the proximal and central humeral shaft.[2] To gain further exposure of the distal humeral shaft, reflect the brachialis muscle cranially and the lateral triceps muscle caudally. Insert the IM pin into the proximal humerus in either a normograde or retrograde manner (Plate 60A). Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments, or a closed reduction technique for nonreducible fractures.[3] Incise the skin and create soft tissue tunnels to the bone for fixator pin placement.

**Reduction:** Place an IM pin (sized to equal 70% to 80% of the medullary canal at the isthmus) in the proximal segment. Direct the pin toward the caudal medial cortex so it will seat in the medial portion of the condyle when the fracture is reduced and the pin is driven distally. Retract the pin within the medullary canal of the proximal segment (see Plate 60A).[4] Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain the reduction manually (for transverse fractures) or with pointed reduction forceps (for oblique fractures). Reduce comminuted, nonreducible fractures by distracting the distal end with the IM pin and aligning the major segments of the bone; or use the distal fixation pin to distract and align the bone during closed reduction. Be sure to restore length and normal rotational alignment to the bone.

*Continued*

# PLATE 60


A
Greater
tubercle
Deltoideus muscle
(acromial part)
Radial nerve
Penrose
drain
Superficial
pectoral muscle
Brachiocephalicus
muscle
Brachialis
muscle

**Stabilization:** Apply an IM pin and a type Ia external fixator to the lateral surface of the humerus (Plate 60B). In each segment, place a fixation pin in the metaphysis and a fixation pin close to the fracture. The external fixator can be connected or tied in to the IM pin to strengthen the fixation.[5] Long oblique fractures benefit from cerclage wire in addition to the IM pin, the external fixator, or both (Plate 60C). Apply a modified type Ib external fixator to a comminuted nonreducible fracture (Plate 60D). Add an IM pin and tie it into the fixator for additional stability for comminuted fractures.[6]

## CAUTIONS

Identify and protect the radial nerve during the procedure. Avoid major nerves and vessels and joint surfaces with the fixation pins. Avoid penetrating the distal joint surface or olecranon fossa with the IM pin. Palpate the range of motion of the elbow to detect pin interference in the joint. Monitor rotational and angular alignment during the reduction and fixation of comminuted fractures.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement. Angular malalignments should be corrected by loosening the clamps and realigning the fixation pins on the connecting bar.

## POSTOPERATIVE CARE

Gauze sponges should be packed around the pins, and the sponges should be secured with a bandage. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Physical therapy should be instituted to restore elbow range of motion. Radiographs should be repeated at 6-week intervals to monitor healing. The fixator should be destabilized by removing the unilateral frame (type Ia and IM pin) or the cranial frame (modified type Ib fixator) when bone bridging is observed. If a tie-in is used, the top fixation pin and its connection to the IM pin should be retained. The IM pin, the remaining external fixator, or both should be removed when the fracture is healed.

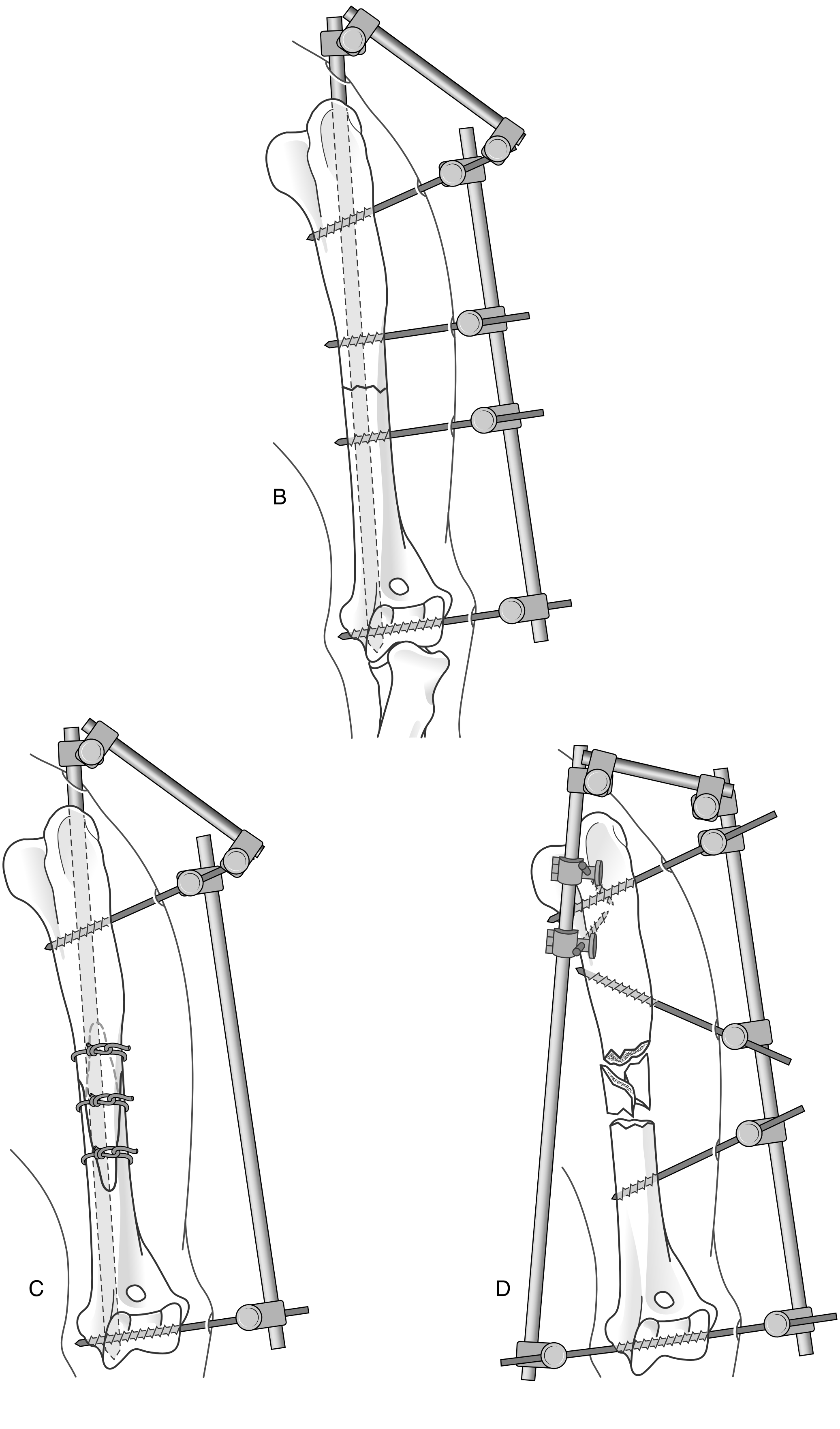
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks (depending on fracture and signalment of the animal). The animal may experience limited function while the external fixator is in place, but a good return to function can be expected.

### References


1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
4. Johnson AL, Hulse DA: Management of specific fractures, humeral fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
5. Aron DN, Dewey C: Experimental and clinical experience with an IM pin external fixator tie-in configuration. Vet Comp Orthop Traumatol 4:86, 1991.
6. Aron DN: External skeletal fixation system application to the humerus and femur. In Proceedings of the 10th Annual Complete Course in External Skeletal Fixation, University of Georgia, 127–141, 2002.

# PLATE 60



## RADIUS

# CHAPTER 61 Application of a Plate to the Radius

## INDICATIONS

Candidates include animals with single or comminuted radial diaphyseal fractures or toy breed dogs with distal diaphyseal fractures.

## OBJECTIVES

- To achieve anatomic reduction and compression of single fracture lines, or restoration of normal bone alignment, in nonreducible comminuted fractures

The plate is used as a compression plate for transverse or short oblique fractures; it is combined with lag screws to compress long oblique fractures, neutralizing bending, rotational, and axial compressive forces. The plate is used as a bridging plate for nonreducible comminuted fractures.

## ANATOMIC CONSIDERATIONS

The flat cranial surface of the radius is ideal for plate placement; however, interference with tendons is possible. The medial surface may be used for plate placement for distal radial fractures. The cephalic vein crosses the medial portion of the distal radius. Limited soft tissue coverage and marginal vascular supply contribute to a high percentage of delayed unions or nonunions in toy breed dogs.[1]

## EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, periosteal elevator, self-centering plate reduction forceps, pointed reduction forceps, high-speed drill, plating equipment, bone curette for harvesting graft

## PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from above the shoulder to the phalanges. Position the animal in dorsal recumbency. Drape the limb out from a hanging position. Roll the animal slightly to allow access to the medial surface of the limb. The ipsilateral proximal humerus serves as a cancellous bone graft donor site.

## PROCEDURE

**Approach:** Palpate the radius directly under the skin and subcutaneous tissue on the craniomedial surface of the limb. Incise the skin and subcutaneous tissue to expose the radial diaphysis. Extend the incision distally, and elevate the extensor tendons to expose the cranial surface of the radius. Extend the incision proximally by incising between the extensor carpi radialis muscle and the pronator teres muscle. If needed, the insertions of the pronator and supinator muscles are incised on the radius (Plate 61A).[2] Limit the exposure to the distal portion of the radius for distal radial diaphyseal fractures.

**Reduction:** Reduce transverse fractures by tenting the bone ends dorsally and levering the bone back into position. Short oblique fractures may be better reduced by tenting the bone ends medially and levering the bone back into position. Distal radial fractures may also be reduced by securing a precontoured plate to the distal segment and reducing the proximal segment to the plate. Maintain reduction by securing the plate with plate-holding forceps. Reduce and secure long oblique fractures with pointed reduction forceps. Reduce comminuted nonreducible fractures by distracting and aligning the major segments of the bone while being careful not to disturb the fragments.

**Stabilization:** Apply an appropriately contoured plate to the cranial surface of the radius (Plate 61B1). The plate can function as a compression plate when used to compress transverse or short oblique fractures. Alternatively, a veterinary T plate or cuttable plate may be used for distal radial transverse or short oblique fractures (Plate 61B2). Round hole plates act as tension band plates and do not allow compression with the plate.[3] A plate may also be applied to the medial surface of the distal radius (Plate 61B3).[4] Plates are used as a neutralization plate to support a reconstructed fracture (Plate 61C) or as a bridging plate spanning a nonreducible comminuted fracture (Plate 61D). If additional support is needed, an intramedullary pin may be placed in the ulna to support the bridging plate fixation.[3]

## CAUTIONS

In immature dogs, crossing the distal radial physis with the plate or screws should be avoided. The articular surface should also be avoided. It is important to pay careful attention to bony anatomic landmarks to avoid rotation of the distal segment.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for fracture reduction or bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be evaluated in 6 weeks. The intramedullary pin should be removed from the ulna after radiographic signs of bone bridging are observed. Radiographs should be repeated at 6-week intervals until the fracture is healed. Plate removal may be necessary after the fracture heals to relieve soft tissue irritation or thermal conduction.

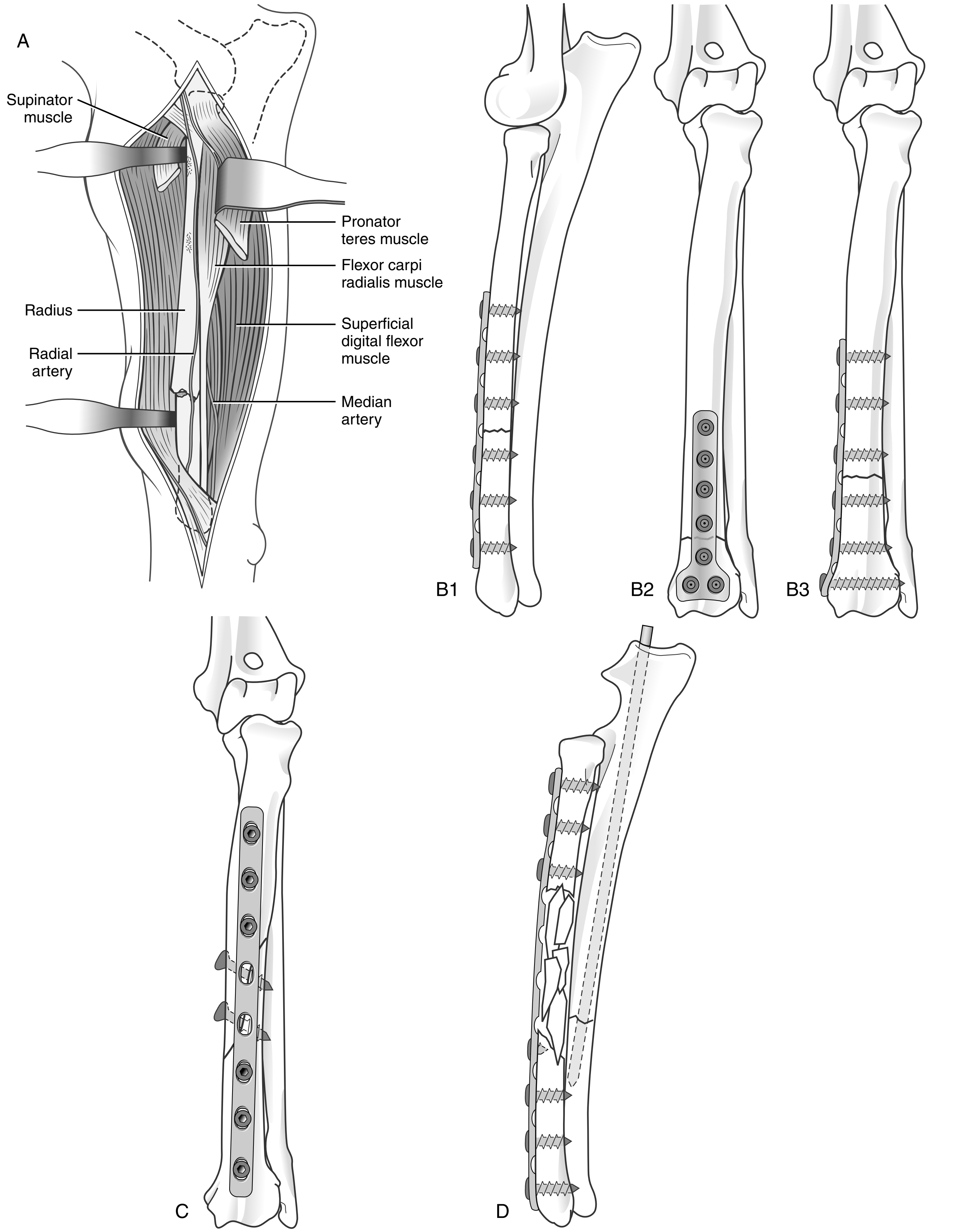
## EXPECTED OUTCOME

Generally, bone healing is seen in 6 to 12 weeks; then good function is expected.[5] Delayed union may occur in toy breed dogs.[1] Bone resorption or osteopenia may occur under the plate in toy breed dogs whose fractures are stabilized with relatively large, stiff plates.[5]

### References


1. Welch JA, Boudrieau RJ, DeJardin LM, et al: The intraosseous blood supply of the canine radius: Implications for healing of distal fractures in small dogs. Vet Surg 26:57, 1997.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Binnington AG, Miller CW: Fractures of the radius and ulna. In Brinker WO, Piermattei D, Flo GL (eds): Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.
4. Sardinas JC, Montavon PM: Use of a medial bone plate for repair of radius and ulna fractures in dogs and cats: A report of 22 cases. Vet Surg 26:108, 1997.
5. Larsen LJ, Roush JK, McLaughlin RM: Bone plate fixation of distal radius and ulnar fractures in small- and miniature-breed dogs. J Am Anim Hosp Assoc 35:243, 1999.

# PLATE 61


A
Supinator muscle
Pronator teres muscle
Flexor carpi radialis muscle
Radius
Superficial digital flexor muscle
Radial artery
Median artery
B1
B2
B3
C
D

## RADIUS

# CHAPTER 62 Application of an External Fixator to the Radius

### INDICATIONS
Candidates include animals with single or comminuted radial diaphyseal fractures.

### OBJECTIVES
- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment for comminuted fractures

The stiffness of the fixator can be increased for animals with low fracture-assessment scores by adding fixation pins and using biplanar or bilateral frames.[1] The fracture and fixator combination, or the fixator alone, resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS
The radius has a flat, wide, cranial surface; narrow medial and lateral surfaces; and variable cranial bowing of the diaphysis. The proximal radial joint surface parallels the distal radial joint surface when viewed on a cranial caudal radiograph. The proximal third of the bone is completely covered with muscle, whereas the medial aspect of the distal two thirds of the radius is covered only by skin and subcutaneous tissue. The cephalic vein crosses the medial portion of the distal radius. In general, fixation pins can be applied on the cranial medial, medial, cranial lateral, and lateral surfaces of the bone.

### EQUIPMENT
- Surgical pack, Senn retractors, small Hohmann retractors, periosteal elevator, pointed reduction forceps, Jacob pin chuck, low-speed power drill, external fixation equipment, pin cutter, bone curette for harvesting cancellous graft

### PREPARATION AND POSITIONING
Prepare the affected forelimb circumferentially from midline to foot. Position the animal in dorsal recumbency, and suspend the affected limb from the ceiling. Drape the limb out in the hanging position. Prepare the ipsilateral proximal humerus for cancellous bone autograft donor site if open reduction is used.

### PROCEDURE
**Approach:** Perform a limited medial approach to the fracture site for reducible fractures (Plate 62A). Use closed reduction techniques for nonreducible fractures (Plate 62B). Incise the skin and create soft tissue tunnels to the bone for pin placement.

**Reduction:** Lower the table to allow the animal's weight to fatigue the muscles. For transverse fracture lines, lever the fragments into position through the limited surgical approach (see Plate 62A). Maintain the reduction manually. Reduce and maintain long oblique fractures with pointed reduction forceps while lag screws or cerclage wires are applied. For closed reduction of comminuted fractures, use the proximal and distal transfixation pins to manipulate the bone and align the joint surfaces. Maintain reduction by securing the connecting bars. Medial and lateral angular alignment is correct when the proximal and distal joint surfaces are parallel (see Plate 62B). Cranial caudal joint surface relationships should mimic the contralateral intact bone. Check rotational alignment by flexing the elbow and the carpus after raising the table: the paw should align with the radius.

**Stabilization:** Apply a type Ia external fixator to the cranial medial surface of the radius (Plate 62C). Place fixation pins in the metaphysis of each segment and close to the fracture line. Place at least two (or preferably three) fixation pins in each bone segment. Use positive profile, end-threaded pins to increase pin bone interface stability. Apply a type Ib frame by placing a unilateral frame on the cranial medial surface of the radius and an additional unilateral frame on the cranial lateral surface of the radius (Plate 62D1). Connect the biplanar frames with articulating bars (Plate 62D2). Apply a type II frame by inserting transfixation pins through the metaphyses and additional fixation pins 1 cm to 2 cm from the fracture line. Place additional pins when there is adequate bone. If the cranial curve of the radius precludes the placement of transfixation pins, unilateral fixation pins can be applied to the diaphysis of the radius (Plate 62E).[2,3]

### CAUTIONS
It is important to avoid major nerves and vessels and joint surfaces with the fixation pins. To accommodate the width of the radius and avoid fracturing the bone, it is advisable to consider using smaller fixation pins when they are inserted medially and laterally. Angular and rotational alignment should be monitored during the reduction. Intraoperative radiographs are useful to verify joint alignment during closed reductions.

### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for fracture reduction or bone alignment and implant placement. Angular malalignments should be corrected by loosening the clamps and realigning the fixation pins on the connecting bar.

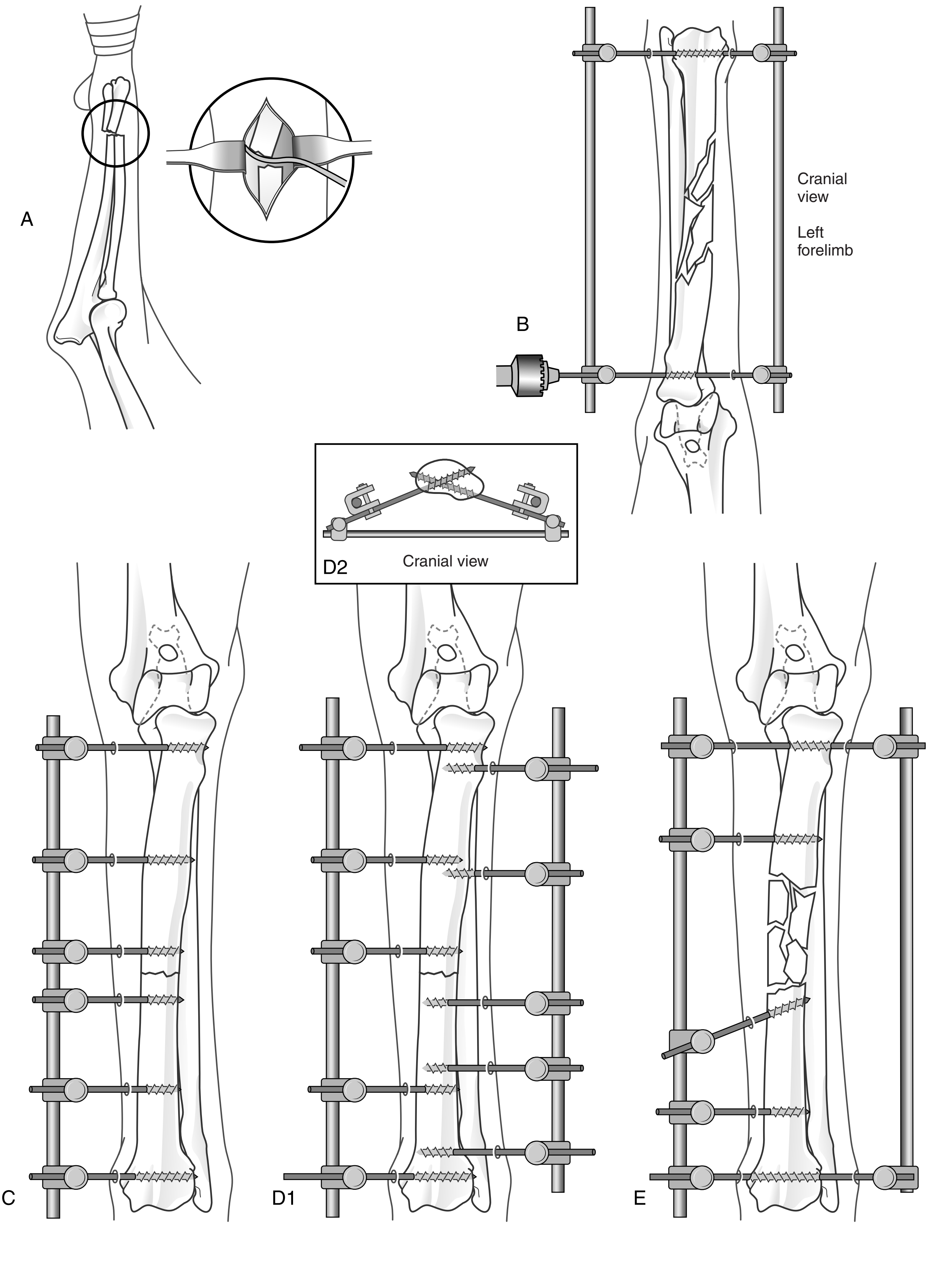
### POSTOPERATIVE CARE
Gauze sponges should be packed around the pins, and the sponges should be secured with a bandage that incorporates the paw to limit postoperative swelling. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Radiographs should be repeated at 6-week intervals to evaluate healing. The fixator should be destabilized by removing one unilateral frame (type Ib fixator), selected fixation pins (type Ia or type II fixator), or one connecting bar (of the type II fixator) when bone bridging is observed. The external fixator should be removed when the fracture is healed.

### EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal. Animals experience limited function while the external fixator is in place but should have a good return to function.[3]

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, external skeletal fixators. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Johnson AL, Seitz SE, Smith CW, et al: Closed reduction and type II external fixation of severely comminuted fractures of the radius and tibia in dogs: 23 cases (1990–1994). J Am Vet Med Assoc 209:1445, 1996.

# PLATE 62



# RADIUS

# Chapter 63 Distal Radial Physeal Fractures

## INDICATIONS

Candidates include animals with Salter I and Salter II fractures of the distal radial physis.

## OBJECTIVES

- To stabilize the fracture and achieve anatomic reduction of the distal radial physis

## ANATOMIC CONSIDERATIONS

The cranial medial surface of the distal radius can be easily palpated to serve as a landmark for location of the incision. The cephalic vein crosses the medial portion of the distal radius. The common and lateral digital extensor tendons lie cranial to the antebrachial carpal joint and may need to be retracted to expose the antebrachial carpal joint surface. The extensor carpi radialis tendon lies over the medial aspect of the joint. The antebrachial carpal joint is supported by the short radial collateral ligaments, which arise from the medial styloid process of the radius; by the dorsal radiocarpal ligament, which arises from the dorsal surface of the distal radius; and by the short ulnar collateral and radioulnar ligaments, which arise from the ulnar styloid process.

## EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, periosteal elevator, pointed reduction forceps, Kirschner wires or small Steinmann pins (for large dogs), pin chuck or high-speed wire driver, wire cutter or pin cutter

## PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from shoulder to the digits. Position the animal in lateral recumbency, with the affected limb up or in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not necessary.

## PROCEDURE

**Approach:** Incise skin and subcutaneous tissue dorsally from distal radial diaphysis to the proximal metacarpus. Elevate and retract the extensor tendons laterally as needed for fracture visualization (Plate 63A).

**Reduction:** Carefully reduce the physeal fracture to avoid crushing or injuring the physeal cartilage. Maintain reduction with pointed reduction forceps or manual pressure (Plate 63B).

**Stabilization with Crossed Kirschner Wires:** Drive a Kirschner wire from the medial styloid process, across the physis into the radial metaphyses, and through the lateral cortex. Drive a second wire from the lateral aspect of the distal radial epiphysis, across the fracture into the metaphysis, and through the medial cortex avoiding the articular surface (Plate 63C). If possible, bend the pins and cut off the excess.[1]

## CAUTIONS

It is important to avoid damaging the physeal cartilage or articular cartilage.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for reduction and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be evaluated in 4 weeks. Implant removal may be required if irritation occurs.

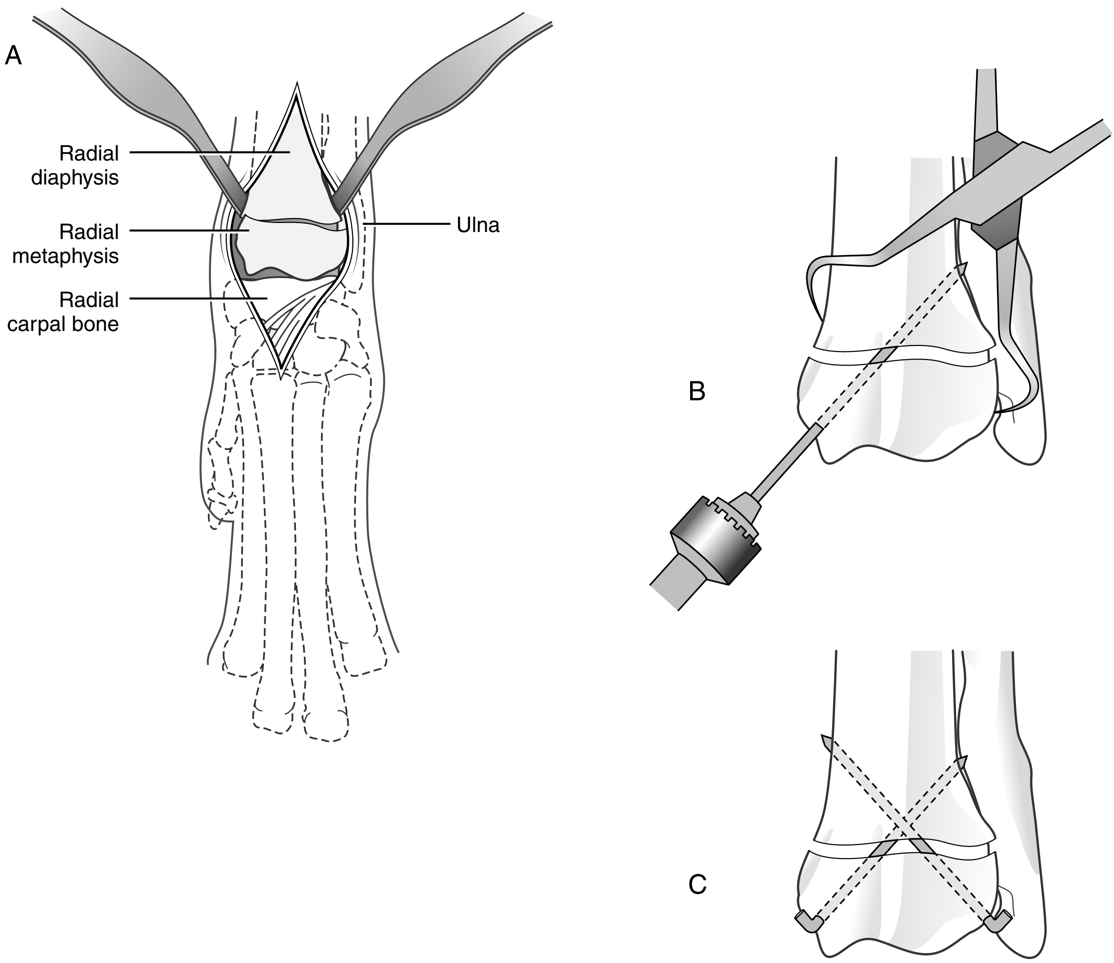
## EXPECTED OUTCOME

Rapid bone healing is usually seen, but premature closure of the physis may occur; this will cause radial shortening if the animal is still growing.

### Reference

1. Johnson AL, Hulse DA: Management of specific fractures, radial and ulnar physeal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 63


A
Radial diaphysis
Radial metaphysis
Radial carpal bone
Ulna
B
C

# ULNA

# Chapter 64 Proximal Ulnar Fractures

## INDICATIONS

Transverse proximal ulnar fractures, including articular fractures, are treated with either a tension band wire or a plate, depending on the size, activity, and healing potential of the animal. Comminuted reducible proximal ulnar fractures, including articular fractures and comminuted nonreducible ulnar fractures, are treated with reconstruction of the articular surface and either a neutralization plate or bridging plate. The tension band wire converts tensile forces to compressive forces at the fracture. The plate provides rigid fixation and resists axial loading, bending, and rotation.

## OBJECTIVES

- To convert the tensile forces resulting from the pull of the triceps muscles to compressive forces at the fracture; to achieve anatomic reduction of the articular surface; and to neutralize the forces acting on the fracture or bridge the fracture with a plate

If an associated luxation of the radial head is present (Monteggia fracture), reduction and stabilization of the radial head are imperative.

## ANATOMIC CONSIDERATIONS

Landmarks for the approach to the proximal ulna are the olecranon and the palpable caudal border of the ulna. The articular surface of the trochlear notch can be exposed surgically by muscle elevation. The ulnar nerve courses over the medial aspect of the elbow, caudal to the medial epicondyle.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, pointed reduction forceps, high-speed drill and Kirschner wire driver, Kirschner wires, orthopedic wire, wire tighteners, plating equipment, bone curette for harvesting cancellous graft

## PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from shoulder to carpus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. The ipsilateral proximal humerus can serve as a cancellous graft harvest site.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue medial to the caudal border of the ulna, starting at the olecranon and extending distally over the ulnar diaphysis. Elevate the flexor carpi ulnaris and deep digital flexor muscles medially, and the ulnaris lateralis muscle laterally, to expose the bone surface. Reflect the origin of the flexor carpi ulnaris muscle to expose the trochlear notch and articular surface (Plate 64A).[1] Use an “open but do not disturb the fragments” technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible nonarticular fractures.[2]

**Reduction:** Extend the elbow to aid reduction. For single fractures, secure the proximal fragment with a pointed reduction forceps and place it into alignment. Oblique fracture reduction may be maintained with pointed reduction forceps, but in transverse fractures, manual maintenance of reduction is necessary. Be sure the articular surface is anatomically aligned. Reduce comminuted, nonreducible fractures by distracting the fracture and aligning the major segments of the bone. Be sure to restore length and normal rotational alignment to the bone.

**Stabilization:** To stabilize a transverse or short oblique fracture, use a tension band wire. Start two Kirschner wires in the proximal fragment, and drive them across the fracture line to lodge in the distal bone segment. Alternatively, retrograde the Kirschner wires before reducing the fracture. Place a transverse drill hole in the distal bone segment, pass a figure-eight wire through the hole and around the Kirschner wires, and tighten the figure-eight wire. Bend the Kirschner wires and rotate the ends over the triceps tendon (Plate 64B). Alternatively, apply an appropriately contoured plate to the lateral surface of the ulna. Compress the fracture line, using the loaded drill guide to insert one or two screws (Plate 64C). To stabilize a comminuted reducible fracture, reduce the articular fragments anatomically, and compress the fracture lines with lag screws. Apply an appropriately contoured plate to the lateral surface of the ulna (Plate 64D). Comminuted, nonreducible fractures that do not affect the joint surface may be bridged with a plate (Plate 64E). Plates may be applied to the caudal surface of the ulna, if size permits.[3]

## CAUTIONS

Articular reduction should be maintained during implant application. It is important to avoid penetrating the articular surface with implants. The hard bone of the ulna makes drilling wires difficult. It is necessary to irrigate during drilling to reduce bone necrosis. Pin placement must follow the contour of the proximal ulna.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for articular surface reduction and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Physical therapy should be performed daily, flexing and extending the elbow until adequate range of motion returns. Radiographs should be repeated at 6-week intervals until the fracture is healed.

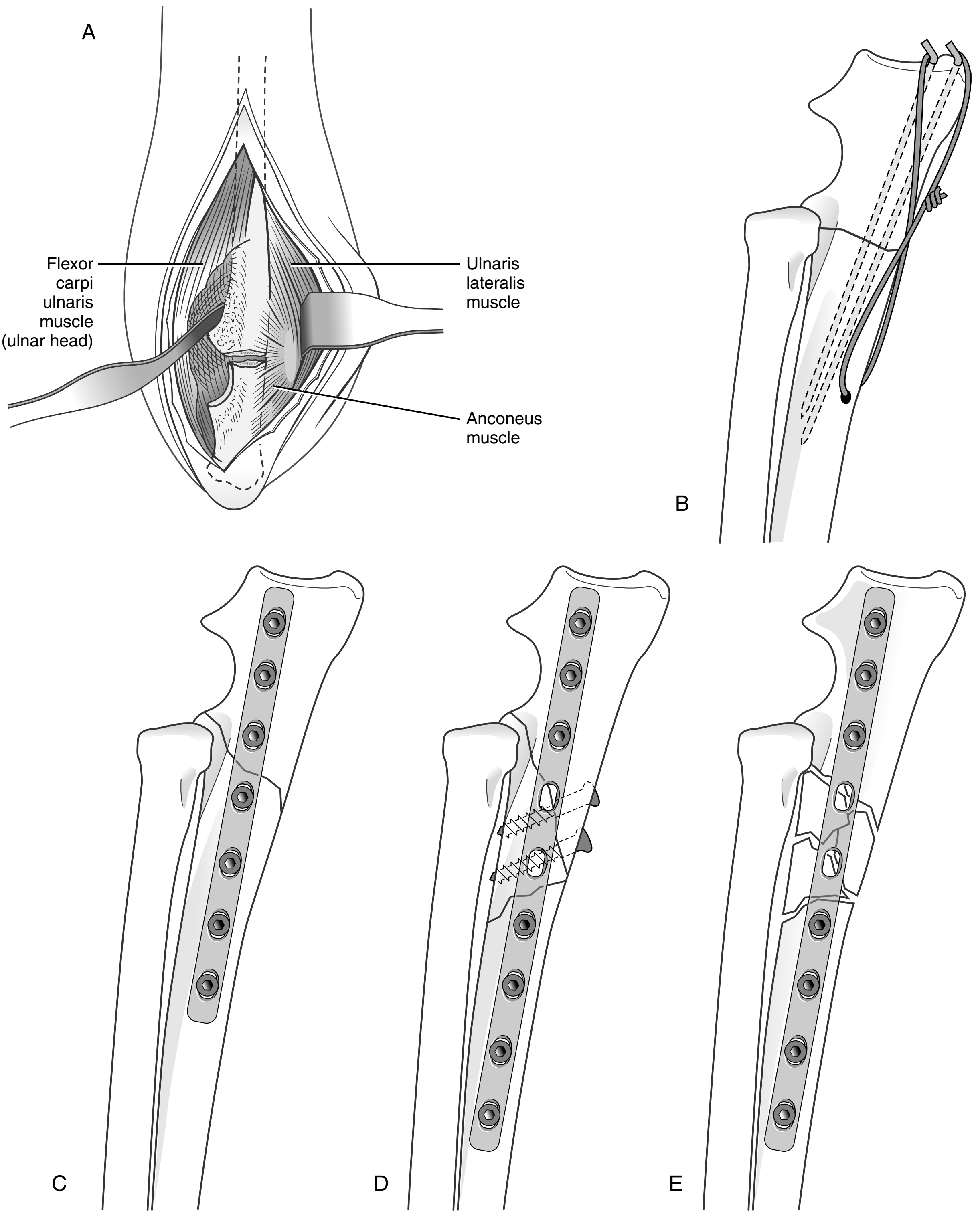
## EXPECTED OUTCOME

Bone healing is usually seen in 6 to 18 weeks, depending on the fracture and signalment of the animal. Animals usually experience a good return to function. Degenerative joint disease may result from articular trauma, with severity depending on accuracy and maintenance of reduction. Pin migration may occur with tension band wires.[3] Implant removal may be necessary if soft tissues are irritated.

### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
3. Muir P, Johnson KA: Fractures of the proximal ulna in dogs. Vet Comp Orthop Traumatol 9:88, 1996.

# PLATE 64


A
Flexor carpi ulnaris muscle (ulnar head)
Ulnaris lateralis muscle
Anconeus muscle
B
C
D
E

# PELVIS

# CHAPTER 65 Sacroiliac Luxation

## INDICATIONS

Candidates include animals with unstable sacroiliac luxations, especially those that cause pelvic canal narrowing.

## OBJECTIVES

- To restore pelvic canal width and stabilize the sacroiliac joint

## ANATOMIC CONSIDERATIONS

The sacroiliac joint has two distinct components: (1) a semilunar, crescent-shaped, synovial joint and (2) a fibrocartilaginous synchondrosis. The landmarks of the notch on the lateral surface of the sacrum and the crescent-shaped auricular cartilage are used to position the screw into the body of the sacrum.[1] The sacral nerve roots and the sciatic nerve course behind the ilial body.

## EQUIPMENT

- Surgical pack, Senn retractors, periosteal elevator, Gelpi retractors, blunt Hohmann retractor, Kern bone-holding forceps, bone screws and instruments for inserting screws, high-speed drill

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia and from 10 cm cranial to the iliac crest to the tail head caudally. Position the animal in lateral recumbency, with the affected limb up and with the dorsal midline raised 45 degrees from the table. A cancellous bone graft is usually unnecessary.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue, beginning over the dorsal iliac crest and extending caudally parallel to the spine to a point even with the hip joint, to expose the iliac crest. Incise through the periosteal origin of the middle gluteal muscle on the lateral ridge of the iliac crest and the deep gluteal fascia and periosteal origin of the sacrospinalis muscle on the medial ridge of the iliac crest. The incisions merge caudally, where it may be necessary to incise through fibers of the superficial gluteal muscle. Reflect the ilium laterally to expose the sacroiliac joint. Elevate the middle gluteal muscle from the lateral surface of the ilium to further expose the ilium for screw placement.[2] Position a blunt Hohmann retractor between the ilium and ventral bony shelf of the sacrum, and reflect the ilium ventrally to expose the sacral joint surface (Plate 65A).[3]

**Reduction:** Place a Kern bone-holding forceps on the wing of the ilium to manipulate the hemipelvis (see Plate 65C). Reduction is achieved and maintained with the bone screw.

**Stabilization:** Use the appropriate-sized drill bit to drill a thread hole 2 mm cranial and 2 mm proximal to the center of the crescent-shaped articular cartilage (Plate 65B). The depth of the thread hole in the sacral body should be such that the screw tip will extend to the midline of the sacral body.[4] Determine the proper location of the glide hole in the ilium by palpating the articular prominence on the medial surface of the iliac wing or by locating the glide hole in the caudal dorsal quadrant of the area of the ilium under the straight portion of the dorsal iliac crest (Plate 65C). Drill the glide hole at the predetermined position with the appropriate-sized drill bit. Advance a cancellous screw of the proper length through the glide hole until the tip appears on the medial surface of the ilium. Use the Kern bone-holding forceps to manipulate the ilium caudally into alignment with the articular surface of the sacroiliac joint. Visually guide the screw tip into the prepared thread hole in the sacrum, and then tighten the screw (see Plate 65C). A second screw may be added if room permits.[5] Large or overweight dogs may benefit from inserting a transilial bolt (generally a small end, threaded, Steinmann pin) through the iliac wings, over the dorsal surface of L7. Bend the smooth end, and place a nut on the threaded end to prevent pin migration (Plate 65D).[5]

## CAUTIONS

The screw must be optimally placed into the sacral body to gain secure bone purchase and avoid implant failure. It is important to avoid damaging nerve roots and to avoid screw insertion into the spinal canal.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture/luxation has stabilized. Radiographs should be evaluated at 6 and 12 weeks after surgery. Radiographic evidence of bone bridging or callus formation at the sacroiliac joint may or may not be evident.

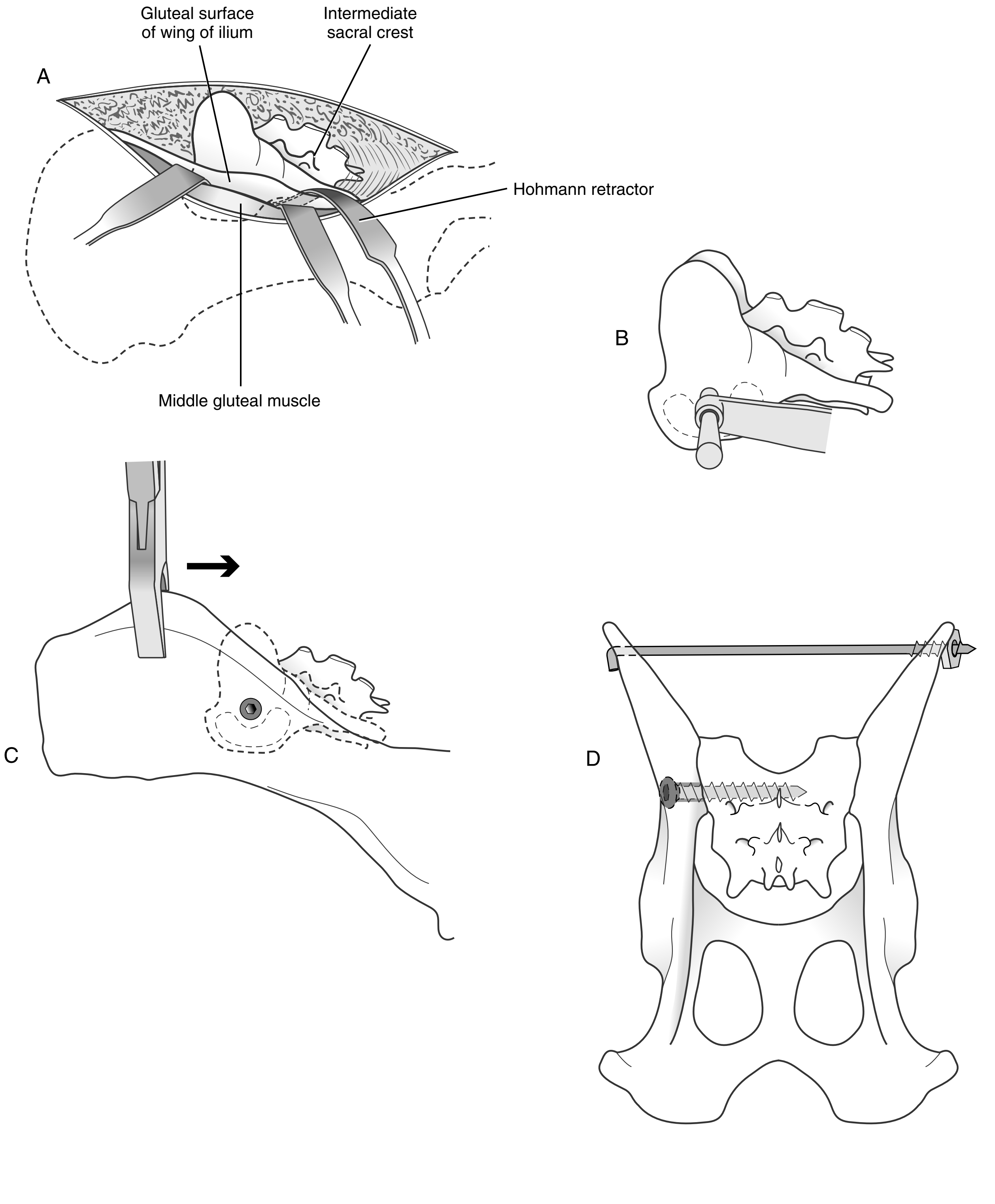
## EXPECTED OUTCOME

Bone healing is usually seen in 6 to 12 weeks. Animals should experience an excellent return to function. Implant loosening and migration, with loss of pelvic canal diameter, can occur.[6]

### References

1. DeCamp CE, Braden TD: The anatomy of the canine sacrum for lag screw fixation of the sacroiliac joint. Vet Surg 14:131, 1985.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Johnson AL, Hulse DA: Management of specific fractures: Sacroiliac luxations/fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
4. DeCamp CE: Principles of pelvic fracture management. Sem Vet Med Surg Sm Anim 7:63, 1992.
5. Piermattei DL, Flo GL: Fractures of the pelvis. In Brinker, Piermattei and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.
6. DeCamp CE, Braden TD: Sacroiliac fracture-separation in the dog: A study of 92 cases. Vet Surg 14:127, 1985.

# PLATE 65


A
Gluteal surface of wing of ilium
Intermediate sacral crest
Hohmann retractor
Middle gluteal muscle
B
C
D

# PELVIS

# CHAPTER 66 Ilial Body Fractures

## INDICATIONS

Candidates include animals with transverse or oblique displaced ilial body fractures.

## OBJECTIVES

- To achieve anatomic fracture reduction, rigid fracture stabilization, and restoration of pelvic canal width

## ANATOMIC CONSIDERATIONS

The iliac wing curves medially to hold the middle and deep gluteal muscles. The bone in the tip of the iliac wing is thin and may not hold implants well. The sacroiliac joint is located medially to the iliac wing. The ilial body is located between the wing of the ilium cranially and the acetabulum caudally. The cranial gluteal artery vein and nerve lie over the ilial body and are often damaged by the injury. The sciatic nerve is located medial to the ilial body. Reestablishment of ilial integrity is required for weight transfer from the limb to axial skeleton. With ilial fractures, the caudal fragment is often displaced medially and cranially to the wing of the ilium.

## EQUIPMENT

- Surgical pack, Senn retractors, periosteal elevator, Gelpi retractors, Myerding retractors, blunt Hohmann retractor, Kern bone-holding forceps, pointed reduction forceps, plate-reduction forceps, plating equipment, high-speed drill

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia and from 10 cm cranial to the iliac crest to the tail head caudally. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is usually unnecessary.

## PROCEDURE

**Approach:** Incise skin and subcutaneous tissue over the ventral third of the iliac wing from the cranial extent of the iliac crest to 1 cm to 2 cm beyond the greater trochanter caudally. Incise the fascia to separate the tensor fasciae latae muscle and middle gluteal muscle cranially, and the tensor fasciae latae and superficial gluteal muscle caudally. Sharply dissect cranially to separate the middle gluteal muscle and long head of the tensor fascia latae muscle. Elevate the deep and middle gluteal muscles from the lateral surface of the ilium. Sharply dissect the origin of the middle gluteal from the cranial wing of the ilium for additional exposure and easier reduction.[1] Maintain exposure using Gelpi retractors and by placing a blunt Hohmann retractor under the dorsal surface of the proximal bone segment (Plate 66A).

**Reduction:** Place Kern bone-holding forceps over the caudal ilial segment, and reposition it lateral to the cranial segment. Contour a plate to fit the normal curvature of the lateral surface of the bone, using a ventrodorsal radiograph of the contralateral ilium as a guide.[2] Attach the plate to the caudal segment first with bone screws. Use a periosteal elevator as a lever to help reduce transverse fractures. Use the Kern forceps to retract the caudal segment caudally, and use pointed reduction forceps to secure long oblique fractures in reduction. Clamp the cranial portion of the plate to the cranial segment of the ilium to obtain lateralization of the caudal ilial segment and to maintain reduction (Plate 66B).

**Stabilization:** Secure the plate by placing screws in the cranial segment. Screws may penetrate the sacrum for additional bone purchase. Place at least three plate screws in the cranial segment and two or three (space permitting) in the caudal segment (Plate 66C).[2,3]

## CAUTIONS

It is important to avoid trapping the sciatic nerve during fracture reduction and to avoid penetrating deeply into the pelvic canal with drill bits and taps. The plate should be contoured sufficiently to open the pelvic canal.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture has healed. Radiographs should be repeated at 6-week intervals until fracture healing is observed.

## EXPECTED OUTCOME

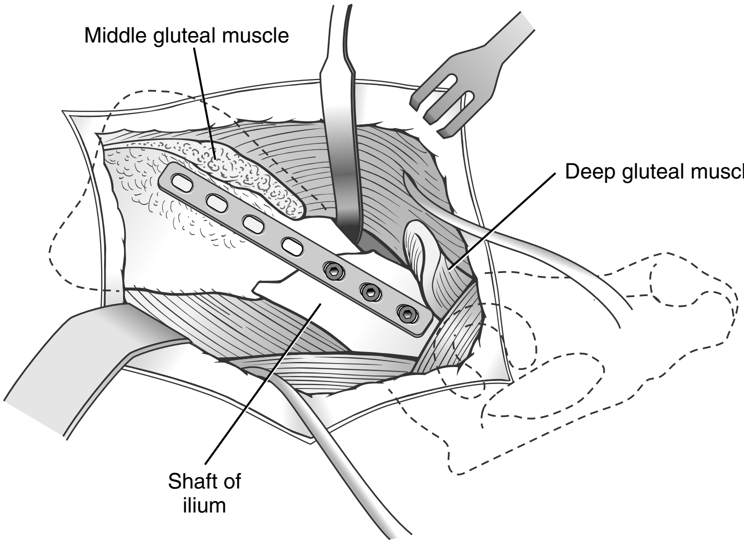
Bone healing is usually seen in 6 to 12 weeks. Animals should experience an excellent return to function. Generally, plates are not removed after bone healing unless there are problems with the implant.

### References

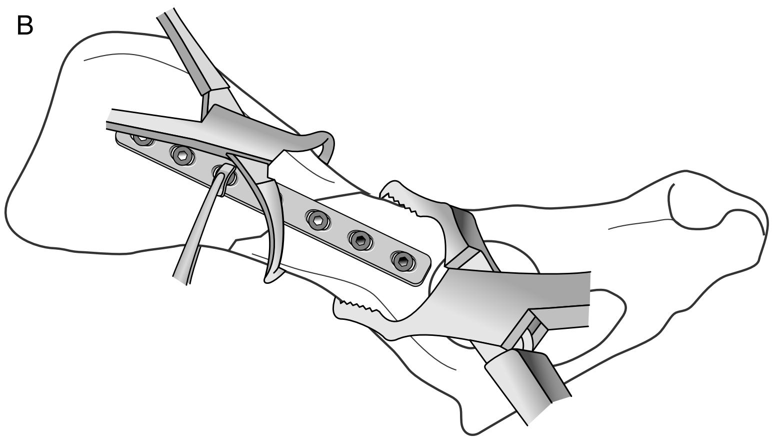
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures: Ilial fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Olmstead ML, Matis U: Fractures of the pelvis. In Brinker WO, Piermattei D, Flo GL (eds): Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 66

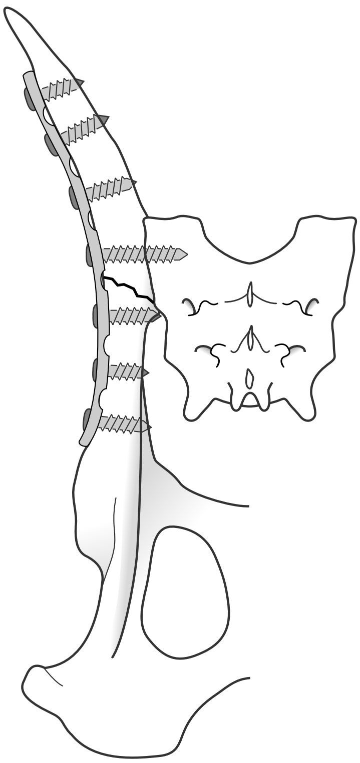
A




B



C



# PELVIS

# CHAPTER 67 Transverse or Short Oblique Acetabular Fractures

## INDICATIONS

Candidates include animals with transverse or short oblique fractures through the dorsal rim of the acetabulum.

## OBJECTIVES

- To achieve anatomic articular surface reduction and rigid fixation to encourage full return to function and minimize development of degenerative joint disease

## ANATOMIC CONSIDERATIONS

The hip joint is a ball-and-socket joint composed of the femoral head and acetabulum. The normal conformation; surrounding musculature (i.e., gluteals, internal and external rotators, and the iliopsoas muscles); suction-like effect of the synovial fluid; and ligament of the femoral head act to stabilize the joint. The articular surface is on the dorsolateral face of the acetabulum, with the round ligament on the medial face. The fibrous joint capsule originates from the lateral acetabular rim and inserts onto the femoral neck. The sciatic nerve courses dorsomedial to the acetabulum.

## EQUIPMENT

- Surgical pack, Senn retractors, periosteal elevator, Gelpi retractors, Myerding retractors, blunt Hohmann retractor, Kern bone-holding forceps, pointed reduction forceps, plating equipment, high-speed drill and K-wire driver, Kirschner wires, orthopedic wire, wire twister, wire cutter

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia, and from 10 cm cranial to the iliac crest to the tail head caudally. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is usually unnecessary.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue starting 3 cm to 4 cm proximal to the dorsal ridge of the greater trochanter and curving 3 cm to 4 cm, following the cranial border of the femur. Incise the superficial leaf of the fascia lata at the cranial border of the biceps femoris muscle, and retract the muscle caudally. Incise the deep leaf of the fascia lata, and carry the incision proximally through the insertion of the tensor fasciae latae muscle at the greater trochanter and along the cranial border of the superficial gluteal muscle. Incise through the insertion of the superficial gluteal muscle at the third trochanter. Reflect the superficial gluteal muscle proximally, and the biceps femoris caudally, to find and visualize the course of the sciatic nerve. Perform an osteotomy of the greater trochanter with an osteotome and mallet or with Gigli wire. Reflect the gluteal muscles and greater trochanter from the joint capsule with a periosteal elevator. Pre-place a suture through the insertions of the gemelli muscles and tendon of the internal obturator, and incise both structures together at the trochanteric fossa. Elevate the gemelli muscles from the caudolateral surface of the acetabulum with a periosteal elevator. Use the suture to retract the muscles proximally and caudally (Plate 67A). Incise the joint capsule to expose the articular fracture.[1]

**Reduction:** Expose the tuber ischium, and place a Kern bone-holding forceps on it. Use caudal segment control to reduce the fracture.[2] In some cases, it is possible to maintain reduction with a pointed reduction forceps or a small Kirschner wire driven across the fracture (Plate 67B). Otherwise, maintain reduction manually. Visualize the alignment of the articular surface by distracting the femoral head from the acetabulum.

**Stabilization:** Position a contoured acetabular plate or reconstruction plate on the dorsal rim of the acetabulum so at least two plate screws secure the caudal fragment and three plate screws secure the cranial fragment[3,4] (see Plate 67B). Move the plate to allow three screws purchase in the caudal segment if the fracture involves the cranial acetabulum. Close the wound by suturing the gemelli and internal obturator tendons to their point of insertion. Reduce and stabilize the greater trochanter with two Kirschner wires and a tension band wire (Plates 67C and 67D). Suture the fascial layers, subcutaneous tissue, and skin.

## CAUTIONS

The sciatic nerve must be protected. It is important to avoid penetrating deep into the pelvic canal or into the articular surface with drill bits, taps, or screws. Accurate plate contouring is essential for maintaining articular surface alignment.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for joint alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture has healed. Radiographs should be repeated at 6-week intervals until the fracture is healed. Slow leash walking and range-of-motion exercises for the hip should be encouraged.

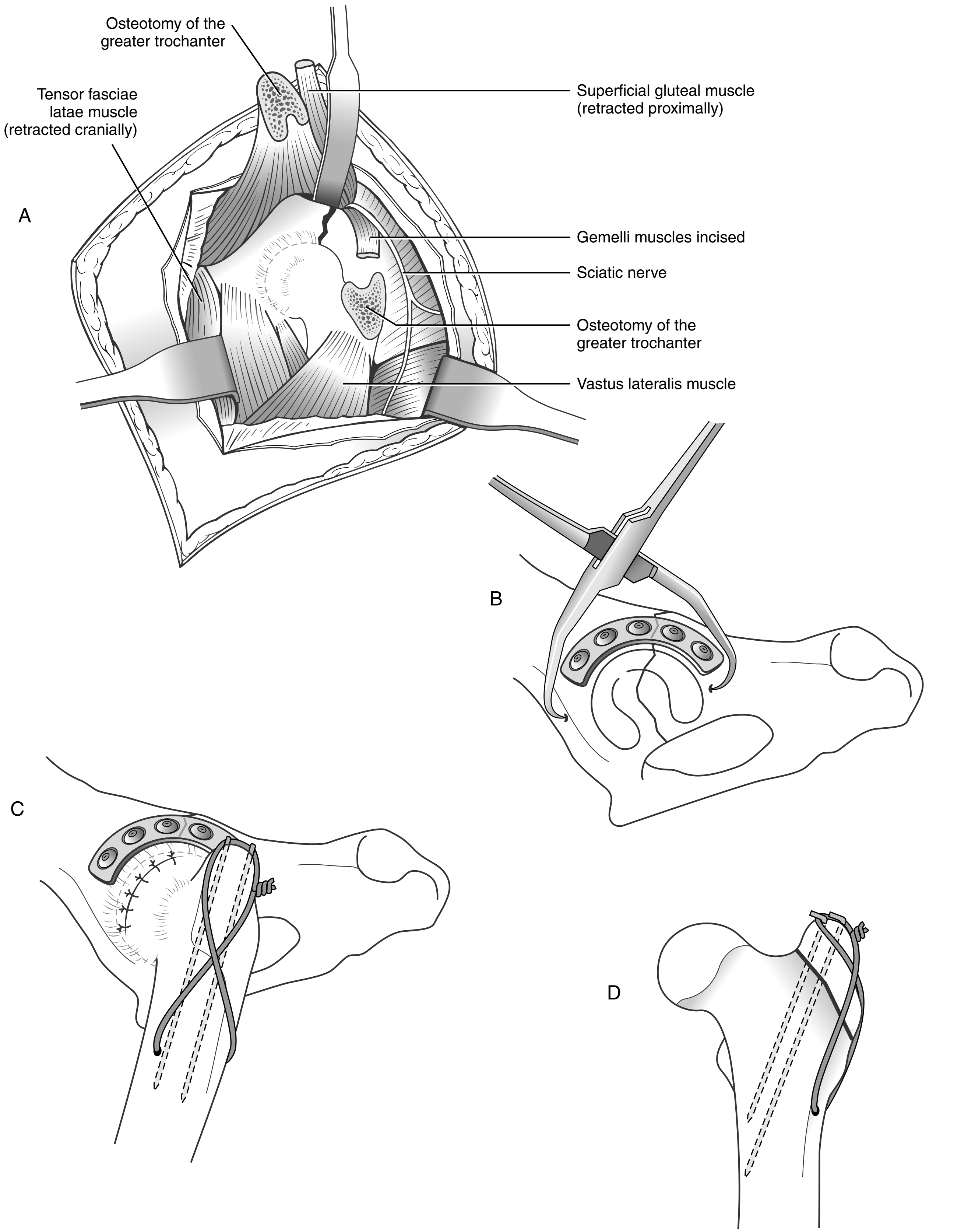
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks. Animals should experience a good return to function if anatomic reconstruction is achieved and maintained. Progressive degenerative joint disease may occur if reduction is not anatomic.[5] Plate removal is generally not necessary. Kirschner wires and orthopedic wire may be removed after bone healing if the implants irritate the soft tissues.

### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures: Acetabular fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Braden TD, Prieur WD: New plate for acetabular fractures: Technique of application and long-term follow-up evaluation. J Am Vet Med Assoc 188:1183, 1986.
4. Dyce J, Houlton JEF: Use of reconstruction plates for repair of acetabular fractures in 16 dogs. J Small Anim Pract 34:547, 1993.
5. Anson LW, DeYoung DJ, Richardson DC, et al: Clinical evaluation of canine acetabular fractures stabilized with an acetabular plate. Vet Surg 17:220, 1988.

# PLATE 67


Osteotomy of the greater trochanter
Tensor fasciae latae muscle (retracted cranially)
Superficial gluteal muscle (retracted proximally)
A
Gemelli muscles incised
Sciatic nerve
Osteotomy of the greater trochanter
Vastus lateralis muscle
B
C
D

FEMUR

# Chapter 68 Proximal Femoral Physeal Fractures

## INDICATIONS

Candidates include animals with Salter I and Salter II fractures of the physis. Occasionally this injury is accompanied by a trochanteric physeal fracture.

## OBJECTIVES

- To achieve anatomic reduction and fracture stabilization

## ANATOMIC CONSIDERATIONS

The proximal femoral physis lies between the femoral epiphysis and femoral neck, and provides neck length until maturity. The blood supply to the femoral epiphysis is a series of cervical ascending vessels lying outside the femoral neck that cross the periphery of the physis and penetrate the epiphysis. Implants must provide stability against rotational and shearing forces.[1]

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Myerding retractors, Hohmann retractors, pointed reduction forceps, periosteal elevator, Kirschner wires, high-speed quick-release wire driver, wire cutter

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not necessary.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue 5 cm proximal to the greater trochanter, curving distally adjacent to the cranial ridge of the trochanter, and extending distally for 5 cm over the proximal femur. Incise between the tensor fasciae latae muscle and deep border of the biceps femoris muscle and superficial gluteal muscle. Retract the tensor fasciae latae cranially, the biceps caudally, and the middle gluteal muscle proximally. Incise the deep gluteal tendon close to its attachment on the trochanter for one third to one half of its width. Reflect the vastus lateralis distally to expose the hip joint. Incise the joint capsule (or enlarge the traumatic tear) parallel to the long axis of the femoral neck near its proximal ridge. Continue the joint capsule incision laterally through the point of origin of the vastus lateralis muscle on the cranial face of the proximal femur (Plate 68A).[2]

**Reduction:** Grasp the proximal femur with a pointed reduction forceps, and retract the femoral neck distally so that it lies cranial and level with the acetabulum (Plate 68B). Derotate the femur, and slide the fracture surface of the femoral neck caudally into the matching surface of the femoral epiphysis. Hold the reduction by pressing against the proximal piece in the acetabulum (Plate 68C).

**Stabilization with Three Kirschner Wires:** Insert the wires from the lateral aspect of the femur, paralleling the femoral neck anteversion angle. Place the wires parallel to one another and position them in the femoral neck so that they lie in a triangle. Drive the wires until the points are just visible at the fracture surface (see Plate 68B). Reduce the fracture, and drive the pins into the femoral epiphysis. Estimate the distance into the epiphysis, and mark an adjacent pin to provide a guide (see 68C; the distance between the pin chuck and the forceps on the adjacent pin, *b*, is equal to the distance the pin will be driven into the epiphysis, *a*). Drive the remaining wires into the femoral epiphysis using a similar guiding process. Move the joint through a normal range of motion after each wire to ensure that it has not penetrated the articular surface. Bend the pins at the lateral surface, and cut off the excess (Plate 68D). Closure is routine.

**Stabilization of a Trochanteric Physeal Fracture with a Tension Band Wire:** Reduce the trochanter, and secure it with a pointed reduction forceps. Start two Kirschner wires in the fragment, and drive them perpendicular to and across the physis to lodge in the medial cortex of the proximal femur. Drill a transverse hole in the major bone segment, and pass a figure-eight wire through the hole and around the Kirschner wire. Tighten the wire (see Plate 68D).

## CAUTIONS

It is important to avoid penetrating the articular surface with the Kirschner wires.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for reduction and implant position. Frog leg and extended hip views may help pin position visualization.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking for 3 to 4 weeks. Radiographs should be evaluated in 4 to 6 weeks.

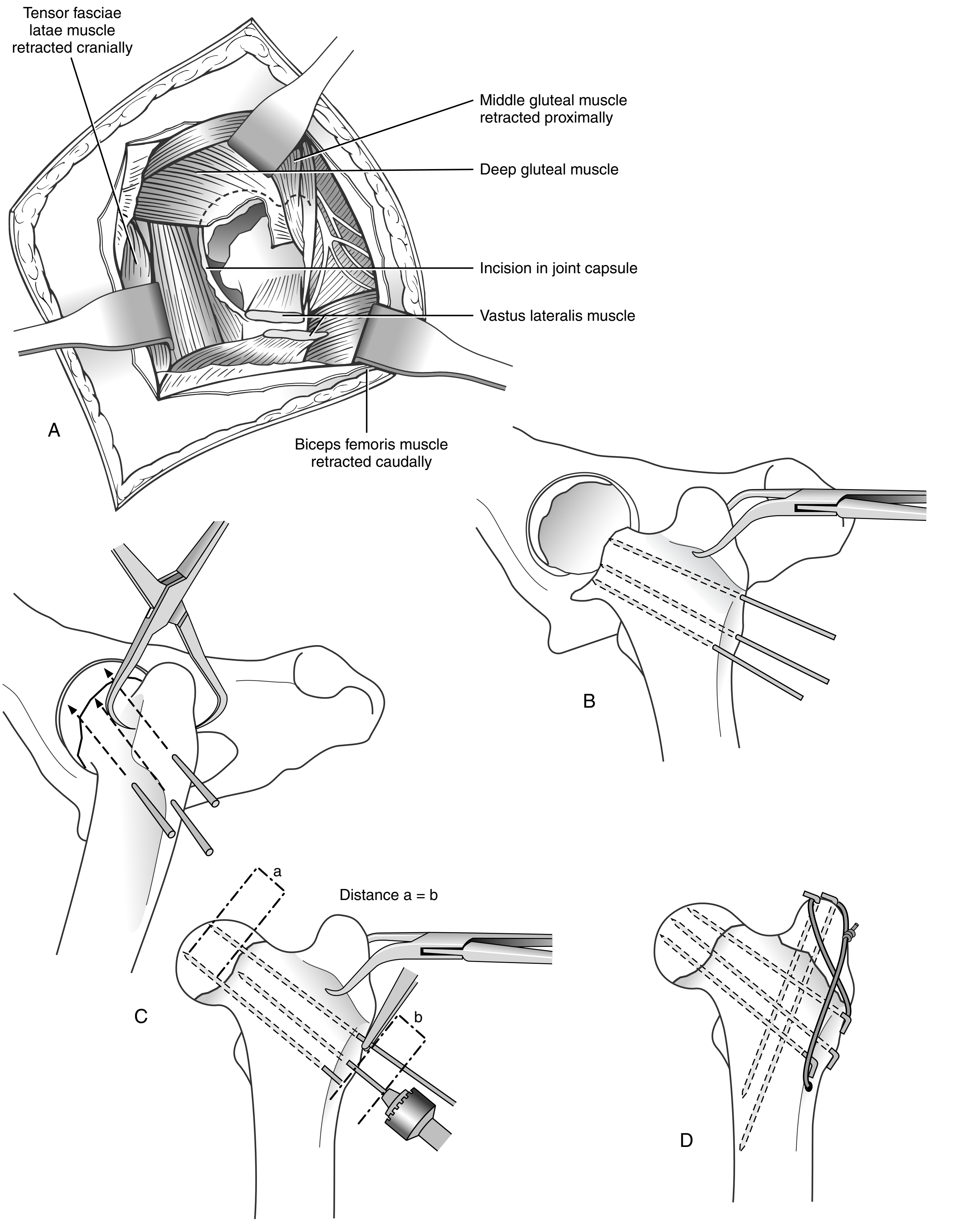
## EXPECTED OUTCOME

Rapid bone healing is usually seen within 3 to 4 weeks. Premature closure of the physis may result in a misshapen femoral head. Partial resorption of the femoral neck (apple coring effect) usually occurs, but this rarely causes a problem.

### References

1. Tillson DM, McLaughlin RM, Roush JK: Fractures of proximal femoral physis in dogs. Compend Cont Educ Pract Vet 18(11):1164, 1996.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.

# PLATE 68


Tensor fasciae
latae muscle
retracted cranially
Middle gluteal muscle
retracted proximally
Deep gluteal muscle
Incision in joint capsule
Vastus lateralis muscle
A
Biceps femoris muscle
retracted caudally
B
C
a
Distance a = b
b
D

# FEMUR

# Chapter 69 Femoral Neck Fractures

## INDICATIONS

Candidates include animals with transverse and short oblique femoral neck fractures.

## OBJECTIVES

- To achieve anatomic reduction and rigid fixation of the fracture to allow early return to function

## ANATOMIC CONSIDERATIONS

The femoral neck/femoral shaft junction in the frontal plane is known as the angle of inclination. This angle is normally 135 degrees and should be approximated when surgical reduction is performed. The normal angle of anteversion is 15 to 20 degrees and must be considered when inserting screws or pins into the femoral neck.[1]

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, Myerding retractors, periosteal elevator, Kirschner wires, bone screws and instruments for inserting bone screws, high-speed drill and wire driver, wire cutter

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from dorsal midline to mid-tibia. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral wing of the ilium for cancellous bone graft harvest.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue 5 cm proximal to the greater trochanter, curving distally adjacent to the cranial ridge of the trochanter, and extending distally for 5 cm over the proximal femur. Incise between the tensor fasciae latae muscle and deep border of the biceps femoris muscle and superficial gluteal muscle. Retract the tensor fasciae latae cranially, the biceps caudally, and the middle gluteal muscle proximally. Incise the deep gluteal tendon close to its attachment on the trochanter for one third to one half of its width. Incise the joint capsule parallel to the long axis of the femoral neck near its proximal ridge. Continue the joint capsule incision laterally through the point of origin of the vastus lateralis muscle on the cranial face of the proximal femur. Reflect the vastus lateralis ventrally to visualize the fracture surface (Plate 69A).[2] A greater trochanteric osteotomy may be required if visualization is not adequate for anatomic reduction and placement of implants.[2]

**Reduction:** Place two Kirschner wires so they lie at the most proximal and distal level of the fracture surface. Drive the pins either from medial to lateral beginning at the fracture surface or from the lateral surface medially, to exit and lie flush at the fracture surface (Plate 69B). Reduce the fracture, and drive the Kirschner wires into the femoral epiphysis to maintain reduction (Plate 69C).

**Stabilization:** Drill a thread hole through the femoral epiphysis with the appropriate-sized drill bit parallel to and centered between the Kirschner wires (see Plate 69C). Measure the length of screw needed, and tap the thread hole. Insert a partially threaded cancellous screw, 2 mm shorter than the length measured, so that all the threads cross the fracture plane and are seated into the femoral head. Leave one or both wires in place to serve as antirotational devices (Plate 69D). Close the incision routinely.

## CAUTIONS

It is important to follow the anteversion angle of the femoral neck with the implants and to avoid penetrating the articular surface with Kirschner wires and the bone screw.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for reduction and implant position. Frog leg and extended hip views may help implant position visualization.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals until the fracture has healed.

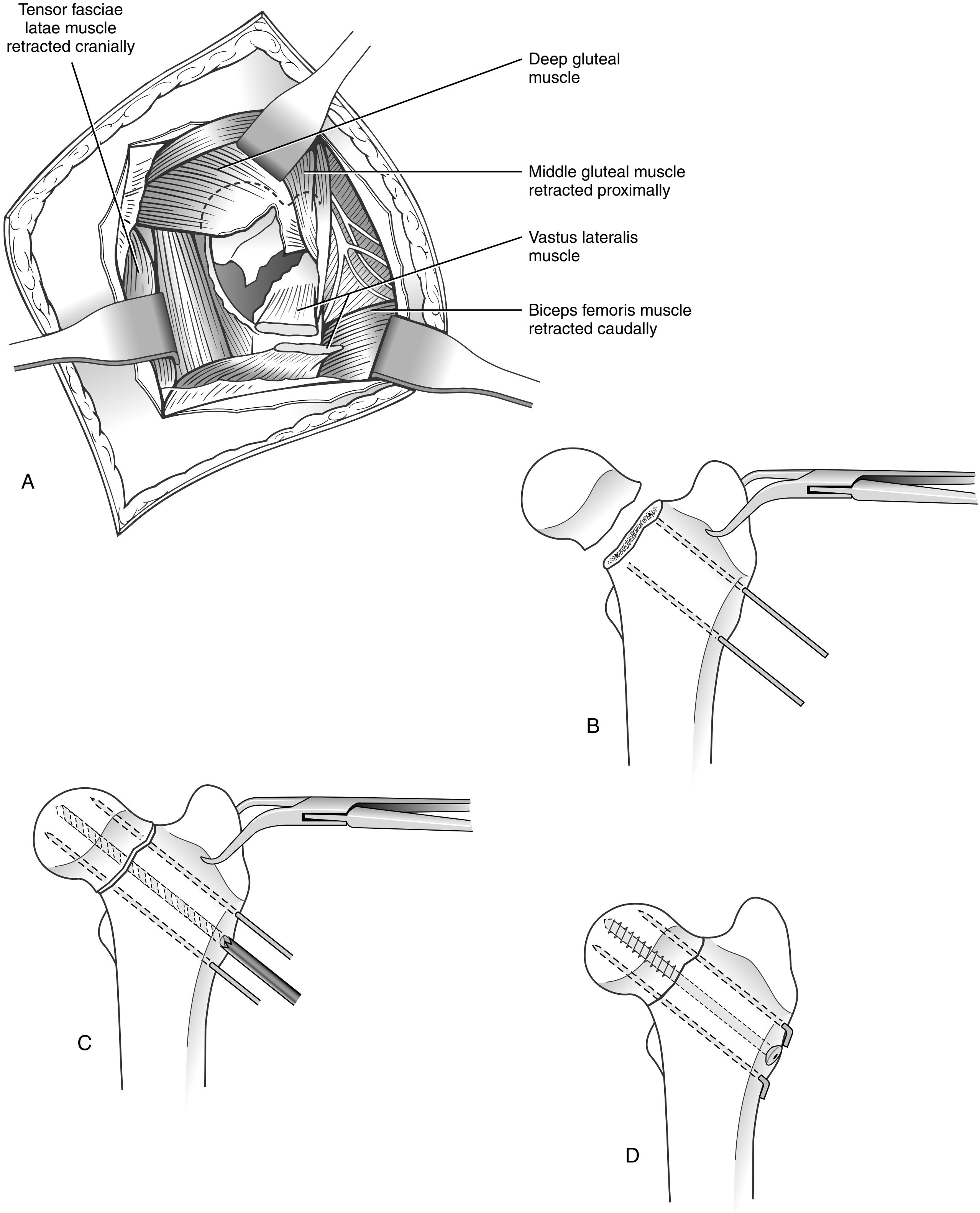
## EXPECTED OUTCOME

Bone healing is usually seen within 6 to 12 weeks. Instability at the fracture site can result in delayed union and implant failure.

### References

1. Johnson AL, Hulse DA: Femoral metaphyseal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.

# PLATE 69


Tensor fasciae latae muscle retracted cranially
Deep gluteal muscle
Middle gluteal muscle retracted proximally
Vastus lateralis muscle
Biceps femoris muscle retracted caudally
A
B
C
D

## FEMUR

# CHAPTER 70 Distal Femoral Physeal Fractures

### INDICATIONS
Candidates include animals with Salter I and Salter II fractures of the distal femoral physis.

### OBJECTIVES
- To achieve fracture stabilization, and anatomic or slight overreduction of the femoral epiphysis

### ANATOMIC CONSIDERATIONS
The distal femoral growth plate is shaped like a W and lies at the joint capsule reflection. A lateral arthrotomy is necessary for exposure. The configuration of the growth plate and cancellous bone surface provide some rotational stability.

### EQUIPMENT
- Surgical pack, Senn retractors, Gelpi retractors, blunt Hohmann retractor, periosteal elevator, Kern bone-holding forceps, pointed reduction forceps, Steinmann pins and Kirschner wires, Jacob pin chuck, wire cutter

### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from dorsal midline to tarsus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not necessary.

### PROCEDURE
**Approach:** Incise skin and subcutaneous tissue on the cranial lateral surface, with the incision centered over the palpable end of the femoral metaphysis. Make a parapatellar arthrotomy through the distal fascia lata and joint capsule, continuing the incision proximally along the caudal border of the vastus lateralis muscle through the intermuscular septum of the fascia lata. Reflect the quadriceps muscles, patella, and patella tendon medially to expose the articular surface of the femoral condyles (Plate 70A).[1]

**Reduction:** Reduce the fracture by levering the condyles cranially and distally with a blunt Hohmann retractor placed between the fracture fragments. Maintain reduction during pin placement by placing a Kern bone-holding forceps on the lateral aspect of the distal femoral metaphysis. Place a pointed reduction forceps from the trochlear surface to the jaws of the Kern (Plate 70B).

**Stabilization with Crossed Pins:** Position two pins to enter the epiphysis at a point cranial to the medial and lateral epicondyles, and drive them proximally to a point where they are just visible at the fracture surface. Reduce the fracture, and drive the pins into the femoral metaphysis and through the opposite cortices (Plate 70C).[2]

**Stabilization with an Intramedullary Pin:** Insert a pin through the articular cartilage, cranial to the origin of the caudal cruciate ligament, to the level of the fracture surface. Reduce the fracture, and direct the pin in a normograde fashion proximally into the femur to exit at the trochanteric fossa. The pin should contact the caudal surface of the medullary canal proximal to the fracture. Cut the distal part of the pin, and countersink it below the level of the articular cartilage. Cut the excess pin off below the skin above the trochanteric fossa.[3] Add a cross pin at the fracture to establish rotational stability if necessary (Plate 70D). Close the incision routinely.

### CAUTIONS
The epiphyseal bone is soft: it is important to avoid excessive bone forceps pressure. To avoid the sciatic nerve, the hip should be extended and the limb adducted when the intramedullary pin is driven through the trochanteric fossa.

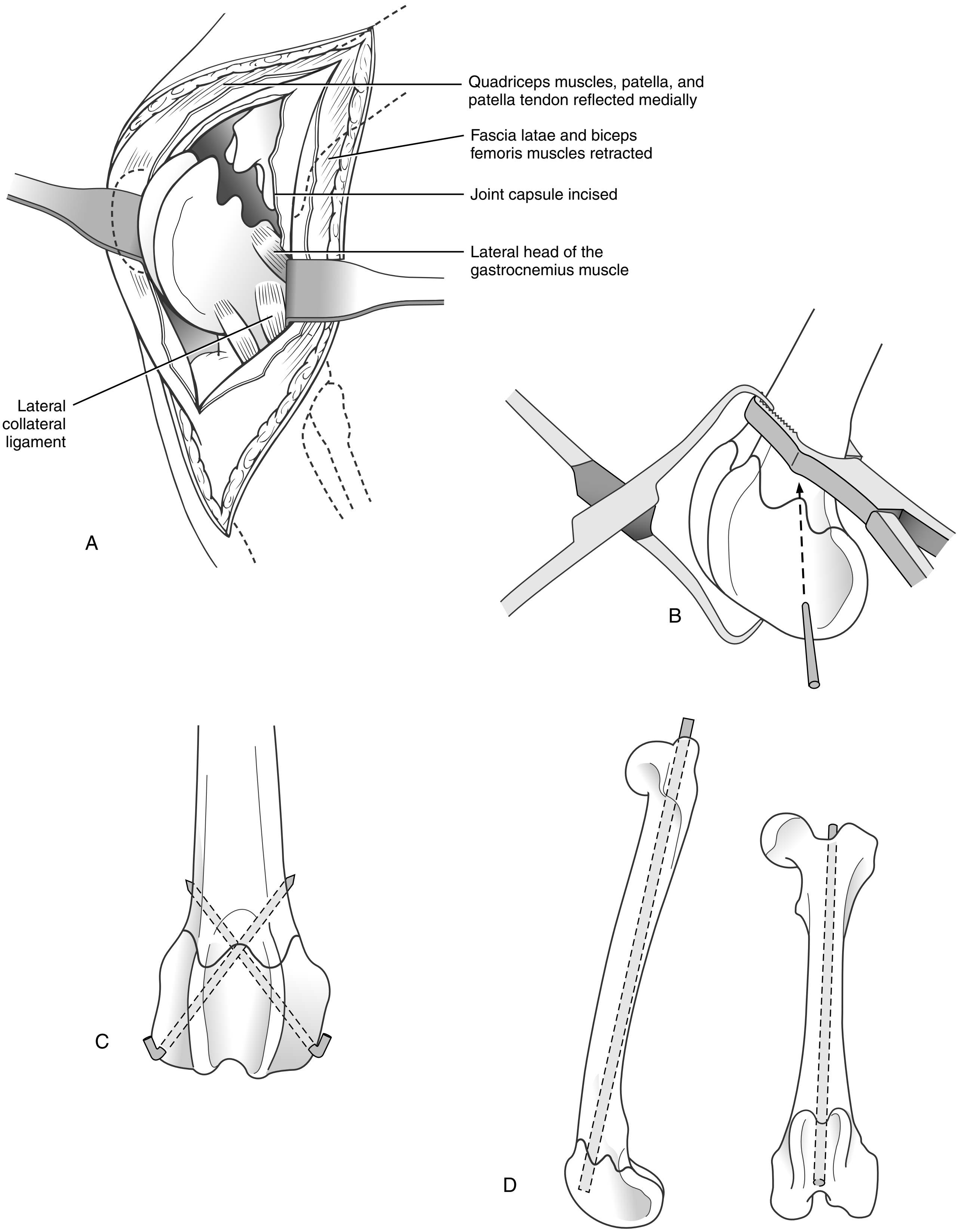
### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for bone alignment and implant placement.

### POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. Physical therapy and early return to function are necessary to avoid extensor tie down. Radiographs should be evaluated in 4 to 6 weeks.

### EXPECTED OUTCOME
Rapid bone healing is usually seen in 3 to 4 weeks. Premature closure of the physis may result in a noticeable shortened leg in very young animals.

#### References
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Sukhiani HR, Holmburg DL: Ex vivo biomechanical comparison of pin fixation techniques for canine distal femoral physeal fractures. Vet Surg 26:398, 1997.
3. Stigen O: Supracondylar femoral fractures in 159 dogs and cats treated using a nomograde intramedullary pinning technique. J small Anim Pract 40:519, 1999.

# PLATE 70


Quadriceps muscles, patella, and patella tendon reflected medially
Fascia latae and biceps femoris muscles retracted
Joint capsule incised
Lateral head of the gastrocnemius muscle
Lateral collateral ligament
A
B
C
D

## FEMUR

# CHAPTER 71 Application of an Intramedullary Pin or Interlocking Nail to the Femur

### INDICATIONS

Candidates include animals with single or comminuted femoral diaphyseal fractures.

### OBJECTIVES

- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment for nonreducible comminuted fractures

The intramedullary (IM) pin is used in animals with high fracture-assessment scores. The IM pin neutralizes bending forces at the fracture; it is combined with cerclage wire for long oblique fractures and with external fixation for transverse or short oblique fractures to neutralize rotational and axial compressive forces. The interlocking nail (ILN) neutralizes bending, rotational, and axial compressive forces at the fracture; it can be used for animals with medium and low fracture-assessment scores.[1]

### ANATOMIC CONSIDERATIONS

The narrowest part of the medullary canal, the isthmus, is located within the proximal third of bone, just distal to the third trochanter. The distal femur has a pronounced cranial bow in most dogs, but it is straight in the cat. Both anatomic features constrain the size of the IM pin or ILN selected. The trochanteric fossa is directly in line with the medullary canal, allowing normograde or retrograde placement of an IM pin and normograde placement of the ILN. The adductor magnus muscle attaches to the caudal surface of the femur and serves as a guide for rotational alignment. Additionally, the greater trochanter is 90 degrees to the patella when the rotational alignment of the femur is correct.

### EQUIPMENT

- Surgical pack, periosteal elevator, Gelpi retractors, Myerding or Hohmann retractors, pointed reduction forceps, Kern bone-holding forceps, Jacob pin chuck, IM pins, cerclage wire, wire tightener, wire cutter, external fixator clamps and connecting bars (or ILN equipment, including high-speed drill), bone curette for harvesting graft

### PREPARATION AND POSITIONING

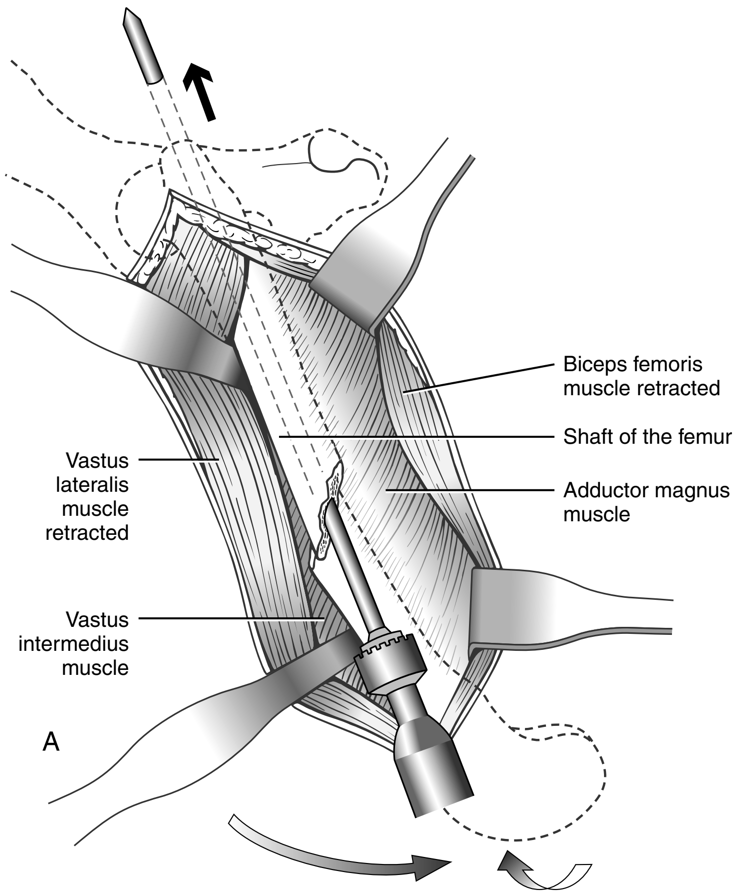
Prepare the rear limb circumferentially from dorsal midline to tarsus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal humerus or ipsilateral ilial wing for surgery for harvesting cancellous bone graft.

### PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue on the lateral surface of the thigh, from the greater trochanter to the femoral condyles. Incise the tensor fascia lata along the cranial border of the biceps femoris to expose the vastus lateralis and biceps femoris muscles. Retract the muscles to expose the femur.[2] Insert the IM pin into the proximal femur in either a normograde or retrograde manner. Extend the hip and adduct the limb when retrograding the IM pin, to avoid injuring the sciatic nerve (Plate 71A).[3] Insert the ILN in a normograde manner, starting at the trochanteric fossa. Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures.[4] Incise the skin, and create soft tissue tunnels to the bone for fixator pin placement.

*Continued*

# PLATE 71


Biceps femoris
muscle retracted
Shaft of the femur
Adductor magnus
muscle
Vastus
lateralis
muscle
retracted
Vastus
intermedius
muscle
A

**Reduction:** Place an IM pin (sized to equal 70% to 80% of the medullary canal at the isthmus) in the proximal segment. Retract the pin within the medullary canal of the proximal segment. Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Drive the IM pin distally to seat in the femoral condyle. Maintain the reduction manually for transverse fractures and with pointed reduction forceps for oblique fractures. Reduce comminuted nonreducible fractures by distracting the distal end with the IM pin or ILN and aligning the major segments of the bone.

**Stabilization:** Apply an IM pin and a type Ia external fixator to the lateral surface of the femur to stabilize a transverse or short oblique fracture. Place fixation pins in the metaphysis of each segment and close to the fracture line. The external fixator can be connected or tied in to the IM pin to strengthen the fixation (Plate 71B). Apply an IM pin and multiple cerclage wires to a long oblique fracture (Plate 71C). An external fixator can be added for additional strength. Apply an ILN and four screws to the femur to treat comminuted nonreducible fractures (Plate 71D).

## CAUTIONS

To avoid penetrating the sciatic nerve when retrograding the IM pin, the limb should be held in a hip extended and adducted position while the pin exits the trochanteric fossa. It is important to avoid the femoral head and distal joint surface with the IM pin or ILN. The range of motion of the stifle should be palpated to detect pin interference in the joint. Angular and rotational alignment should be monitored during the realignment of comminuted fractures.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking, until the fracture is healed. External fixator management includes daily pin care and pin packing as needed. Physical therapy is needed to restore stifle range of motion. Radiographs should be evaluated in 6 weeks. Fixator pins should be removed after radiographic signs of bone bridging are observed. If a tie-in is used, the top fixation pin and its connection to the IM pin should be retained. Radiographs should be repeated at 6-week intervals until the fracture is healed. The IM pin should be removed when the fracture has healed.

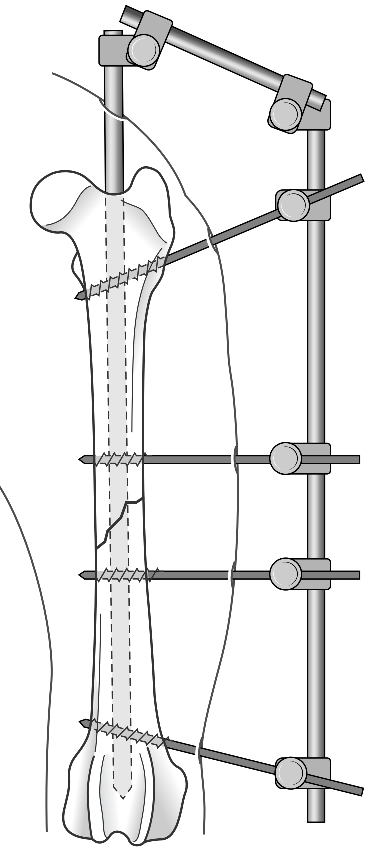
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal.

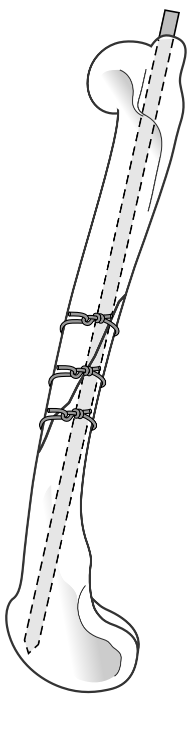
### References

1. Johnson AL, Hulse DA: Decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Palmer RH, Aron DN, Purinton PT: Relationship of femoral intramedullary pins to the sciatic nerve and gluteal muscles after retrograde and normograde insertion. Vet Surg 17:65, 1988.
4. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.

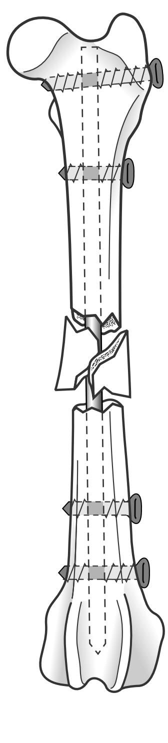
# PLATE 71



B



C



D

FEMUR

# Chapter 72 Application of a Plate to the Femur

## INDICATIONS
Candidates include animals with single or comminuted femoral diaphyseal fractures.

## OBJECTIVES
- To achieve anatomic reduction and compression of single fracture lines or restoration of normal bone alignment for nonreducible comminuted fractures

The plate is used as a compression plate for transverse or short oblique fractures, and it is combined with lag screws to compress long oblique fractures. The plate is used as a bridging plate for nonreducible comminuted fractures and may be combined with an intramedullary (IM) pin to reduce strain on the plate and to extend fatigue life of the fixation. The plate neutralizes bending, rotational, and axial compressive forces.

## ANATOMIC CONSIDERATIONS
The plate is placed on the lateral surface of the femur. The trochanteric fossa is directly in line with the medullary canal, allowing normograde or retrograde placement of an IM pin. The adductor magnus muscle attaches to the caudal surface of the femur and serves as a guide for rotational alignment. Additionally, the greater trochanter is 90 degrees to the patella when the rotational alignment of the femur is correct.

## EQUIPMENT
- Surgical pack, periosteal elevator, Gelpi retractors, Myerding or Hohmann retractors, pointed reduction forceps, Kern bone-holding forceps, self-centering plate-holding forceps, Jacob pin chuck, IM pins, high-speed drill, plating equipment, bone curette for harvesting graft

## PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from dorsal midline to tarsus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal humerus or ipsilateral ilial wing for surgery for harvesting cancellous bone graft.

## PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue on the lateral surface of the thigh, from the greater trochanter to the femoral condyles. Incise the tensor fascia lata along the cranial border of the biceps femoris to expose the vastus lateralis and biceps femoris muscles. Retract the muscles to expose the femur.[1] Insert the IM pin into the proximal femur in either a normograde or retrograde manner.[2] Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures (Plate 72A).[3]

**Reduction:** Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain the reduction manually for transverse fractures and with pointed reduction forceps for oblique fractures. Reduce comminuted nonreducible fractures by distracting the distal segment with an IM pin (sized to equal 40% to 50% of the medullary canal at the isthmus) and aligning the major segments of the bone (see Plate 72A). Be sure to restore length and normal rotational alignment to the bone.[4] Precontour the plate to the cranial caudal radiographic view of the contralateral femur to prevent angular deformities.[4]

**Stabilization:** Apply an appropriately contoured plate to the lateral surface of the femur. The plate can function as a compression plate (Plate 72B) when used to compress transverse or short oblique fratures; as a neutralization plate to support a reconstructed fracture (Plate 72C); or as a bridging plate, spanning a nonreducible comminuted fracture (Plate 72D).

## CAUTIONS
To avoid penetrating the sciatic nerve when retrograding the IM pin, the limb should be held in a hip extended and adducted position while the pin exits the trochanteric fossa. It is important to avoid the femoral head and distal joint surface with the IM pin or bone screws. The range of motion of the stifle should be palpated to detect implant interference in the joint. Angular and rotational alignment should be monitored during the realignment of comminuted fractures.

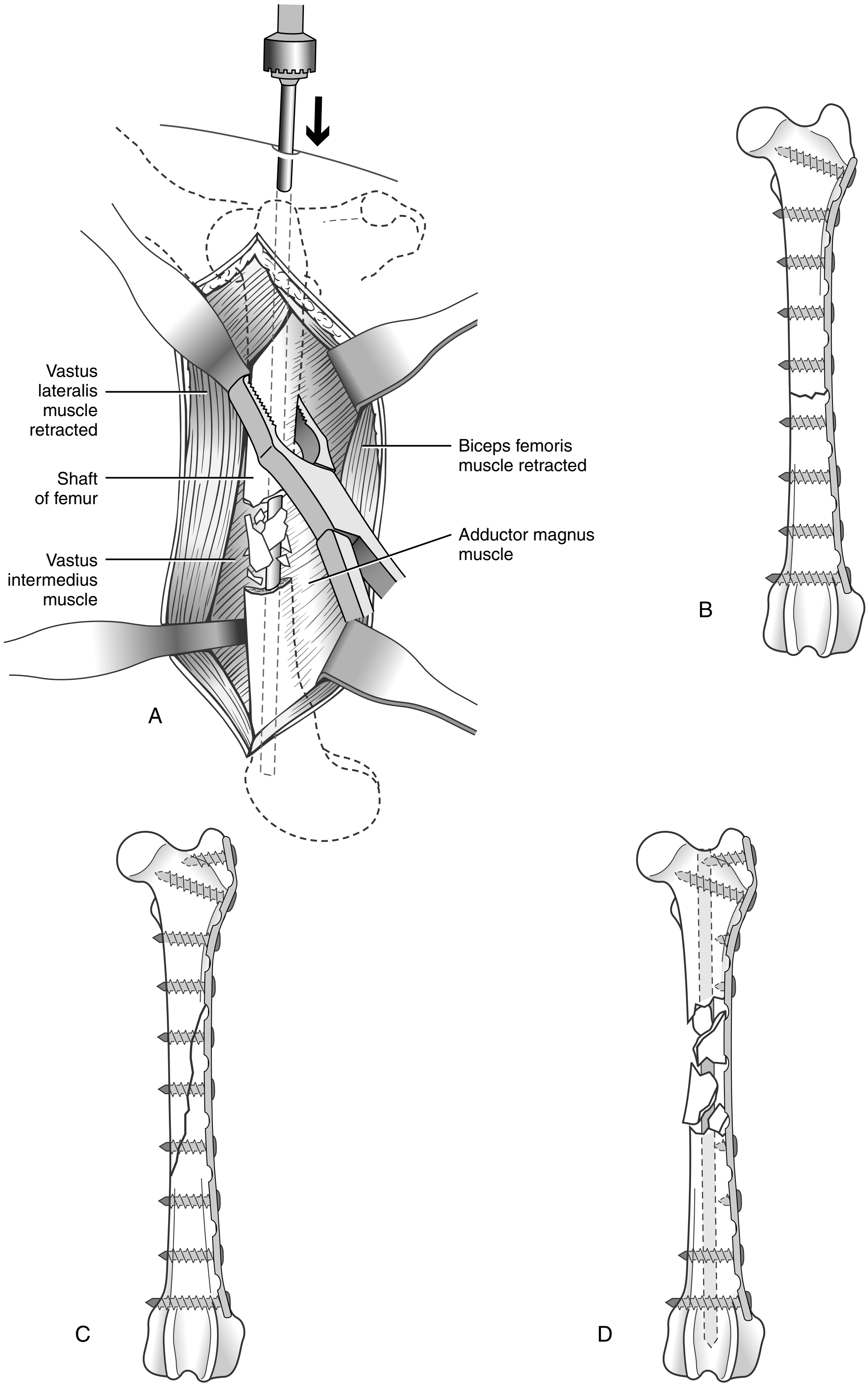
## POSTOPERATIVE EVALUATION
Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. Physical therapy is needed to restore stifle range of motion. Radiographs should be evaluated in 6 weeks. If left long, the IM pin should be removed after signs of bone bridging are observed. Radiographs should be repeated at 6-week intervals until the fracture is healed. Plate removal may be necessary after the fracture heals.

## EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal.

### References
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Palmer RH, Aron DN, Purinton PT: Relationship of femoral intramedullary pins to the sciatic nerve and gluteal muscles after retrograde and normograde insertion. Vet Surg 17:65, 1988.
3. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
4. Johnson AL, Smith CW, Schaeffer DJ: Fragment reconstruction and bone plate fixation compared with bridging plate fixation for treating highly comminuted femoral fractures in dogs: 35 cases (1987–1997). J Am Vet Med Assoc 213:1157, 1998.

# PLATE 72


Vastus lateralis muscle retracted
Shaft of femur
Vastus intermedius muscle
Biceps femoris muscle retracted
Adductor magnus muscle
A
B
C
D

## FEMUR

# CHAPTER 73 Application of an External Fixator to the Femur

### INDICATIONS
Candidates include animals with single or comminuted femoral diaphyseal fractures.

### OBJECTIVES
- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment for comminuted fractures

The stiffness of the fixator can be increased for animals with low fracture-assessment scores by adding fixation pins, incorporating an intramedullary (IM) pin or using biplanar frames.[1] The IM pin and fixator combination resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS
The narrowest part of the medullary canal, the isthmus, is located within the proximal third of bone, just distal to the third trochanter. The distal femur has a pronounced cranial bow in most dogs, but it is straight in the cat. Both anatomic features constrain the size of IM pin selected. The trochanteric fossa is directly in line with the medullary canal, allowing normograde or retrograde placement of an IM pin. The adductor magnus muscle attaches to the caudal surface of the femur and serves as a guide for rotational alignment. Additionally, the greater trochanter is 90 degrees to the patella when the femur is in correct rotational alignment. The proximity of the abdomen prohibits use of bilateral frames in the proximal femur.

### EQUIPMENT
- Surgical pack, Senn retractors, small Hohmann retractors, Gelpi retractors, Myerding retractors, periosteal elevator, Kern bone-holding forceps, pointed reduction forceps, Jacob pin chuck, IM pins, low-speed power drill, external fixation equipment, pin cutter, bone curette for harvesting graft

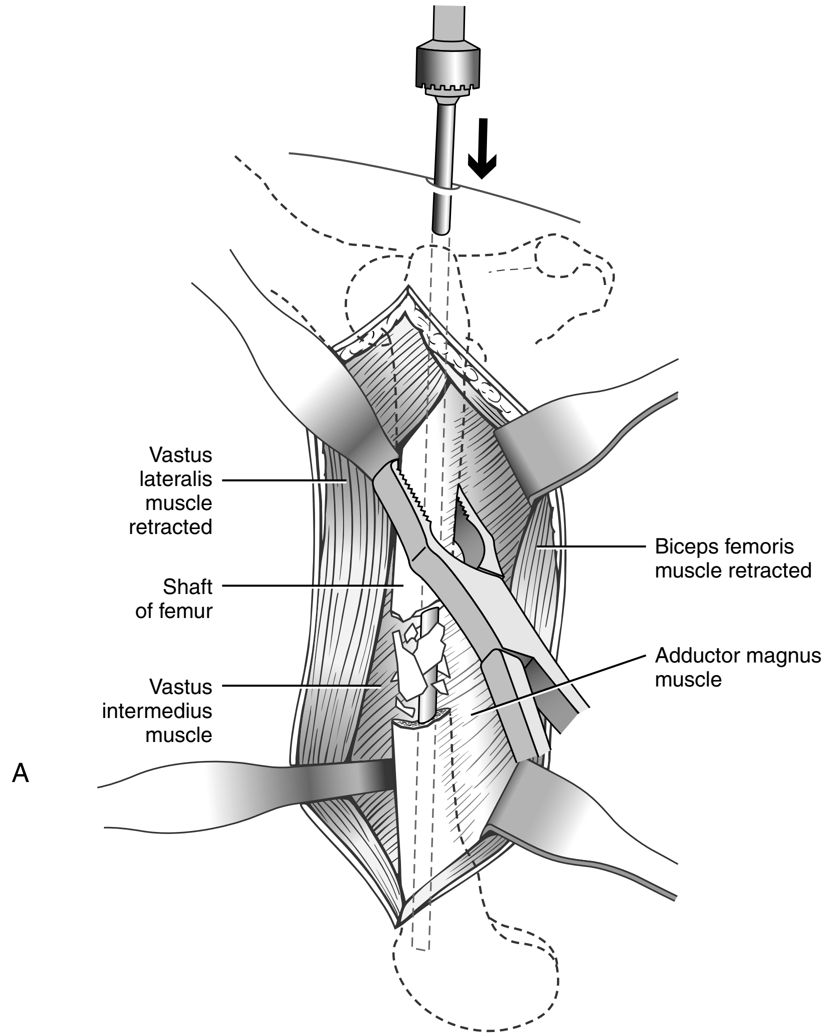
### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from dorsal midline to tarsus. Position the animal in lateral recumbency, with the affected limb up. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the ipsilateral proximal humerus or ilial wing for harvesting a cancellous bone graft.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue on the lateral surface of the thigh, from the greater trochanter to the femoral condyles. Incise the tensor fascia lata along the cranial border of the biceps femoris to expose the vastus lateralis and biceps femoris muscles.[2] Retract the muscles to expose the femur (Plate 73A). Insert the IM pin into the proximal femur in either a normograde or retrograde manner. Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures.[3] Incise the skin, and create soft tissue tunnels to the bone for fixator pin placement.

**Reduction:** Place an IM pin (sized to equal 60% to 70% of the medullary canal at the isthmus) in the proximal segment. Retract the pin within the medullary canal of the proximal segment. Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Drive the pin distally to seat in the femoral condyle. Maintain the reduction manually for transverse fractures and with pointed reduction forceps for oblique fractures. Reduce comminuted nonreducible fractures by distracting the distal femur with the IM pin and aligning the major segments of the bone (see Plate 73A). Be sure to restore length and normal rotational alignment to the bone.

*Continued*

# PLATE 73


Vastus lateralis muscle retracted
Shaft of femur
Vastus intermedius muscle
A
Biceps femoris muscle retracted
Adductor magnus muscle

**Stabilization:** Apply an IM pin and a type Ia external fixator to the lateral surface of the femur. Place fixation pins in the metaphysis of each segment and close to the fracture line. The external fixator can be connected or tied in to the IM pin to strengthen the fixation (Plate 73B).[4] Apply a modified type Ib external fixator and an IM pin to a comminuted nonreducible fracture.[5] Place a cancellous bone autograft at the fracture site (Plate 73C). Long oblique fractures benefit from cerclage wire or lag screw fixation in addition to the IM pin and external fixator (Plate 73D).

## CAUTIONS

It is important to avoid major nerves, vessels, and joint surfaces with the fixation pins and to avoid the distal joint surface with the IM pin. The range of motion of the stifle should be palpated to detect pin interference in the joint. Rotational alignment should be monitored during the realignment of comminuted fractures.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement. Rotational malalignments should be corrected by loosening the clamps and realigning the fixation pins on the connecting bar.

## POSTOPERATIVE CARE

Gauze sponges should be packed around the pins, and the sponges should be secured with a bandage. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Physical therapy is needed to restore stifle range of motion. Radiographs should be repeated at 6-week intervals to monitor healing. The fixator should be destabilized by removing the unilateral frame (from a type Ia and IM pin combination) or the cranial frame (from a modified type Ib fixator) when bone bridging is observed. If a tie-in is used, the top fixation pin and its connection to the IM pin should be retained. The IM pin, the remaining external fixator, or both should be removed when the fracture has healed.

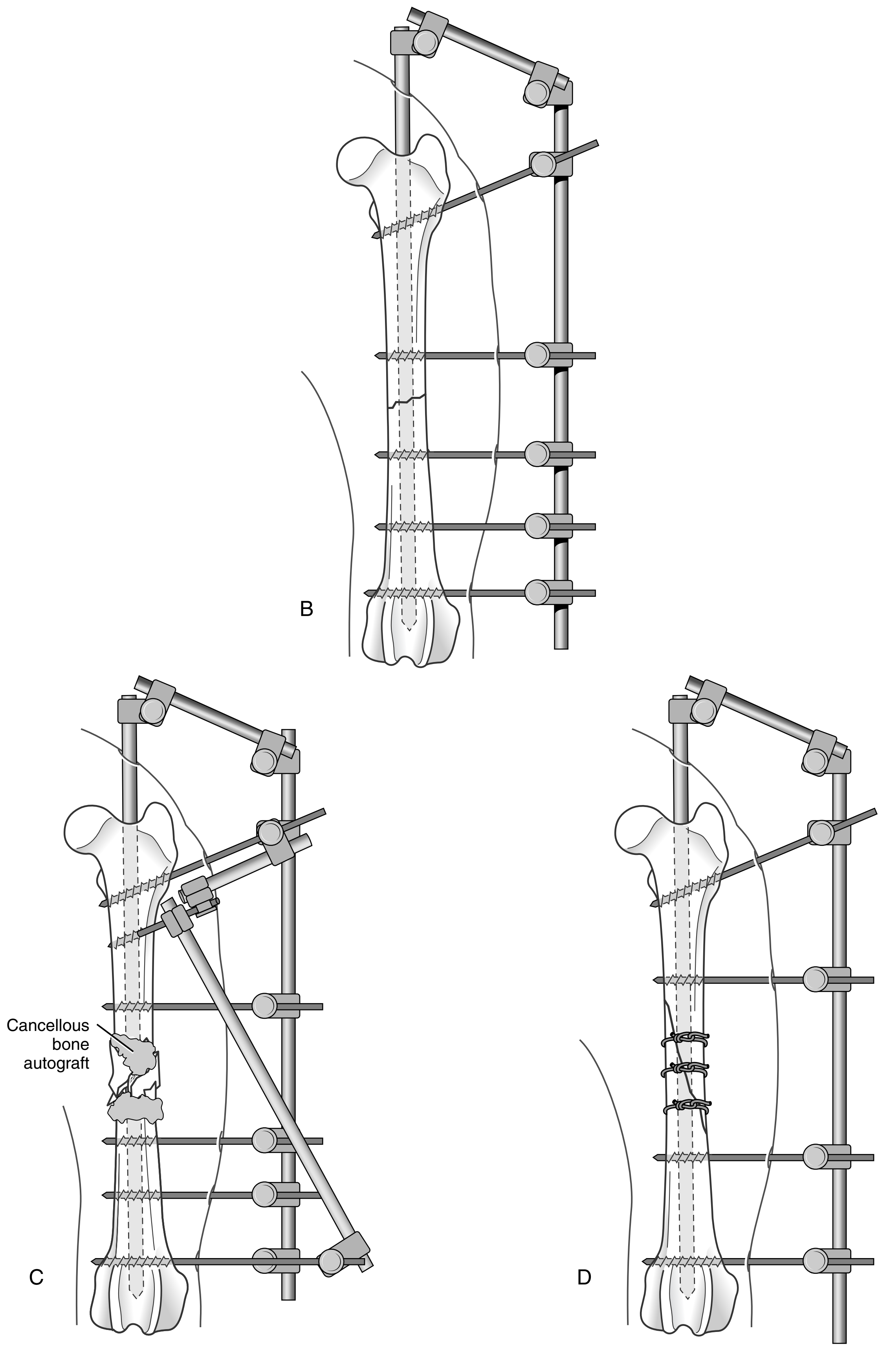
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal. The animal will experience limited function while the external fixator is in place but should eventually have a good return to function.

### References


1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management: Decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
4. Aron DN, Dewey C: Experimental and clinical experience with an IM pin external skeletal fixator tie-in configuration. Vet Comp Orthop Traumatol 4:86, 1991.
5. Aron DN: External skeletal fixation system application to the humerus and femur. In Proceedings of the 10th Annual Complete Course in External Skeletal Fixation, University of Georgia, 127–141, 2002.

## PLATE 73



## TIBIAL FRACTURES

# CHAPTER 74 Proximal Tibial Physeal Fractures and Tibial Tuberosity Fractures

### INDICATIONS
Candidates include animals with Salter I and Salter II fractures of the proximal tibial physes.

### OBJECTIVES
- To achieve anatomic reduction of the proximal tibial physis and fracture stabilization

### ANATOMIC CONSIDERATIONS
The medial aspect of the proximal tibia is covered only with skin, subcutaneous tissue, and crural fascia and can easily be palpated and approached. The saphenous artery vein and nerve lies caudal to the medial surface of the proximal tibia.

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kirschner wires or small Steinmann pins for large dogs, orthopedic wire, wire tightener, pin chuck or high-speed wire driver, wire cutter or pin cutter

### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from the hip to below the hock. Position the animal in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is unnecessary.

### PROCEDURE
**Approach:** Incise the skin, subcutaneous tissue, and crural fascia craniomedially from the distal femur to the proximal diaphysis of the tibia to expose the fracture. Retract the skin laterally to expose the lateral tibial epiphysis. Elevate the fascia and muscle to expose both medial and lateral surfaces of the fracture (Plate 74A).[1]

**Reduction:** Reduce the proximal physeal fracture by extending the stifle and gently levering the epiphysis into position. Maintain reduction using a pointed reduction forceps (Plate 74B). Reduce the avulsed tibial tuberosity by extending the limb and putting pressure on the tuberosity. Maintain reduction with a pointed reduction forceps (see Plate 74B).

**Stabilization of a Proximal Tibial Physeal Fracture:** Drive a Kirschner wire from the lateral surface of the tibial epiphysis across the physis, into the tibial metaphysis, and through the medial cortex. Drive a second wire from the medial tibial epiphysis across the physis, into the metaphysis, and through the lateral cortex. Bend the wires to prevent migration and aid removal (Plate 74C).[2]

**Stabilization of an Avulsion of the Tibial Tuberosity:** Drive two Kirschner wires into the tuberosity and across the physis to lodge in the proximal tibia. Check the repair to see if stabilization is sufficient to prevent avulsion of the fracture. If not, place a tension band wire by drilling a transverse hole in the tibial crest and passing a figure-eight wire through the hole and around the Kirschner wires. Tighten the wire (Plate 74D). Most repairs require a tension band wire.[1]

### CAUTIONS
It is important to avoid damaging the physeal cartilage during reduction and to avoid penetrating the articular cartilage with the Kirschner wires.

### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for reduction and implant placement.

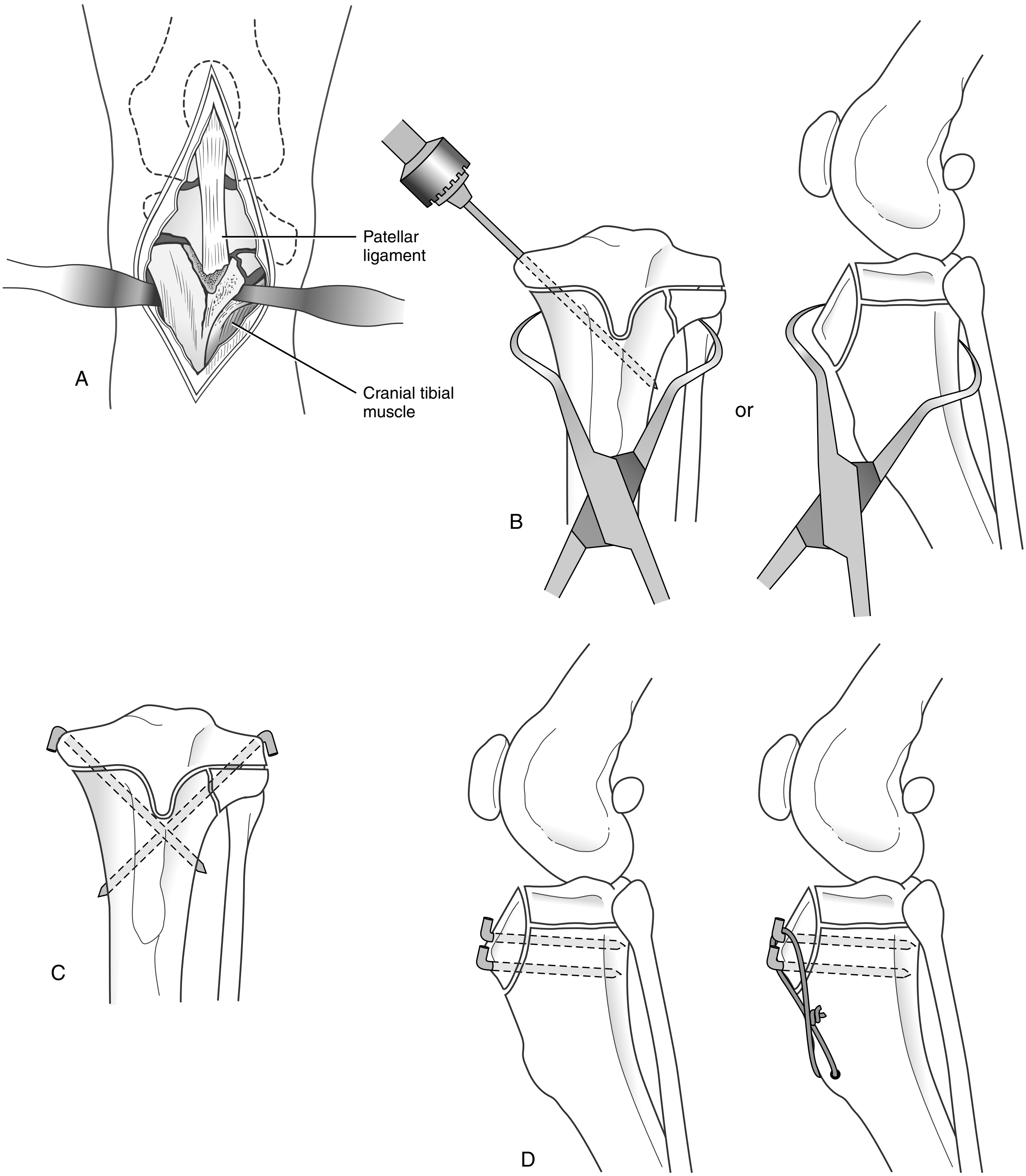
### POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. Radiographs should be evaluated in 3 to 4 weeks. The tension band wire should be removed at 3 weeks to allow physeal function. Additional implant removal may be required if soft tissue irritation occurs.

### EXPECTED OUTCOME
Rapid bone healing is usually seen, but premature closure of the physis will probably occur. Premature closure of the tibial tuberosity physis in a very young animal may affect stifle conformation.

### References

1. Piermattei D, Flo GL: Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.
2. Johnson AL, Hulse DA: Management of specific fractures: Tibia and fibular physeal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 74



# TIBIAL FRACTURES

# Chapter 75 Distal Tibial Physeal Fractures

## INDICATIONS

Candidates include animals with Salter I and Salter II fractures of the distal tibial physis.

## OBJECTIVES

- To achieve anatomic reduction of the distal tibial physis and fracture stabilization

## ANATOMIC CONSIDERATIONS

The medial malleolus of the distal tibia and the lateral malleolus of the fibula extend distal to the articulating surfaces of the distal tibia and talus. The long and short parts of the medial collateral ligaments arise from the medial malleolus of the tibia. The long and short parts of the lateral collateral ligaments arise from the lateral malleolus of the fibula. These ligaments are essential for hock stability. Tendons of the cranial tibial and long digital extensor muscles cross the cranial surface of the distal tibia. The medial saphenous vein crosses the medial surface of the distal tibia.

## EQUIPMENT

- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kirschner wires (or small Steinmann pins for large dogs), pin chuck or high-speed wire driver, wire cutter or pin cutter

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from hip to below the hock. Position the animal in lateral recumbency, with the affected limb up or in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is unnecessary.

## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue on the cranial medial surface from the distal diaphysis to the tarsus to expose the medial surface of the fracture (Plate 75A).[1] Alternatively, make a cranial skin incision and retract the extensor tendons. This approach allows visualization of the fibula.[2]

**Reduction:** Carefully reduce the physeal fracture in order to avoid crushing or injuring the physeal cartilage. Maintain reduction with pointed reduction forceps or with manual pressure.

**Stabilization with Crossed Kirschner Wires:** Drive a Kirschner wire from the medial malleolus, across the physis, into the tibial metaphysis, and through the lateral cortex (Plate 75B). Drive a second wire from the medial aspect of the distal tibial metaphysis, across the fracture into the epiphysis, while avoiding the articular surface (Plate 75C). Alternatively, drive the second wire from the lateral aspect of the tibial epiphysis or the fibular malleolus into the tibia.[3] In larger dogs, the second wire may driven from the fibular malleolus across the fibular fracture and into the proximal segment of the fibula (Plate 75D).

## CAUTIONS

It is important to avoid damaging either the physeal cartilage or articular cartilage.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for reduction and implant placement.

## POSTOPERATIVE CARE

A lateral splint should be used to support the fixation.[2] The animal should be confined, with activity limited to leash walking. Radiographs should be evaluated in 4 weeks. Implant removal may be required if soft tissue irritation occurs.

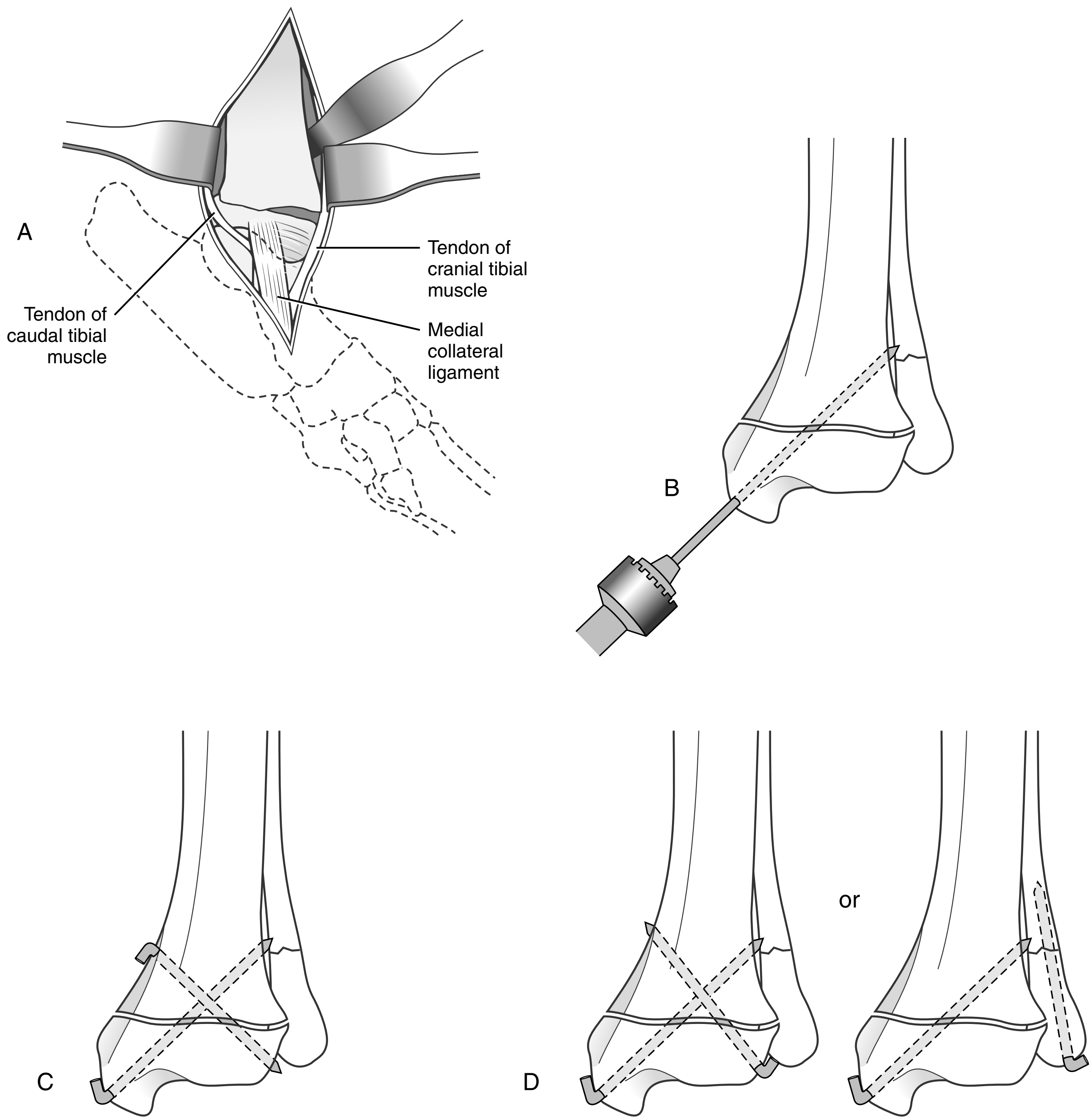
## EXPECTED OUTCOME

Rapid bone healing is usually seen, but premature closure of the physis will probably occur.

### References

1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Piermattei D, Flo GL: Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.
3. Johnson AL, Hulse DA: Management of specific fractures: Tibia and fibular physeal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 75


A
Tendon of cranial tibial muscle
Tendon of caudal tibial muscle
Medial collateral ligament
B
C
D
or

## TIBIAL FRACTURES

# CHAPTER 76 Malleolar Fractures

### INDICATIONS
Candidates include animals with transverse or oblique medial or lateral malleolar fractures.

### OBJECTIVES
- To achieve anatomic reduction of the malleoli and distal tibial articular surface, convert the tensile forces resulting from the pull of the collateral ligaments to compressive forces at the fracture, and stabilize the tarsus

### ANATOMIC CONSIDERATIONS
Tendons of the cranial tibial and long digital extensor muscles cross the cranial surface of the distal tibia. The medial saphenous vein crosses the medial surface of the distal tibia. The long and short parts of the medial collateral ligaments arise from the medial malleolus of the tibia. The long and short parts of the lateral collateral ligaments arise from the lateral malleolus of the fibula. These ligaments are essential for hock stability. The medial malleolus of the distal tibia and the lateral malleolus of the fibula extend distal to the articulating surfaces of the distal tibia and talus.

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kirschner wires, orthopedic wire, wire tightener, wire cutter, bone screws and the instruments for screw insertion, high-speed wire driver or drill

### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from hip to below the hock. Position the animal in dorsal recumbency. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is unnecessary.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue on the cranial medial surface from the distal diaphysis to the tarsus to expose the medial malleolus (Plate 76A).[1] Approach the lateral malleolus via a lateral skin incision over the malleolus, and use blunt and sharp dissection of surrounding tissues to expose the fracture (Plate 76B).[1]

**Reduction:** Reduce the fracture (i.e., medial malleolus of the tibia or lateral malleolus of the fibula) by securing the fragment with small or mini pointed reduction forceps and placing it into alignment. In some cases, the fragment may be secured with pointed reduction forceps; in other cases, manual maintenance of reduction is necessary.

**Stabilization:** Start two Kirschner wires in the medial malleolar fragment. Drive the wires across the fracture line to lodge in the tibia. Place a transverse drill hole in the tibia, pass a figure-eight wire through the hole and around the Kirschner wires, and tighten it. Drill a transverse hole in the fibula proximal to the fracture, and pass a figure-eight wire through the hole. Drive a Kirschner wire into the lateral malleolar fragment, across the fracture line, and proximally into the fibula. Pass the figure-eight wire around the Kirschner wire and tighten it (Plate 76C). Alternatively, if the fibula is too small to pass a Kirschner wire proximally, drive the Kirschner wire through the lateral malleolar fragment and into the tibia.

To apply the lag screw, drill a gliding hole (equal to the diameter of the threads on the screw) in the medial malleolar fragment. Place a drill sleeve into the gliding hole, reduce the fracture, and drill a smaller hole (equal to the core diameter of the screw) across the tibia. Measure, tap, select, and place a screw of the appropriate length. Compression of the fracture should occur (Plate 76D). To stabilize the fibular malleolus with a screw, treat the fibular malleolus as the fragment by drilling the gliding hole through the fibula and the tapped hole in the tibia (Plate 76E).[2]

### CAUTIONS
Articular reduction should be maintained during implant application. It is important to take care when manipulating and drilling the small malleolar fragments to avoid further fragmentation.

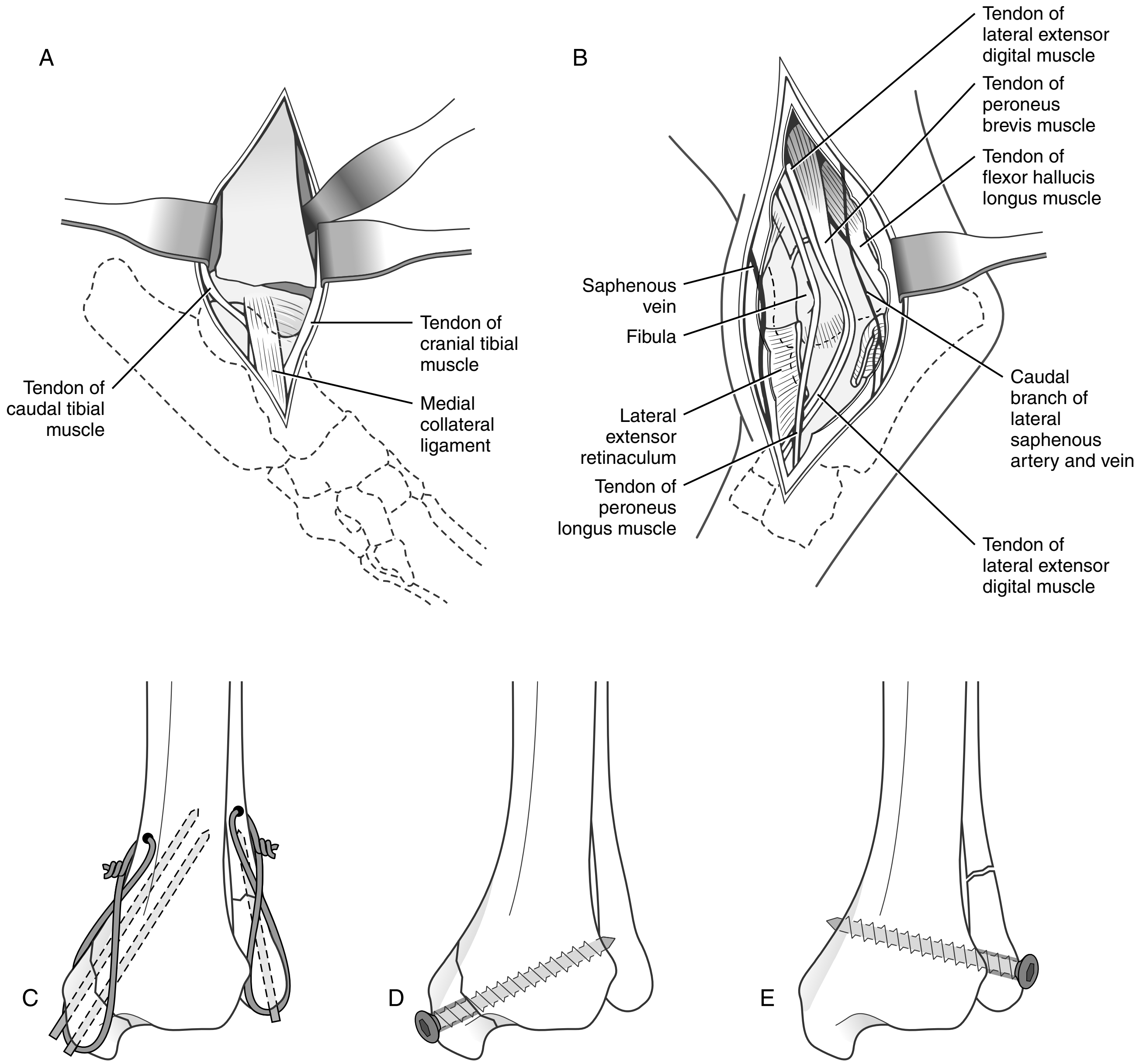
### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for articular surface reduction and implant placement.

### POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. A bivalve cast should be used to externally support the tarsus for 4 to 6 weeks.[3] The cast should be destabilized as healing progresses by eliminating the cranial part of the case. Radiographs should be repeated at 6-week intervals.

### EXPECTED OUTCOME
Bone healing is usually seen in 6 to 12 weeks with animals experiencing a good return to function. Degenerative joint disease may result from articular trauma, with the severity depending on accuracy and maintenance of reduction. Implant removal may be necessary if soft tissues are irritated.

#### References
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures: Tibia and fibular metaphyseal and epiphyseal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Piermattei D, Flo GL: Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 76


A
Tendon of
caudal tibial
muscle
Tendon of
cranial tibial
muscle
Medial
collateral
ligament
B
Tendon of
lateral extensor
digital muscle
Tendon of
peroneus
brevis muscle
Tendon of
flexor hallucis
longus muscle
Saphenous
vein
Fibula
Lateral
extensor
retinaculum
Tendon of
peroneus
longus muscle
Caudal
branch of
lateral
saphenous
artery and vein
Tendon of
lateral extensor
digital muscle
C
D
E

# TIBIAL FRACTURES

# CHAPTER 77 Application of an Intramedullary Pin or Interlocking Nail to the Tibia

## INDICATIONS

Candidates include animals with single or comminuted tibial diaphyseal fractures.

## OBJECTIVES

- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment for nonreducible comminuted fractures

The intramedullary (IM) pin is used in animals with high fracture-assessment scores.[1] The IM pin neutralizes bending forces at the fracture, and is combined with cerclage wire for long oblique fractures and with external fixation for transverse or short oblique fractures to neutralize rotational and axial compressive forces. The interlocking nail (ILN) neutralizes bending, rotational, and axial compressive forces at the fracture; it can be used for animals with medium and low fracture-assessment scores.[1]

## ANATOMIC CONSIDERATIONS

The tibia has a pronounced S-shaped curve in most dogs. The proximal and distal tibial articular surfaces cover the ends of the long bone, leaving little nonarticular surface to introduce an IM pin or ILN. The cranial branch of the medial saphenous artery and vein and the saphenous nerve cross the medial aspect of the tibia. The medial and lateral malleoli extend distally to the distal tibial articular surface.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, pointed reduction forceps, Kern bone-holding forceps, Jacob pin chuck, IM pins, cerclage wire, wire tightener, wire cutter, external fixator clamps and connecting bars (or ILN equipment, including high-speed drill), bone curette for harvesting cancellous graft

## PREPARATION AND POSITIONING

Prepare the rear limb circumferentially from mid-femur to the phalanges. Position the animal in dorsal recumbency. Drape the limb out from a hanging position. Roll the animal slightly to access the medial aspect of the limb. The ipsi-lateral proximal humerus serves as a cancellous bone graft donor site.

## PROCEDURE

**Approach:** Insert the IM pin or the ILN from a point on the proximal medial tibial plateau midway between the tibial tuberosity and the medial tibial condyle (Plate 77A).[2] Perform a limited medial approach through the skin and subcutaneous tissue to the fracture site for reducible fractures (see Plate 77A).[3] Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures. Incise the skin, and create soft tissue tunnels to the bone for fixator pin placement (Plate 77B).

**Reduction:** Place an IM pin (sized to equal 60% to 70% of the medullary canal at the isthmus) in the proximal segment.[2] Retract the pin within the medullary canal of the proximal segment. Reduce transverse and short oblique fractures by tenting the bone ends and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain the reduction manually for transverse fractures and with pointed reduction forceps for oblique fractures. Reduce comminuted nonreducible fractures by distracting the distal bone end with the IM pin or ILN and aligning the major segments of the bone.

**Stabilization:** Apply an IM pin and type Ia external fixator to the cranial medial surface of the tibia to stabilize a transverse fracture (see Plate 77B). The IM pin should be smaller (50–60% of the medullary canal) to accommodate the fixation pins within the medullary canal. Place fixation pins in the metaphysis of each segment and about 1 cm on either side of the fracture line. Apply an IM pin and cerclage wire to a long oblique fracture (Plate 77C). Apply an ILN and four screws to the tibia for treatment of comminuted nonreducible fractures (Plate 77D).[4]

## CAUTIONS

It is important to avoid the joint surfaces with the IM pin or ILN. The range of motion of the hock should be palpated to detect pin interference in the joint. Rotational alignment should be monitored during the realignment of comminuted fractures.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for fracture reduction or bone alignment and implant placement.

## POSTOPERATIVE CARE

The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing as needed. Radiographs should be repeated at 6-week intervals. Fixator pins should be removed after radiographic signs of bone bridging are observed. Radiographs should continue at 6-week intervals until the fracture has healed. The IM pin should be removed when the fracture has healed.

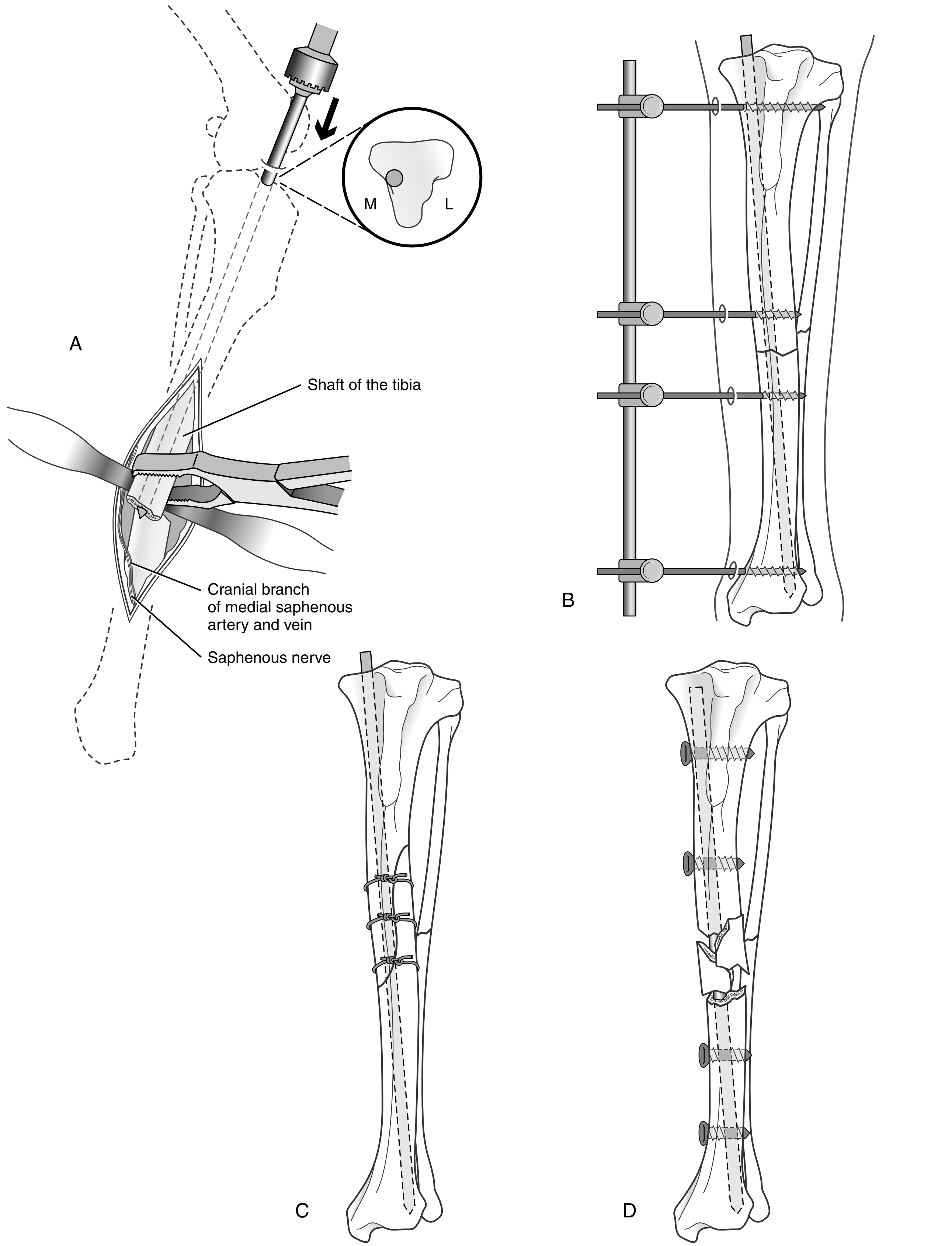
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal.

### References


1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Johnson AL, Hulse DA: Management of specific fractures: Tibial and fibular diaphyseal fractures. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
4. Dueland RT, Johnson KA, Roe SC, et al: Interlocking nail treatment of diaphyseal long bone fractures in dogs. J Am Vet Med Assoc 214:59, 1999.

# PLATE 77


A
M
L
Shaft of the tibia
Cranial branch
of medial saphenous
artery and vein
Saphenous nerve
B
C
D

## TIBIAL FRACTURES

# Chapter 78 Application of a Plate to the Tibia

## INDICATIONS
Candidates include animals with single or comminuted tibial diaphyseal fractures.

## OBJECTIVES
- To achieve anatomic reduction and compression of single fracture lines or restoration of normal bone alignment for nonreducible comminuted fractures

The plate is used as a compression plate for transverse or short oblique fractures, and it is combined with lag screws to compress long oblique fractures. The plate is used as a bridging plate for nonreducible comminuted fractures and may be combined with an intramedullary pin to reduce strain on the plate and to extend fatique life of the fixation. The plate neutralizes bending, rotational, and axial compressive forces.

## ANATOMIC CONSIDERATIONS
Plates are generally placed on the medial surface of the tibia. The tibia has an S-shaped curve that must be reproduced when contouring the plate. The cranial branch of the medial saphenous artery and vein and the saphenous nerve cross the medial aspect of the tibia. The medial malleolus extends distally to the distal tibial articular surface.

## EQUIPMENT
- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, pointed reduction forceps, self-centering plate-holding forceps, high-speed drill, plating equipment, bone curette for cancellous bone harvest

## PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from mid-femur to the phalanges. Position the animal in dorsal recumbency. Drape the limb out from a hanging position. Roll the animal slightly to allow access to the medial side of the bone. The ipsilateral proximal humerus serves as a cancellous bone graft donor site.

## PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue on the craniomedial surface of the tibia. Incise the crural fascia, and retract the cranial tibial muscle cranially and the flexor muscles caudally to expose the medial surface of the tibia (Plate 78A).[2] Use an "open but do not disturb the fragments" technique to expose the proximal and distal bone segments with minimal disturbance of the fracture hematoma and bone fragments for nonreducible fractures.[3]

**Reduction:** Reduce transverse and short oblique fractures by tenting the bone ends medially and levering the bone back into position. Reduce long oblique fractures by distracting the bone segments and approximating the fracture surfaces. Use pointed reduction forceps to manipulate the bone segments into reduction. Maintain the reduction manually for transverse fractures and with pointed reduction forceps for oblique fractures. Reduce comminuted nonreducible fractures by distracting and aligning the major segments of the bone. An intramedullary pin can be used to obtain axial alignment and distraction of the distal segment. Be sure to restore length and normal rotational alignment to the bone. Precontour the plate to the cranial caudal radiographic view of the contralateral tibia to prevent angular deformities.

**Stabilization:** Apply an appropriately contoured plate to the medial surface of the tibia. The plate can function as a compression plate (Plate 78B) when used to compress transverse or short oblique fractures; as a neutralization plate to support a reconstructed fracture (Plate 78C); or as a bridging plate, with or without an intramedullary pin, spanning a nonreducible comminuted fracture (Plate 78D).[4]

## CAUTIONS
In immature dogs, it is important to avoid crossing the distal tibial physis with the plate or screws. It is also important to avoid the distal articular surface. Careful attention must be paid to bony anatomic landmarks to avoid rotation of the distal segment. Failure to contour the plate to the normal S shape of the tibia will result in a valgus angulation of the limb. Monocortical screws may be necessary to avoid interference with the intramedullary pin.

## POSTOPERATIVE EVALUATION
Radiographs should be evaluated for fracture reduction or bone alignment and implant placement.

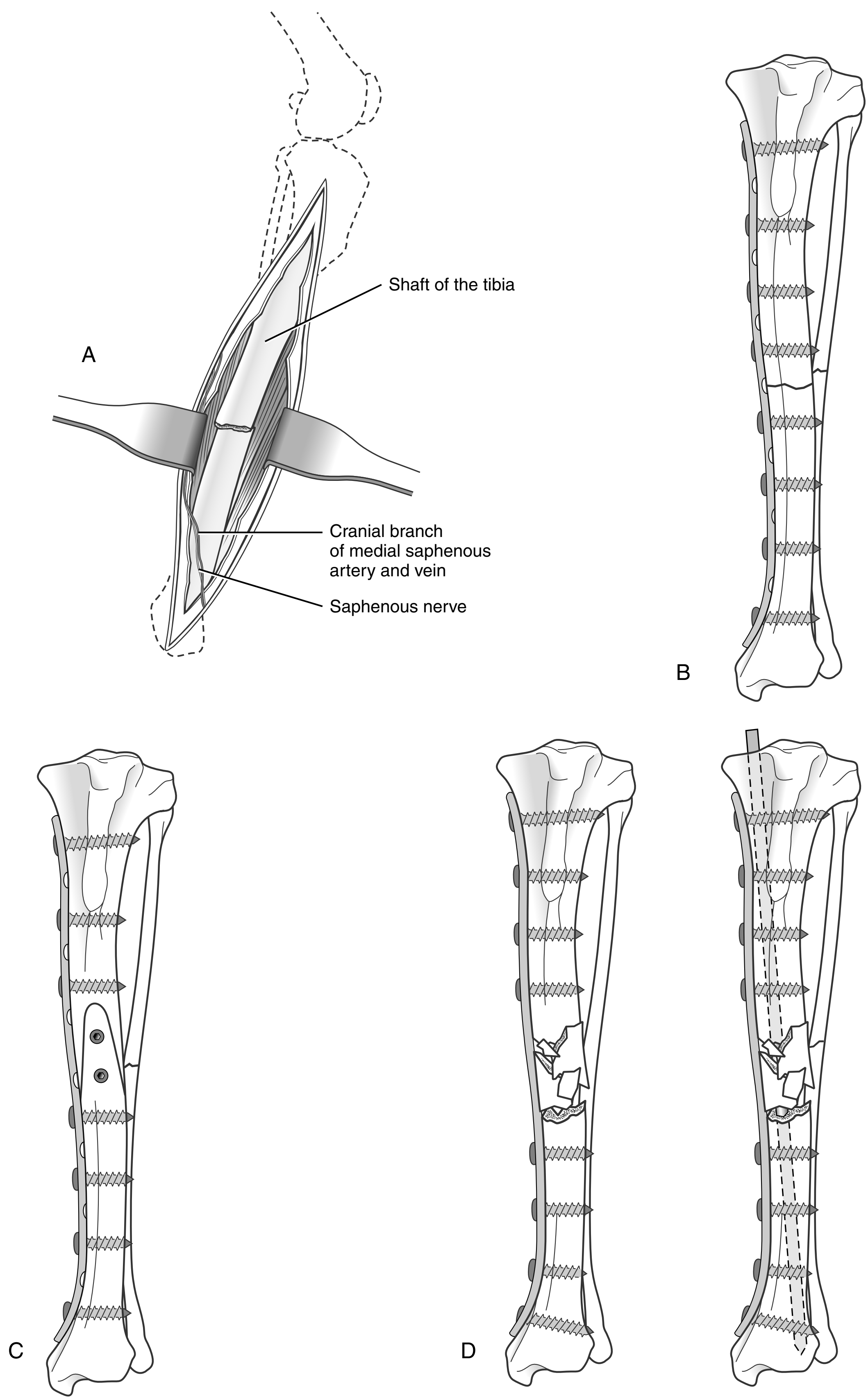
## POSTOPERATIVE CARE
The animal should be confined, with activity limited to leash walking. Radiographs should be repeated at 6-week intervals until the fracture has healed.

## EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal. Plate removal may be necessary after the fracture heals if soft tissue irritation or cold sensitivity occurs.

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, plates and screws. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
4. Houlton JEF: Fractures of the tibia. In Brinker WO, Olmstead ML, Sumner-Smith G, et al (eds): Manual of Internal Fixation in Small Animals. New York, Springer-Verlag, 1998.

# PLATE 78


A
Shaft of the tibia
Cranial branch
of medial saphenous
artery and vein
Saphenous nerve
B
C
D

## TIBIAL FRACTURES

# CHAPTER 79 Application of an External Fixator to the Tibia

### INDICATIONS

Candidates include animals with single or comminuted tibial diaphyseal fractures.

### OBJECTIVES

- To achieve anatomic reduction of single fracture lines or restoration of normal bone alignment for comminuted fractures

The stiffness of the fixator can be increased in animals with low fracture-assessment scores by adding fixation pins and by using biplanar or bilateral frames.[1] The fracture and fixator combination, or the fixator alone, resists axial loading, bending, and rotational forces at the fracture.

### ANATOMIC CONSIDERATIONS

The tibia has a triangular cross section in the proximal third, with a round cross section over the rest of the bone. The proximal tibial joint surface parallels the distal tibial joint surface. The medial aspect of the tibia is covered only by skin and subcutaneous tissue. The saphenous artery vein and nerve spiral across the medial surface of the mid-diaphysis. In general, fixation pins can be applied on the medial, cranial medial, cranial lateral, and lateral surfaces of the bone.

### EQUIPMENT

- Surgical pack, Senn retractors, small Hohmann retractors, Gelpi retractors, periosteal elevator, Kern bone-holding forceps, pointed reduction forceps, Jacob pin chuck, low-speed power drill, external fixation equipment, pin cutter, bone curette for harvesting cancellous graft

### PREPARATION AND POSITIONING

Prepare the affected rear limb circumferentially from midline to foot. Position the animal in dorsal recumbency, and suspend the affected limb from the ceiling.[2] Drape the limb out in the hanging position. Prepare the ipsilateral proximal humerus for cancellous bone autograft harvest if open reduction is used.

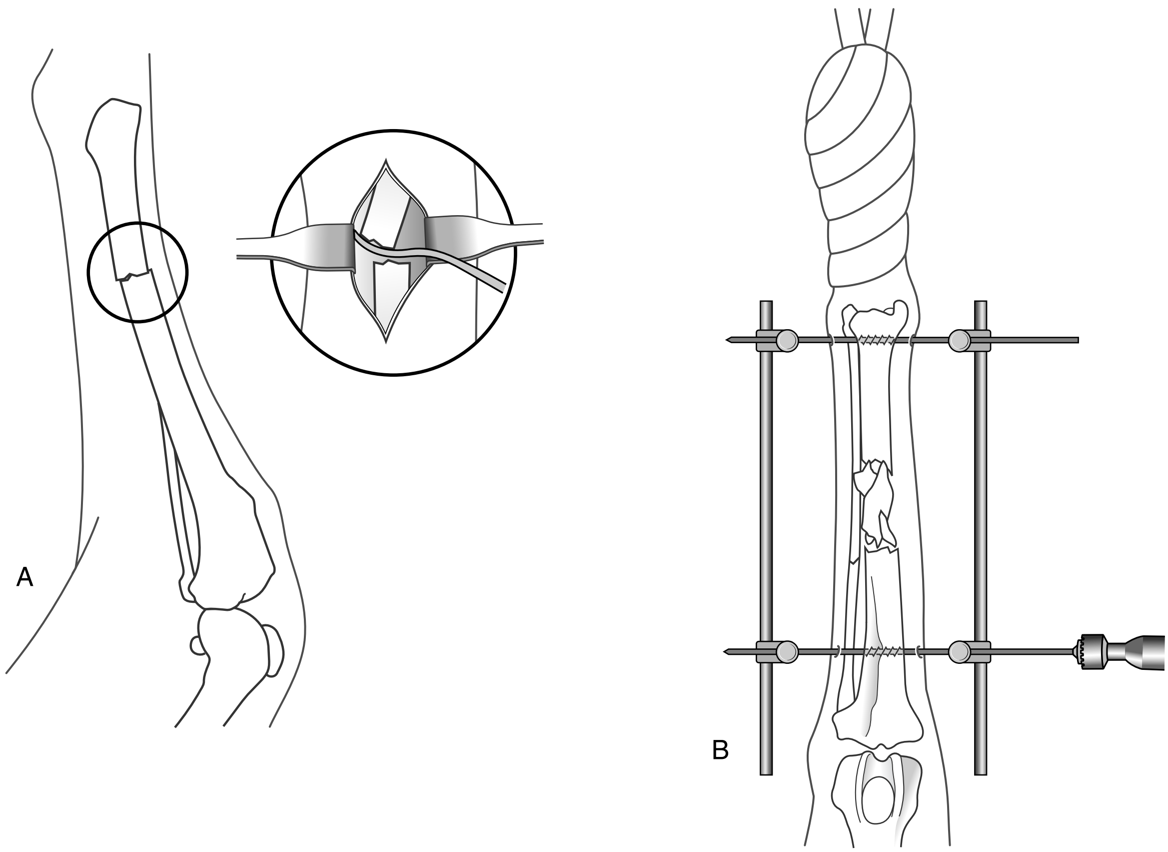
### PROCEDURE

**Approach:** Perform a limited medial approach to the fracture site for reducible fractures (Plate 79A).[3] Use closed reduction techniques for nonreducible fractures (Plate 79B).[4] Incise the skin, and create soft tissue tunnels to the bone for pin placement.

**Reduction:** Lower the table to allow the animal's weight to fatigue the muscles. For single fracture lines, lever the fragments into position through the limited surgical approach (see Plate 79A). Maintain the reduction manually for transverse fractures and with reduction forceps for oblique fractures. For closed reduction of comminuted fractures, manipulate the proximal and distal fixation pins to align the joint surfaces. Medial and lateral angular alignment is correct when the proximal and distal joint surfaces are parallel (see Plate 79B). Make sure that cranial caudal joint surfaces are also parallel. Check rotational alignment by flexing the stifle and hock after raising the table: the paw should align with the tibia. Maintain reduction by securing the connecting bars (see Plate 79B).

*Continued*

# PLATE 79



**Stabilization:** Apply a type Ia external fixator to the cranial medial surface of the tibia (Plate 79C). Place fixation pins in the metaphysis of each segment and about 1 cm from either side of the fracture line. At least two (and preferably three) fixation pins are placed in each bone segment. Use positive profile end-threaded pins to increase pin bone interface stability. Apply a type Ib frame by placing a unilateral frame on the cranial medial surface of the tibia and an additional unilateral frame on the cranial lateral surface of the tibia (Plate 79D) Connect the biplanar frames with articulating bars. Apply a type II frame by inserting transfixation pins through the metaphyses and additional fixation pins about 1 cm from either side of the fracture. Place additional pins when there is adequate bone (Plate 79E). Long oblique fractures benefit from cerclage wire or lag screw fixation in addition to the external fixator (see Plate 79D).[5]

## CAUTIONS

It is important to avoid major nerves, vessels, and joint surfaces with the fixation pins and to avoid the tibial crest when inserting fixation pins. Angular and rotational alignment should be monitored during the reduction. Intraoperative radiographs are useful to verify joint alignment during closed reductions.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for fracture reduction or bone alignment and implant placement. Angular malalignments should be corrected by loosening the clamps on the pins through the distal segment and repositioning the clamps attaching the fixation pins to the connecting bar.

## POSTOPERATIVE CARE

To limit postoperative swelling, gauze sponges should be packed around the pins, and the sponges should be secured with a bandage that also incorporates the paw. The animal should be confined, with activity limited to leash walking. External fixator management includes daily pin care and pin packing, as needed. Radiographs should be repeated at 6-week intervals to evaluate healing. When bone bridging is observed, the fixator should be destabilized by removing one unilateral frame (type Ib fixator), selected fixation pins (type Ia or type II fixator), or the lateral connecting bar of the type II fixator. The external fixator should be removed when the fracture is healed.

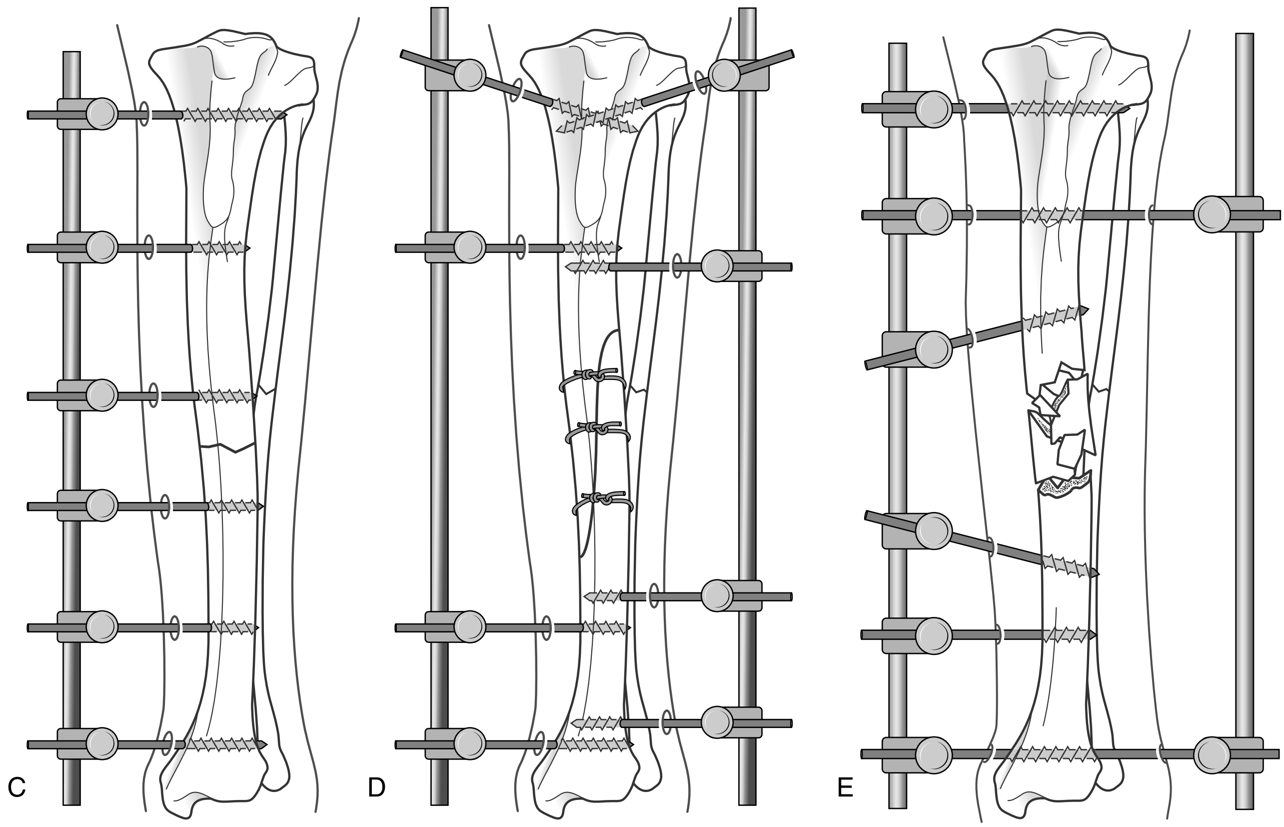
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal. Animals may experience limited function while the external fixator is in place, but good return to function generally occurs after the fixator is removed.

### References

1. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management: Decision making in fracture management. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
2. Aron DN, Palmer RH, Johnson AL: Biologic strategies and a balanced concept for repair of highly comminuted long bone fractures. Compend Cont Educ Pract Vet 17:35, 1995.
3. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
4. Johnson AL, Seitz SE, Smith CW, et al: Closed reduction and type II external fixation of severely comminuted fractures of the radius and tibia in dogs: 23 cases (1990–1994). J Am Vet Med Assoc 209:1445, 1996.
5. Johnson AL, Hulse DA: Fundamentals of orthopedic surgery and fracture management, external skeletal fixators. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.

# PLATE 79



## CARPUS/TARSUS

# Chapter 80 Radial Carpal Bone Fractures

## INDICATIONS

Candidates include animals with transverse or short oblique fractures of the radial carpal bone. Dogs with radial carpal bone fractures may present with chronic lameness; these conditions are more appropriately treated with carpal arthrodesis.[1]

## OBJECTIVES

- To achieve anatomic reduction of the articular surface and rigid fixation of the fracture to promote function and minimize degenerative changes

## ANATOMIC CONSIDERATIONS

The carpus is composed of the proximal (radial, ulnar, and accessory) and distal rows (II, III, and IV) of carpal bones. The radial carpal bone articulates primarily with the radius and serves as the major weight-bearing area in the joint. It is the most common carpal bone fractured in companion animals.

## EQUIPMENT

- Surgical pack, Senn retractors, Gelpi retractors, Hohmann retractors, periosteal elevator, pointed reduction forceps, Velsellum forceps, high-speed drill, bone screws and equipment for inserting bone screws

## PREPARATION AND POSITIONING

Prepare the forelimb circumferentially from elbow to digits. Position the animal in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is not generally used.

## PROCEDURE

**Approach:** An Esmarch bandage or tourniquet may be used to control bleeding. Incise the skin and subcutaneous tissue mid-dorsally, beginning 3 cm to 4 cm proximal to the radiocarpal joint and extending distally to the mid-metacarpus. Continue deep dissection between the extensor carpi radialis tendon and the common digital extensor tendon to expose the joint capsule. Retract the tendons, and incise the joint capsule to expose the radial carpal bone (Plate 80A).[2]

**Reduction:** Remove fragments that are too small to handle and fragments that are associated with chronic fractures. Reduce large fragments, and maintain reduction with pointed reduction forceps or Velsellum forceps.

**Stabilization:** Stabilize dorsal slab fractures with one or two small lag screws (Plate 80B).[3] Countersink the proximal fragment so that the screw heads lie beneath the articular surface. Stabilize oblique fractures through the body of the radial carpal bone with a lag screw (Plate 80C). Place the head of the screw through the insertion of the radial collateral ligament to avoid interfering with the joint motion.[3]

## CAUTIONS

It is important to avoid articular surfaces with implants.

## POSTOPERATIVE EVALUATION

Radiographs should be evaluated for bone alignment and implant placement.

## POSTOPERATIVE CARE

A soft, padded bandage should be placed to control bleeding and swelling. A splint should be used for 3 weeks. The animal should be confined, with activity limited to leash walks until bone healing is complete. Radiographs should be repeated at 6-week intervals until fracture healing is observed.

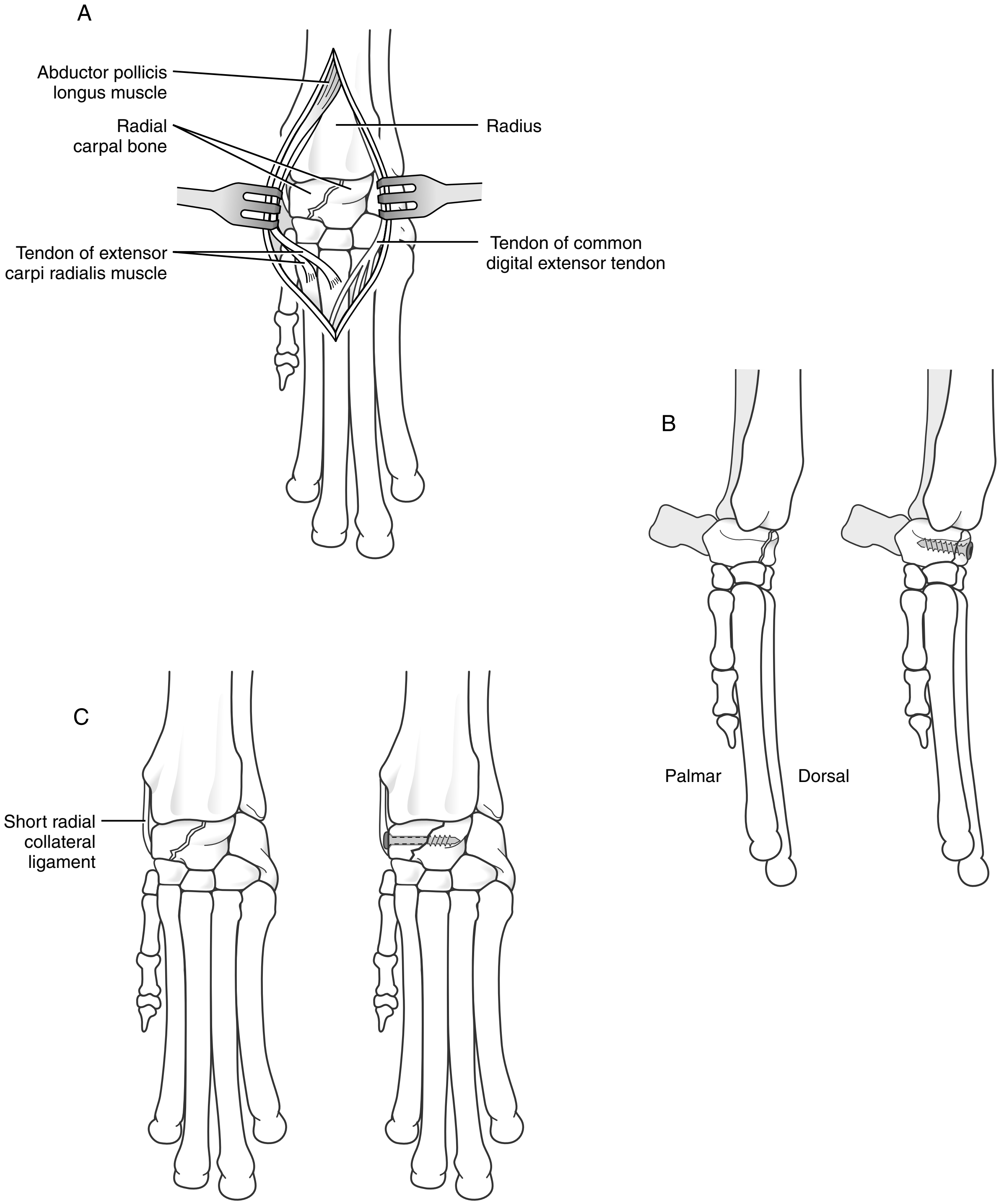
## EXPECTED OUTCOME

Bone healing is usually seen in 12 to 18 weeks, depending on fracture and signalment of the animal. Degenerative joint disease and limited range of motion of the carpus may occur.[1,4]

### References

1. Tomlin JL, Pead MJ, Langley-Hobbs SJ, et al: Radial carpal bone fractures in dogs. J Am Anim Hosp Assoc 37:173, 2001.
2. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
3. Piermattei DL, Flo GL: Fractures of the pelvis. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.
4. Li A, Bennet D, Gibbs C, et al: Radial carpal bone fractures in 15 dogs. J Small Anim Pract 41:74, 2000.

# PLATE 80


A
Abductor pollicis longus muscle
Radial carpal bone
Radius
Tendon of extensor carpi radialis muscle
Tendon of common digital extensor tendon
B
Palmar
Dorsal
C
Short radial collateral ligament

## CARPUS/TARSUS

# CHAPTER 81 Tarsal Fractures

### INDICATIONS
Candidates include animals with transverse or short oblique fractures of the calcaneus or the neck of the talus.

### OBJECTIVES
- To achieve anatomic reduction and rigid fixation of the fracture to promote function and minimize degenerative changes and to convert tension forces to compressive forces in calcaneal fractures

### ANATOMIC CONSIDERATIONS
The calcaneus articulates with the talus to form a stable joint. Proximally, the Achilles tendon inserts on the tuber calcanei. The medial and lateral trochleas of the talus articulate proximally with the tibia and fibula, and the body articulates distally with the central tarsal bone.

### EQUIPMENT
- Surgical pack, Senn retractors, Hohmann retractors, Gelpi retractors, periosteal elevator, pointed reduction forceps, Kirschner wires, orthopedic wire, wire tighteners, wire cutter, high-speed drill and wire driver, bone screws and instruments for inserting bone screws

### PREPARATION AND POSITIONING
Prepare the rear limb circumferentially from hip to digits. Position the animal in lateral recumbency for calcaneal fractures and in dorsal recumbency for greater flexibility with talar fractures. Drape the limb out from a hanging position to allow maximal manipulation during surgery. A cancellous bone graft is unnecessary.

### PROCEDURE
**Approach:** For calcaneal fractures, incise the skin, subcutaneous tissue, and deep crural fascia along the lateral surface of the calcaneus from just proximal to the tuber calcanei distally to the tarsometatarsal joint. Incise parallel to the lateral aspect of the superficial digital flexor tendon, and retract the tendon medially to expose the caudal surface of the calcaneus (Plate 81A).[1] For talar fractures, incise the skin, subcutaneous tissue, and deep fascia from the medial malleolus to the tarsometatarsal joint. Elevate the fascia to expose the bones (Plate 81B).[1]

**Reduction:** For the calcaneal fracture, reduce the proximal segment by extending the hock and manipulating the fragment with pointed reduction forceps. Maintain the reduction by driving the Kirschner wires. For the talar neck fracture, reduce the distal fragment by manipulating the fragment with the pointed reduction forceps. Maintain reduction manually or with pointed reduction forceps, holding the talar body to the calcaneus.

**Stabilization:** For calcaneal fractures, drill a transverse hole in the proximal segment and in the distal segment. Place a wire through the proximal hole. Place two Kirschner wires through the proximal bone segment, exiting at the fracture. It may be necessary to pre-drill the bone for the Kirschner wires. Reduce the fracture, and drive the Kirschner wires distally. Retract the wires, cut, and countersink them into the calcaneus. Secure the tension band wire (Plate 81C).[2] For a talar neck fracture, angle a lag screw from the caudal medial surface of the head of the talus into the trochlea of the talus (Plate 81D). Drill the glide hole from inside out before reducing the fracture to center the hole and ensure purchase in the trochlea. Alternatively, place a screw from the craniomedial surface of the base of the talus into the calcaneus. If the reduction can be maintained with forceps, the screw may be placed as a position screw; otherwise, it may be placed as a lag screw (Plate 81E).[2]

### CAUTIONS
It is important to avoid placing implants where they will interfere with articular surfaces.

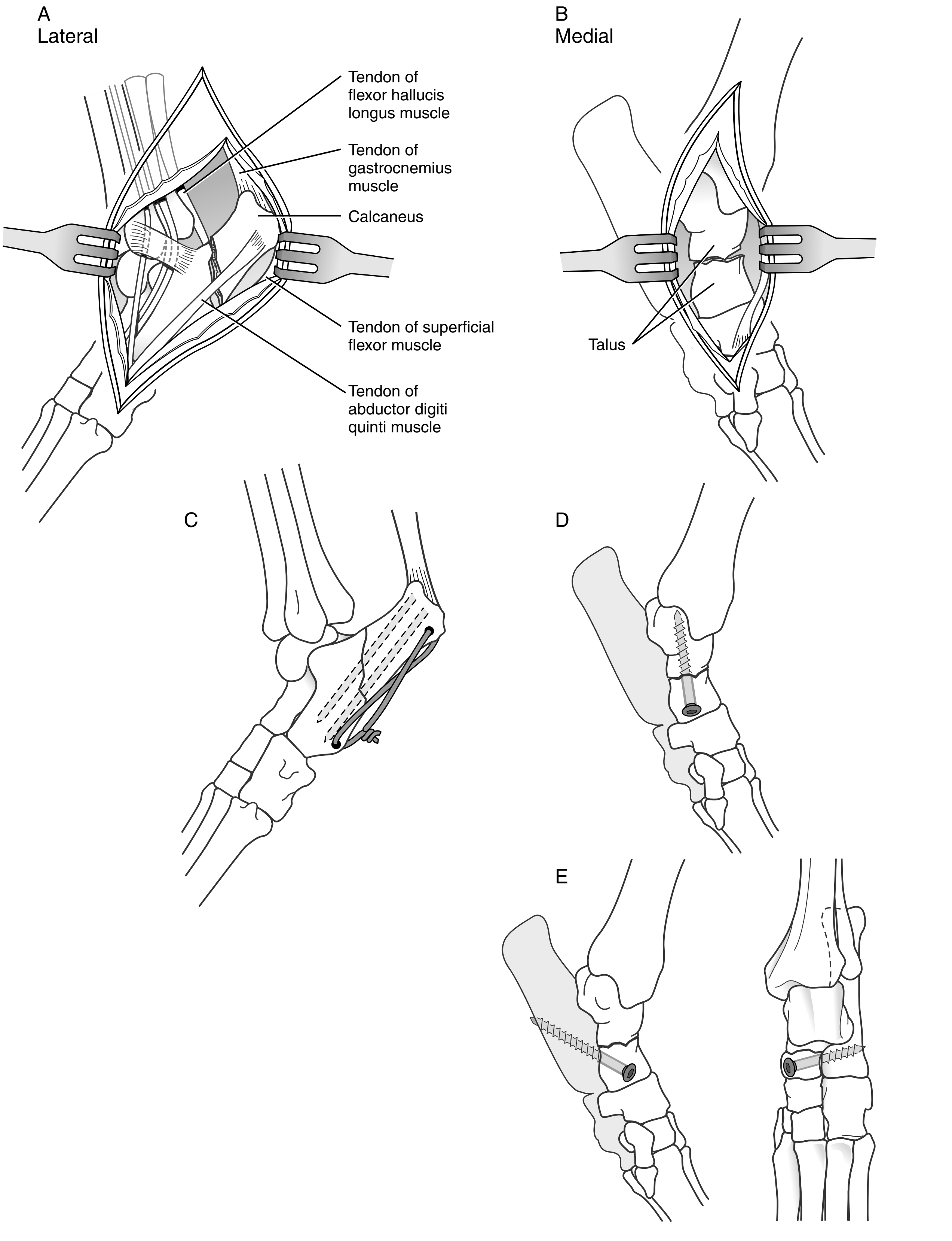
### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for bone alignment and implant placement.

### POSTOPERATIVE CARE
A soft padded bandage should be placed to control bleeding and swelling. A splint should be used for 3 weeks. The animal should be confined, with activity limited to leash walks, until bone healing is complete. Radiographs should be repeated at 6-week intervals until fracture healing is observed. If soft tissue irritation occurs, the orthopedic wire used in the tension band should be removed after bone healing.

### EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks, depending on the fracture and signalment of the animal. Degenerative joint disease and limited range of motion of the hock may occur.

#### References
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Piermattei DL, Flo GL: Fractures and other orthopedic injuries of the tarsus, metatarsus and phalanges. In Brinker, Piermattei, and Flo's Handbook of Small Animal Orthopedics and Fracture Repair, 3rd ed. Philadelphia, WB Saunders, 1997.

# PLATE 81


A
Lateral
Tendon of
flexor hallucis
longus muscle
Tendon of
gastrocnemius
muscle
Calcaneus
Tendon of superficial
flexor muscle
Tendon of
abductor digiti
quinti muscle
B
Medial
Talus
C
D
E

## METACARPAL BONES, METATARSAL BONES, AND DIGITS

# CHAPTER 82 Fractures of the Metacarpal and Metatarsal Bones

### INDICATIONS
Candidates include animals with multiple unstable fractures of the metacarpal and metatarsal bones.

### OBJECTIVES
- To realign the bones and stabilize the fractures

### ANATOMIC CONSIDERATIONS
The primary weight-bearing bones are the third and fourth digits. The superficial dorsal metacarpal or metatarsal artery courses over the dorsal aspect of the paw. The extensor tendons course down the dorsal aspect of each digit. The flexor tendons and superficial and deep metacarpal or metatarsal artery and vein lie on the palmar or plantar aspect of the digits. There is minimal soft tissue coverage, and the bones and joints can be easily palpated.

### EQUIPMENT
- Surgical pack, Senn retractors, small Hohmann retractors, mini pointed reduction forceps, Kirschner wires or small Steinmann pins, high-speed drill and burr, pin chuck, pin cutters, plating equipment, bone curette for harvesting cancellous bone

### PREPARATION AND POSITIONING
Prepare the distal limb circumferentially from elbow or stifle to the digits. Position the animal in dorsal recumbency for greater flexibility. Drape the limb out from a hanging position to allow maximal manipulation during surgery. Prepare the proximal humerus or proximal tibia as a donor site for cancellous bone harvest.

### PROCEDURE
**Approach:** Incise the skin and subcutaneous tissue on the dorsal surface of the paw, either on the midline (for fractures of the third and fourth bones) or directly over the fractured bone. Retract the extensor tendons and ligaments of the dorsal surface of the paw to expose the fractures (Plate 82A).[1]

**Reduction:** Lever transverse fractures into position. Maintain reduction with the implants. Use pointed reduction forceps to reduce and maintain the position of oblique fractures.

**Stabilization:** Stabilize simple transverse (or very short oblique) fractures in young or small dogs and cats with intramedullary pins. Use a high-speed burr to develop a slot in the distal dorsal surface of the fractured bone (Plate 82B). Blunt the tip of the pin to prevent it from penetrating the intact opposite cortex, and drive the pin through the slot and proximally across the fracture line to seat in the proximal bone segment. Bend the distal end of the pin to prevent migration and to simplify removal. Repeat the procedure for at least the third and fourth metacarpal or metatarsal bones (Plate 82C).[2]

For older and larger dogs, or animals with expected athletic function, use plates or screws (or both) to achieve fracture stability.[3] Stabilize oblique or avulsion fractures with lag screws (Plate 82D, *1*). A plate may be used with the lag screws to support the repair. Stabilize distal metaphyseal transverse fractures with a veterinary T plate (see Plate 82D, *2*). Bridge comminuted fractures with a dynamic compression plate or veterinary cuttable plate (see Plate 82D, *3*). Stabilize mid-diaphyseal transverse fractures with a dynamic compression plate (see Plate 82D, *4*).

### CAUTIONS
It is important to avoid placing intramedullary pins where they will interfere with the joints. The extensor tendons should be protected.

### POSTOPERATIVE EVALUATION
Radiographs should be evaluated for fracture reduction and implant placement.

### POSTOPERATIVE CARE
The fixation should be protected with a splint or cast for 4 to 6 weeks. The animal should be confined, with activity limited to leash walking, until the fracture has healed. Radiographs should be repeated at 6-week intervals until the fracture has healed.

### EXPECTED OUTCOME
Bone healing is usually seen in 12 to 18 weeks. The animal should experience a good return to function if anatomic reconstruction is achieved and maintained.[4]

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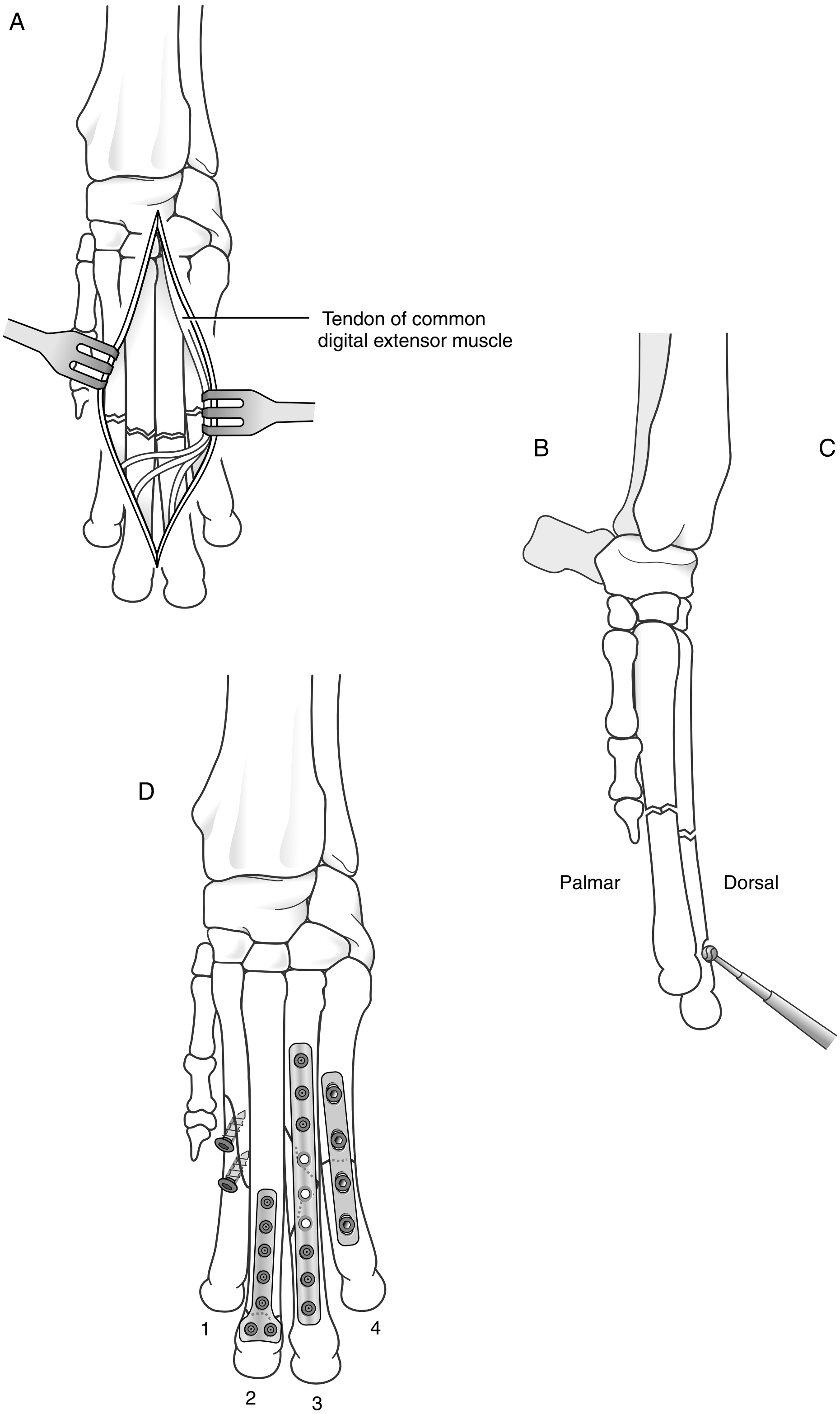
1. Piermattei DL, Johnson KA: An Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat, 4th ed. Philadelphia, WB Saunders, 2004.
2. Johnson AL, Hulse DA: Management of specific fractures: Metacarpal, metatarsal, phalangeal and sesamoid fractures and luxations. In Fossum TW (ed): Small Animal Surgery, 2nd ed. St. Louis, Mosby, 2002.
3. Bellenger CR, Johnson KA, Davis PE, et al: Fixation of metacarpal and metatarsal fractures in greyhounds. Aust Vet J 57:205, 1981.
4. Muir P, Norris JL: Metacarpal and metatarsal fractures in dogs. J Small Anim Pract 38:344, 1997.

# PLATE 82



A
Tendon of common digital extensor muscle
B
Palmar
Dorsal
C
D
1
2
3
4

# CHAPTER 83 Ventral Fenestration of Cervical Discs

## INDICATIONS[1]

Ventral fenestration of the cervical spine is often performed in combination with ventral decompression and surgical stabilization. It may be performed as a prophylactic or therapeutic measure for degenerative intervertebral disc (IVD) disease of the cervical region.

## OBJECTIVES

- To prevent herniation of the degenerative IVD into the vertebral canal and to resolve clinical signs associated with invertebral disc disease (e.g., pain)

## ANATOMIC CONSIDERATIONS[1,2]

The IVD is a complex composite of ligamentous and fibrous tissue; it is located at all interveterbral spaces except C1-2 and the fused sacral segments. It is classified as an amphiarthrodial joint and collectively constitutes the largest avascular structure in the body. Nutrition to the discs is via diffusion from the cartilaginous end-plates and is facilitated by normal vertebral movement. The IVD is composed of two anatomically distinct regions: (1) the annulus fibrosus and (2) the nucleus pulposus (NP). The annulus fibrosus is composed of fibrocartilaginous material arranged in woven concentric layers that allow limited vertebral motion in three directions: (1) lateral, (2) dorsoventral, and (3) rotation. The ventral and lateral portions of the annulus are 1.5 to 3 times thicker than the dorsal annulus, which means that the NP is always dorsally eccentric; this explains the propensity of the nucleus to herniate dorsally. The NP is a gelatinous mass that arises from the embryonic notochord. It contains an intercellular mass of mesenchymal cells in a dense network of poorly arranged fibers. In the young animal, the NP has a high water content, which provides the hydroelastic qualities needed to maintain function. The IVD forms a cushion between the adjacent bony vertebrae to allow movement, to minimize and absorb shock, and to unite the segments of the vertebral column. Age-related metaplastic degeneration results in significant changes in the biochemistry and biomechanics of the disc. There are two different types of metaplastic changes that have been described: (1) fibroid and (2) chondroid metaplasia. Fibroid metaplasia occurs in nondystrophic breeds. It is characterized by a slow degeneration or fibrocytic change of the annulus fibrosus, resulting in the thinning of the annulus dorsally and a protrusion of the disc upon compression of the spinal cord. Chondroid metaplasia occurs primarily in the chondystrophic breeds of dogs. It is characterized by the dystrophic calcification of the NP and extrusion of the disc material into the vertebral canal.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), bipolar and unipolar cautery, suction hose and small Frazier suction tip, no. 11 Bard Parker scalpel blade, Adson periosteal elevator, two Senn retractors, Army-Navy retractors, DeBakey thumb forceps, ear loop, tartar scraper, small bone curette

## PREPARATION AND POSITIONING

Prepare the patient from the mid-mandible to just past the manubrium. Position the animal in dorsal recumbency, crossing its forelimbs and securing them caudally. Pay careful attention to patient positioning, and make every effort to ensure that the animal is straight and in true dorsal recumbency. Stabilize the head and neck with towels, sandbags, or a vacuum-activated surgical positioning system.* Secure the head by taping the mandible to the table.

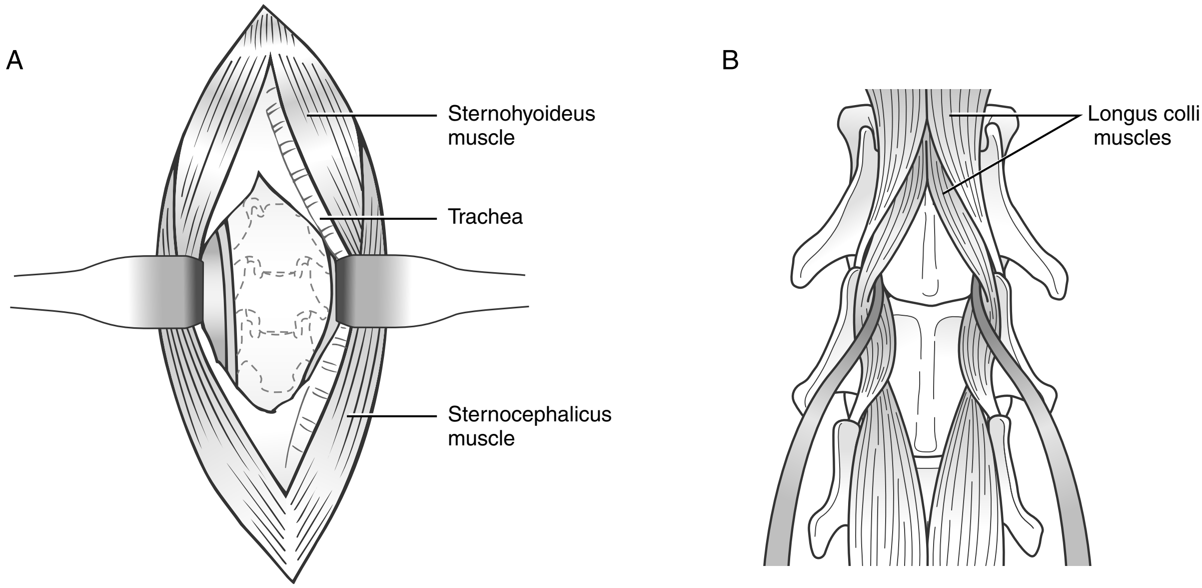
## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue on ventral midline from the caudal aspect of the thyroid cartilage to the manubrium. Reflect the skin and subcutaneous tissue medially and laterally with blunt dissection. Bluntly separate the sternohyoideus and sternomastoideus muscles along the midline. Identify and retract the esophagus and trachea to the left with moistened laparotomy sponges and either self-retaining or Army-Navy retractors (Plate 83A). Identify the paired carotid sheaths, and gently maneuver them out of the surgical field. Palpate the ventral spinous processes of the vertebral column to locate the appropriate disc space(s). The large transverse processes of C6 and the wings of C1 are important anatomic landmarks that assist in anatomic orientation. Once the IVD space(s) to be fenestrated have been located, cauterize the musculotendinous attachments of the longus colli muscle to the ventral spinous processes. The use of cautery will reduce the amount of muscular bleeding and improve visualization. Once it is free of its attachments, elevate the longus colli muscle to expose the ventral annulus fibrosus at the affected disc space (Plate 83B).

*Continued*

*Hug-U-Vac, South Salem, Oregon.

# PLATE 83


A
Sternohyoideus muscle
Trachea
Sternocephalicus muscle
B
Longus colli muscles

**Cervical Disc Fenestration:** Using a no. 11 blade, excise a rectangular window in the ventral annulus that is large enough to allow removal of the calcified NP (Plate 83C). Remember that the IVD space angles cranially, and angle the instrumentation accordingly to facilitate complete disc removal. Remove all disc material with an ear loop, tartar scraper, or small bone curette (Plates 83D and 83E).

Lavage and close longus colli in one layer with a simple continuous suture pattern. Remove the retractors, and return the trachea and esophagus to their normal positions. Lavage the soft tissues, and close the sternohyoideus and sternomastoideus with a simple continuous suture pattern. Close the subcutaneous tissues and skin in a routine fashion.

## CAUTIONS[1,3]

Ventral fenestration is a technically easier procedure to perform in comparison to ventral decompression; however, complete removal of disc material from the vertebral canal is not possible, and therefore complete resolution of the clinical signs associated with disc herniation may not be achievable with this procedure alone. Animals that display more advanced dysfunction associated with spinal cord compression (e.g., paresis or paralysis) are candidates for ventral decompression. In addition, in vitro studies of cadaveric spines have shown that ventral fenestration produces sagittal instability of the caudal cervical spine, which may contribute to the development of secondary instability and subsequent disc herniation (“domino lesions”) at adjacent disc sites.

## POSTOPERATIVE EVALUATION[1,3–6]

The neurologic status of the patient should be serially evaluated upon recovery from anesthesia and surgery. Neurologic deterioration associated with ventral fenestration has been reported in the literature; it is thought to be caused by residual disc material herniating into the canal. Most animals experience a decrease in cervical pain associated with IVD disease; however, recovery times may vary, depending on the severity of neurologic dysfunction. Postoperative radiographs or ancillary imaging (computed tomography or magnetic resonance imaging) of the cervical vertebrae is usually not indicated. A clinical study evaluating the width of the IVD space and the radiographic changes before and after IVD fenestration found that there was spondylosis and narrowing of the IVD space associated with the ventral fenestration procedure.

## POSTOPERATIVE CARE

General supportive care and pain management are indicated in all neurosurgery patients. Clean, dry, soft, padded bedding is important for patients that are nonambulatory or weakly ambulatory. Maintenance fluid therapy is routine for the first 24 to 48 hours or until the animal is able to eat and drink without assistance. Urine output and quantitation should be closely monitored for the first 24 to 48 hours, and bladder expression or catheterization (or both) should be provided in those patients not urinating on a voluntary basis. Rehabilitation may be implemented as soon as the acute postoperative pain has subsided (usually after 24 hours). Depending on the level of neurologic dysfunction, therapy may consist of massage, assisted standing, proprioceptive exercises, and controlled therapeutic exercise. Neck and buckle collars should be exchanged for a harness.

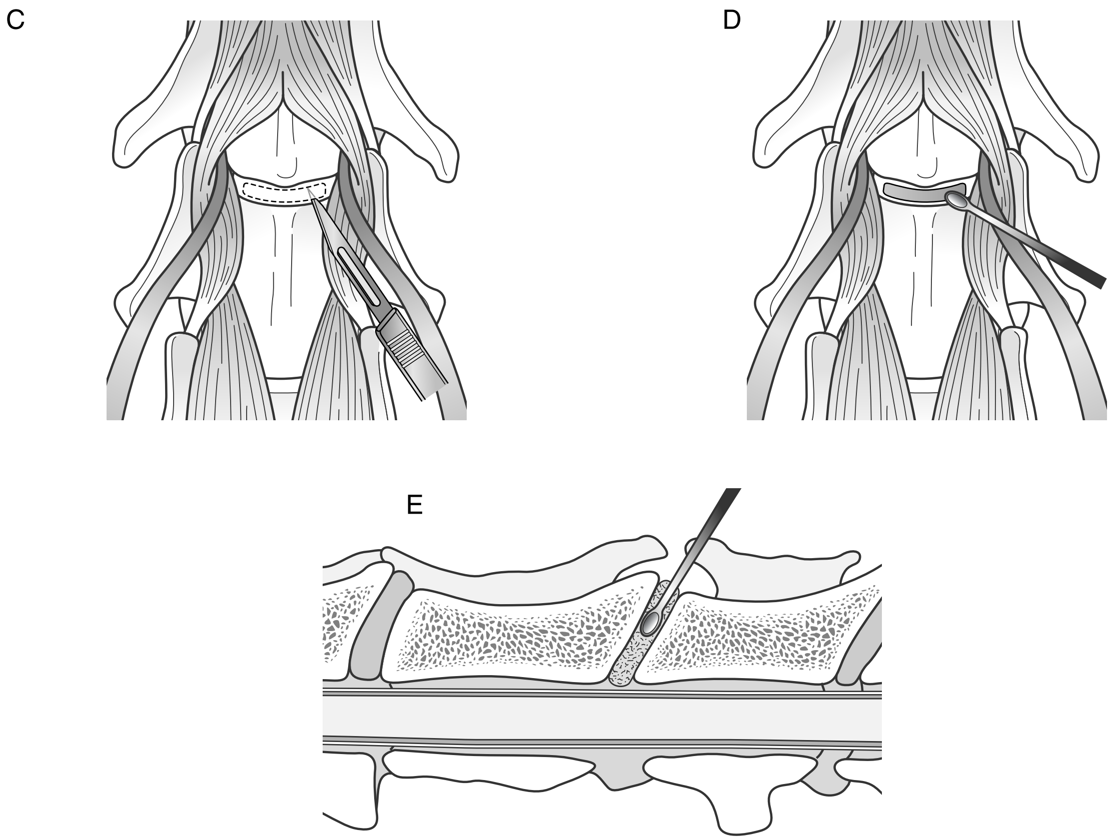
## EXPECTED OUTCOME[3–5]

The prognosis will vary depending on the level of neurologic dysfunction. Most animals will improve following surgical intervention, given a sufficiently long convalescent period.

### References


1. Macy NB, Les CM, Stover SM, et al: Effect of disc fenestration on sagittal kinematics of the canine C5-C6 intervertebral space. Vet Surg 28(3):171–179, 1999.
2. Bray JP, Burbidge HM: The canine intervertebral disc. Part two: Degenerative changes—nonchondrodystrophoid versus chondrodystrophoid discs. J Am Anim Hosp Assoc 34(2):135–144, 1998.
3. Wheeler SJ, Sharp NJH: Cervical disc disease. In Wheeler SJ, Sharp NJH (eds): Small Animal Spinal Disorders: Diagnosis and Surgery. London, Mosby, 1994.
4. Nakama S, Taura Y, Tabaru H, et al: A retrospective study of ventral fenestration for disc diseases in dogs. J Vet Med Sci 55(5):781–784, 1993.
5. Tomlinson J: Tetraparesis following cervical disc fenestration in two dogs. J Am Vet Med Assoc 187(1):76–77, 1985.
6. Dallman MJ, Moon ML, Giovannitti-Jensen A: Comparison of the width of the intervertebral disc space and radiographic changes before and after intervertebral disc fenestration in dogs. Am J Vet Res 52(1):140–145, 1991.

# PLATE 83



# CHAPTER 84 Ventral Cervical Slot

## INDICATIONS[1]

Ventral decompression of the cervical spine is performed for intervertebral disc (IVD) disease of the cervical spine. It is often performed in combination with ventral fenestration. Surgical candidates for a ventral slot are those animals that have exhibited multiple bouts of cervical pain, that are unresponsive to previous conservative treatment, or that are nonambulatory tetraparetic or quadriplegic and that have been diagnosed with extradural compression of the spinal cord via myelography, computed tomography, or magnetic resonance imaging.

## OBJECTIVES

- To relieve compression of the cervical spine from extruded or protruded disc material

## ANATOMIC CONSIDERATIONS[2–4]

Cervical spinal cord compression accounts for 15% of the reported cases of IVD in the dog, with 80% occurring in the chondrodystrophic breeds. The most common site of disc protrusion is C2-C3, followed by C3-4 and C7-T1. Clinical signs associated with disc disease can vary from a nerve root signature and neck pain to quadriplegia, depending on the degree and location of spinal cord compression. Myelography or ancillary imaging of computed tomography and magnetic resonance imaging are important for both diagnostic confirmation and neuroanatomical localization of the lesion; they also determine lateralization of the disc extrusion and rule out the presence of multiple lesions.

The midline location of the ventral slot must be precise to avoid the internal vertebral venous plexus. The internal vertebral venous plexus or sinuses comprise two valveless veins, which reside on the floor of the vertebral canal. These two thin-walled veins converge and diverge at the vertebral midbody and IVD space, respectively. To avoid damage of these vertebral sinuses and instability of the vertebral spine, the dimensions of the slot must be no greater than one third the width and length of the body of the vertebra, centering the slot slightly cranial to the IVD space (Plate 84A).

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of dog), bipolar and unipolar cautery, suction hose and small Frazier suction tip, no. 11 Bard Parker scalpel blade, Adson periosteal elevator, Senn retractors and/or Army-Navy retractors, DeBakey thumb forceps, Lempert rongeur, Kerrison rongeur, pneumatic drill system with burr guard and a variety of sizes of round and oval burrs, bone wax,* gelfoam,† or Avitene Sheets‡ (Microfibrillar Hemostat).

Additional instrumentation that is useful for removing extruded disc material from the vertebral canal includes a Buck ear curette, Ball burnisher, tartar scraper, double-ended curette, Iris spatula, and small bone curette.

## PREPARATION AND POSITIONING

Prepare the patient from the mid-mandible to just past the manubrium. Position the animal in dorsal recumbency, crossing its forelimbs and securing them caudally. Pay careful attention to patient positioning, and make every effort to ensure that the animal is straight and in true dorsal recumbency. The head and neck can be stabilized with towels, sandbags, or a vacuum-activated surgical positioning system.§ Secure the head by taping the mandible to the table.

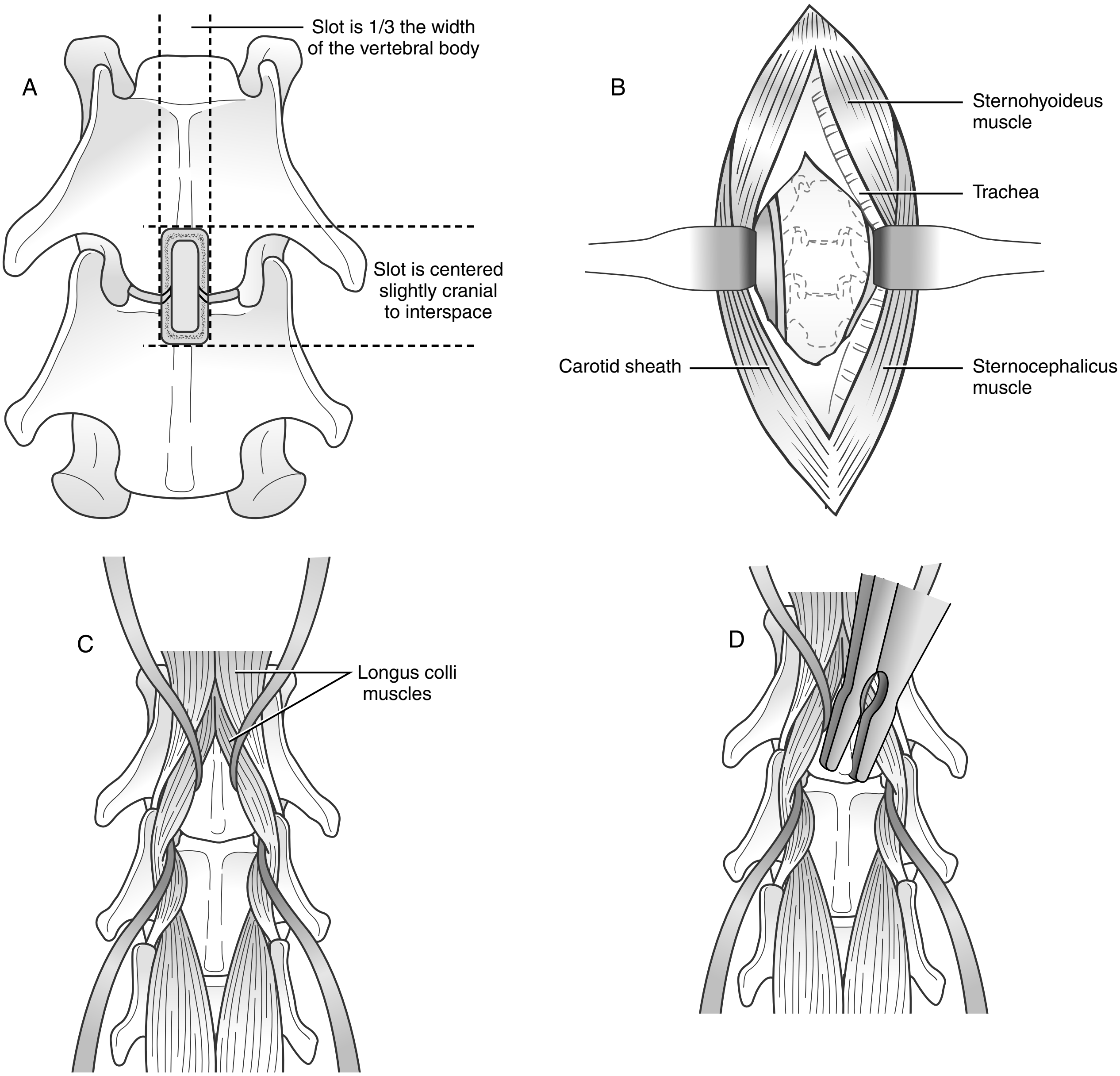
## PROCEDURE

**Approach:** Incise the skin and subcutaneous tissue on the ventral midline from the caudal aspect of the thyroid cartilage to the manubrium. Reflect the skin and subcutaneous tissue medially and laterally with blunt dissection. Bluntly separate the sternohyoideus and sternomastoideous muscles along the midline. Identify and retract the esophagus and trachea to the left with moistened laparotomy sponges and either self-retaining or Army-Navy retractors (Plate 84B). Identify the paired carotid sheaths, and gently maneuver them out of the surgical field. Palpate the ventral spinous processes of the vertebral column to locate the appropriate disc space(s). The large transverse processes of C6 and the wings of C1 are important landmarks that assist in anatomical orientation. Once the IVD space(s) has been located, cauterize the musculotendinous attachments of the longus colli muscle to the ventral spinous processes. The use of cautery will reduce the amount of muscular bleeding and improve visualization. Once it is free of its attachments, elevate and retract the longus colli muscle to expose the ventral annulus fibrosus at the affected disc space and the adjacent vertebral bodies (Plate 84C), and remove the ventral spinous process with a rongeur (Plate 84D).

*Continued*

*Bone wax, Ethicon, Johnson & Johnson, Somerville, New Jersey.
†Gelfoam, Pharmacia and Upjohn, Kalamazoo, Michigan.
‡Avitene, Davol, Cranston, Rhode Island.
§Hug-U-Vac, South Salem, Oregon.

# PLATE 84


A
Slot is 1/3 the width of the vertebral body
Slot is centered slightly cranial to interspace
B
Sternohyoideus muscle
Trachea
Carotid sheath
Sternocephalicus muscle
C
Longus colli muscles
D

**Ventral Cervical Slot:** Drill the proposed ventral slot site with a pneumatic air drill using a burr of appropriate size (Plate 84E). Generally, select a burr that is equal to the width of the slot to promote even bone removal. Slowly trickle warm saline over the burr while drilling to prevent heat transfer from the burr to the hemilaminectomy site, and intermittently lavage the entire laminectomy site to remove bone debris and to keep the tissues moist. Once most of the bone has been removed, a smaller bit can be used to remove the edges of inner cortical bone plate. Any bone bleeding may be controlled with bone wax. Once the inner cortex has been removed, use a nerve root probe, ear loop, or tartar scraper to palpate the inner bone and periosteal shelf. When it is thin and pliable, use a probe to penetrate the site gently and create a long window to allow a Kerrison rongeur to remove any remaining bone in the oblong window. If necessary, excise the dorsal longitudinal ligament with a no. 11 blade to visualize and decompress the cord. Remove any remaining extruded disc with a Buck ear curette, ball burnisher, or iris scapula (Plate 84F). Avoid damaging the venous sinuses that circumferentially surround the slot ventral to the cord. If a venous sinus is damaged, control the bleeding with the gelfoam or Avitene Sheets. Wait 5 minutes for the cessation of bleeding before removing the hemostatic devices and reinitiating the exploratory surgery. Once the spinal cord has been fully decompressed, all sinus bleeding should cease.

**Closure:** Lavage and close the longus colli in one layer with a simple continuous suture pattern. Remove the retractors, and return the trachea and esophagus to their normal position. Lavage the soft tissues, and close the sternohyoideus and sternomastoideus with a simple continuous suture pattern. Close the subcutaneous tissues and skin in a routine fashion.

## CAUTIONS[1,5]

Proper anatomic orientation is key to the identification of the correct surgical site. Postoperative or intraoperative radiographs should be taken if there is any doubt about lesion location. Severe hemorrhage can occur as a result of ventral sinus laceration. It is important to cross-match any animal that is a candidate for a coagulopathy before surgery.

## POSTOPERATIVE EVALUATION[1,5–8]

The neurologic status of the patient should be serially evaluated upon recovery from anesthesia and surgery. Neurologic deterioration associated with ventral fenestration has been reported in the literature and is thought to be due to the herniation of residual disc material into the canal. Most animals experience a decrease in cervical pain associated with IVD disease; however, recovery times may vary depending on the severity of the neurologic dysfunction and the intraoperative complications. Postoperative radiographs or ancillary imaging (computed tomography or magnetic resonance imaging) of the cervical vertebrae is usually not indicated.

## POSTOPERATIVE CARE

General supportive care and pain management are indicated in all neurosurgery patients. Clean, dry, soft padded bedding is important for patients that are nonambulatory or weakly ambulatory. Maintenance fluid therapy is routine for the first 24 to 48 hours, until the animal is able to eat and drink without assistance. Urine output and quantitation should be closely monitored for the first 24 to 48 hours, and bladder expression or catheterization should be provided for those patients that are not urinating on a voluntary basis. Rehabilitation may be implemented as soon as the acute postoperative pain has subsided (usually after 24 hours). Depending on the level of neurologic dysfunction, therapy may consist of massage, assisted standing, proprioceptive exercises, and controlled therapeutic exercise. Neck and buckle collars should be exchanged for a harness.

## EXPECTED OUTCOME[5,7]

Most patients with cervical IVD have a fair to good prognosis; however, expected outcomes vary depending on the level of neurologic dysfunction. Most animals improve following surgical intervention, given a convalescence period of reasonable length (6 to 8 weeks). Recurrence of signs associated with IVD has been reported within the literature and should be discussed with the owner prior to surgery.

### References

1. Macy NB, Stover SM, Kass PH: Effect of disk fenestration on sagittal kinematics of the canine C5-C6 intervertebral space. Vet Surg 28:171–179, 1999.
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7. Nakama S, Tabaru H, Yasuda M: A retrospective study of ventral fenestration for disk diseases in dogs. J Vet Med Sci 55(5):781–784, 1993.
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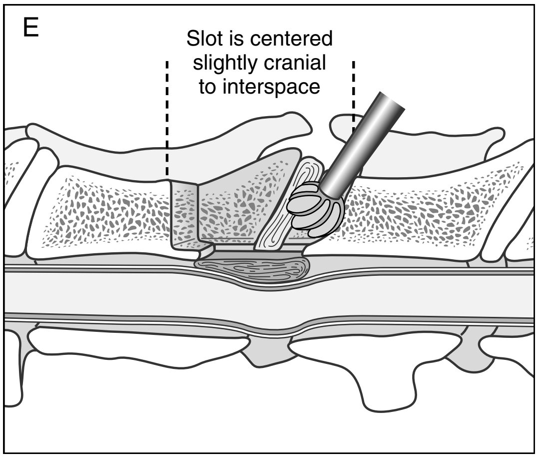
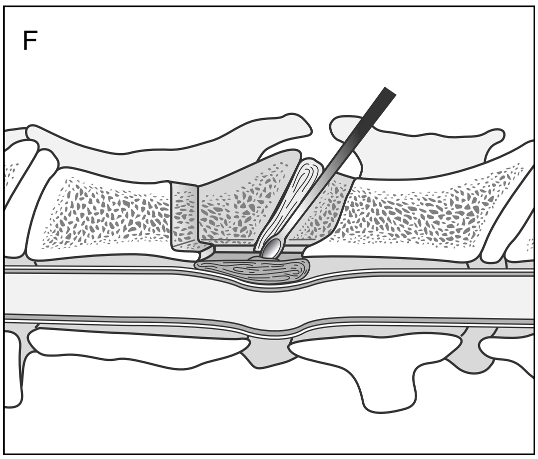
# PLATE 84



# CHAPTER 85 Hemilaminectomy

## INDICATIONS[1–3]

Surgical candidates for a hemilaminectomy are those animals that have exhibited multiple bouts of thoracolumbar pain, that are unresponsive to previous conservative treatment, that exhibit loss of voluntary motor function, or that have been diagnosed with compression of the spinal cord via myelography, computed tomography, or magnetic resonance imaging.

## OBJECTIVES[1,4]

- To decompress the spinal cord of the thoracolumbar spine

Hemilaminectomy is often performed in combination with lateral fenestration.

## ANATOMIC CONSIDERATIONS[5]

The vertebrae are key components of the axial skeleton; they lie along the midline of the body. Vertebral body anatomy varies depending on the location in the axial skeleton, but each has a basic structural configuration despite minor differences in morphology. Each vertebral bone has a body that lies directly beneath the spinal cord. Interposed between and connecting each vertebral body is an intervertebral disc (see Chapter 83 for an in-depth discussion of disc anatomy). The spinal cord is surrounded and protected by the lamina and pedicle, which collectively make up the vertebral arch. Dorsal spinous processes project from the lamina. In the cranial thoracic vertebra, these processes are tall and slant caudally; however, they change direction and decrease in size at the anticlinal vertebra, usually located at T10. In the lumbar region, the processes become more substantial, shorter, and wider. Each vertebra also has two sets of articular facets located on the dorsal lateral aspect of the vertebral arch, which demarcate the position of the intervertebral foramina, where the nerve root exits the spinal canal. In addition to articulating with each other, the thoracic vertebrae also articulate with a pair of ribs just ventral and caudal to the intervertebral foramina. Each rib projects in a perpendicular fashion from the vertebral body. Location of the proximal rib head with the vertebra is an important anatomic landmark for identification of the proper intervertebral disc space. The articulation of the rib head with the vertebral body is easily palpated and distinguished from the transverse process of the lumbar vertebra, which slopes craniolaterally from the vertebral body. A Freer or other small periosteal elevator may be used to palpate these landmarks to avoid excessive soft tissue dissection.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), bipolar and unipolar cautery, suction hose and small Frazier suction tip, no. 11 and no. 15 Bard Parker scalpel blades, Freer periosteal elevator, Senn retractors, Lempert rongeur, Kerrison rongeur, pneumatic drill system with burr guard and a variety of sizes of round and oval burrs, DeBakey thumb forceps, bone wax,* gelfoam,† or Avitene Sheets‡ (Microfibrillar Hemostat).

Additional instrumentation that is useful for removing extruded disc material from the vertebral canal includes a Buck ear curette, Ball burnisher, tartar scraper, double-ended curette, Iris spatula, and small bone curette.

## PREPARATION AND POSITIONING[1,4,6,7]

Position the animal in sternal recumbency, and prepare the back from the mid-thoracic region to the lower lumbar area. Support the animal with sandbags on each side of the abdomen, or use a vacuum-activated surgical positioning system.§ If needed, further secure the animal in position with white tape to prevent malposition during surgery. Perfect positioning and alignment assist in the approach and ensure proper orientation; however, some surgeons prefer that the patient be rotated slightly, with the operated side being most dorsal.

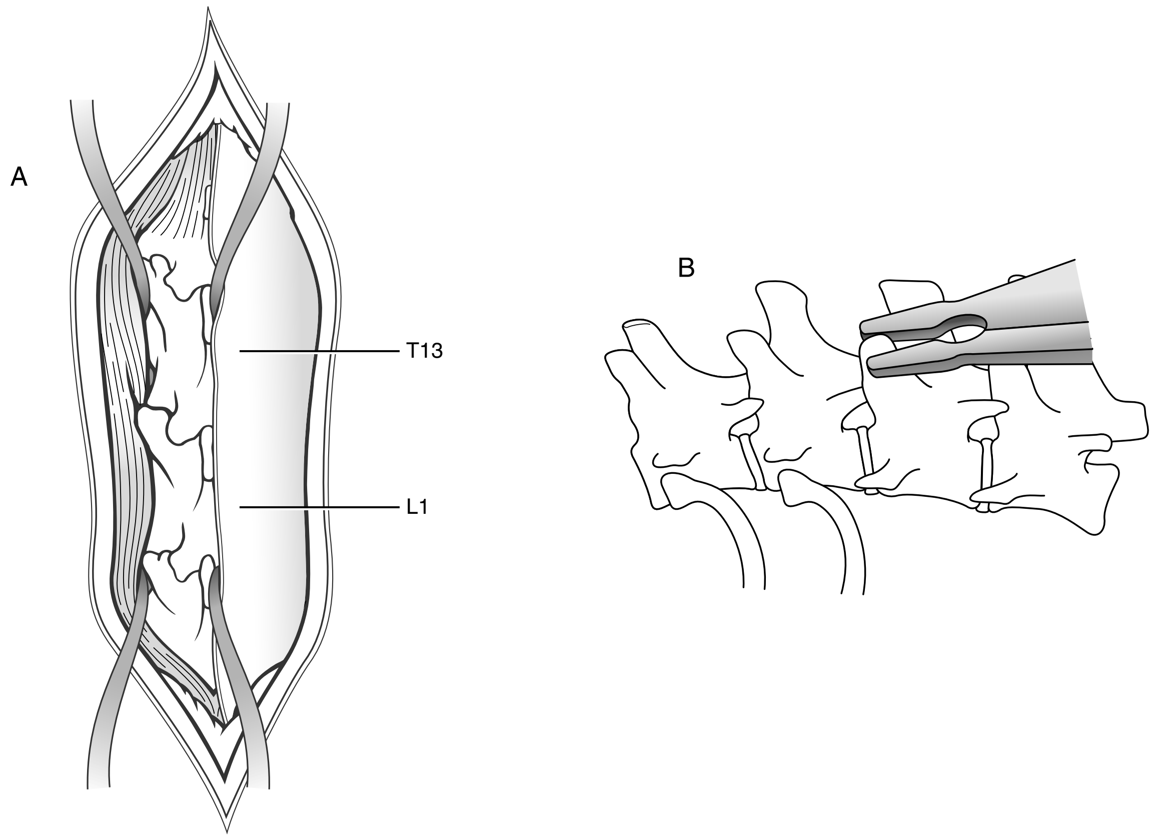
## PROCEDURE

**Approach:**[1,4,6,7] Incise the skin and subcutaneous tissue on dorsal midline centered from the mid-thoracic vertebra to the mid-lumbar region, and suture in two quarter drapes to decrease skin contamination. The incision location and length will vary somewhat depending on the lesion location(s) and the number of sites that need to be decompressed. Incise the thoracodorsal fascia and supraspinous ligaments with a no. 15 scalpel blade, extending the incision at least two dorsal spinous processes proximal and distal to the site(s) to be decompressed. In order to minimize muscular hemorrhage, deviate the incision toward the side of the hemilaminectomy at each dorsal spinous process and then return the incision back to midline. Elevate the epaxial musculature (multifidus thoracis and lumborum muscles) away from the dorsal spinous process, pedicle, and lamina to the level of the articular facet using an Adson or Freer periosteal elevator. Retract the elevated muscles using two Gelpi self-retaining retractors (Plate 85A). Using the bipolar cautery, cauterize the musculotendinous attachments of the longissimus muscles originating on the articular facets, avoiding the nerve root coursing deep and caudoventrally under the facet. Elevate any remaining tissue attached to the exposed facet, lamina, and pedicle, and repeat the procedure, one site cranial and one site caudal to the hemilaminectomy, to provide adequate exposure. Reposition the Gelpi retractors to improve visualization, and remove the articular facets with a Lempert rongeur (Plate 85B).

*Continued*

*Bone wax, Ethicon, Johnson & Johnson, Somerville, New Jersey.
†Gelfoam, Pharmacia and Upjohn, Kalamazoo, Michigan.
‡Avitene, Davol, Cranston, Rhode Island.
§Hug-U-Vac, South Salem, Oregon.

# PLATE 85



**Hemilaminectomy:**[1,4,6] Drill the proposed hemilaminectomy site with a pneumatic air drill using a burr of appropriate size. Generally, select a burr that is equal to the width of the hemilaminectomy site to promote even bone removal (Plate 85C). Slowly trickle warm saline over the burr while drilling to prevent heat transfer from the burr to the hemilaminectomy site, and intermittently lavage the entire laminectomy site to remove bone debris and to keep the tissues moist. Once most of the bone has been removed, a smaller bit can be used to remove the edges of inner cortical bone plate. Any bone bleeding may be controlled with bone wax. Once the inner cortex has been removed, use a nerve root probe, ear loop, or tartar scraper to palpate the inner bone and periosteal shelf. When it is thin and pliable, use a probe to gently penetrate the site and create a long window to allow admission of a Kerrison or small Lempert rongeur to remove any remaining bone in the oblong window (see Plate 85C). Remove the extruded disc with a Buck ear curette, ball burnisher, or iris scapula (Plate 85D). Gently pass a neural probe under and dorsal to the spinal cord to ensure complete decompression. Avoid damaging the venous sinuses ventral to the cord. If a venous sinus is damaged, control the bleeding with the gelfoam or Avitene Sheets. Wait 5 minutes for the cessation of bleeding before removing the hemostatic devices and reinitiating the exploratory. Once the spinal cord has been decompressed, gently lavage the hemilaminectomy site, and harvest a fat graft from the subcutaneous region of the back. Place the fat graft over the hemilaminectomy site to prevent fibrous scarring and adhesion. Suture the epaxial muscular fascia in a simple continuous pattern with absorbable suture. Close the subcutaneous tissues and skin in a routine fashion.

## CAUTIONS[8–11]

No more than four adjacent continuous hemilaminectomy sites (or, bilaterally, up to two adjacent sites) should be performed to prevent destabilizing the spinal column. Accurate anatomic identification of the hemilaminectomy site is important for the success of the surgery. Prior to the surgery, a radiograph of a sterile needle placed in a dorsal spinous process can be used to assist in vertebral body identification.

## POSTOPERATIVE EVALUATION

The neurologic status of the patient should be serially evaluated upon recovery from anesthesia and surgery. Urinary continence generally returns with the advent of voluntary ambulation.

## POSTOPERATIVE CARE

General supportive care and pain management are indicated in all neurosurgery patients. Clean, dry, soft, padded bedding is important for patients that are nonambulatory or weakly ambulatory. Maintenance fluid therapy is routine for the first 24 to 48 hours or until the animal is able to eat and drink without assistance. Urine output and quantitation should be closely monitored for the first 24 to 48 hours, and bladder expression or catheterization (or both) should be provided in those patients that are not urinating on a voluntary basis. Rehabilitation may be implemented as soon as the acute postoperative pain has subsided (usually after 24 hours). Depending on the level of neurologic dysfunction, therapy may consist of massage, assisted standing, proprioceptive exercises, and controlled therapeutic exercise. Most overweight animals also benefit from a weight loss program, because excessive weight can impair neurologic recovery.

## EXPECTED OUTCOME[1–3,12]

Most patients with thoracolumbar intervertebral disc disease have good to excellent prognosis; however, expected outcomes will vary, depending on the level of neurologic dysfunction. Animals with intact pain sensation generally have a greater than 90% chance of full recovery. Prognostic indicators for time to ambulation after hemilaminectomy include the presence of postoperative voluntary motor function. Most animals improve following surgical intervention given a convalescent period of reasonable length (6 to 8 weeks). Recurrence of signs associated with intervertebral disc disease has been reported within the literature and should be discussed with the owner prior to surgery.

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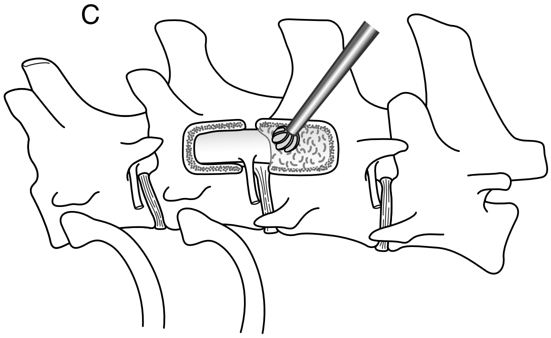
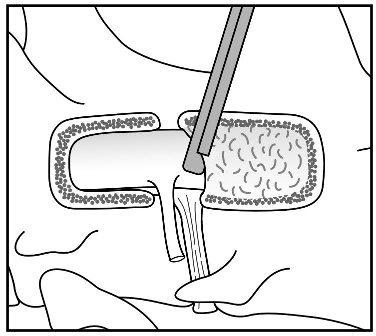
## PLATE 85

C





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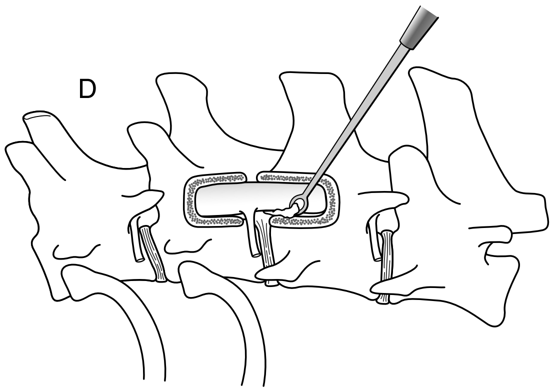


# CHAPTER 86 Fenestration of Thoracolumbar Discs

## INDICATIONS[1–3]

Dorsolateral fenestration of the thoracolumbar spine may be performed as a prophylactic or therapeutic measure for degenerative intervertebral disc disease; however, considerable debate exists regarding the indications and therapeutic benefit of fenestration. To date, clinical studies have yet to prove its therapeutic benefit over the hemilaminectomy procedure. In addition, thoracolumbar fenestration has not been proven to prevent future herniation of discs. In general, most surgeons electing to perform this procedure do so in combination with a hemilaminectomy at adjacent intervertebral discs that are calcified in situ.

## OBJECTIVES

- To prevent herniation of a degenerative intervertebral disc into the vertebral canal and to resolve clinical signs associated with intervertebral disc disease (e.g., pain)

## ANATOMIC CONSIDERATIONS[4,5]

A dorsolateral approach (as described here) may be used to gain access to intervertebral disc sites from T10 to L5. Discs above and below these sites are not routinely fenestrated via this approach because of technical difficulties in the approach caused by anatomic differences and to avoid inadvertent damage to the femoral nerve segments. The intervertebral disc site of the thoracic vertebra lies just cranial and ventromedial to the tubercle of the rib and adjacent to the head of the rib. The intervertebral disc site of the lumbar vertebra lies just cranial to the area where the transverse process joins the vertebral body. Retraction of the multifidus thoracis or lumborum and longissimus dorsi muscles with the blunt end of a Senn retractor reveals the spinal nerve and artery, which lie over the lateral wall of the annulus fibrosus.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), bipolar and unipolar cautery, suction hose and small Frazier suction tip, no. 11 Bard Parker scalpel blade, Freer periosteal elevator, Senn retractors, Lempert rongeur, Kerrison rongeur, DeBakey thumb forceps, bone wax,* gelfoam,† or Avitene Sheets‡ (Microfibrillar Hemostat).

Additional instrumentation that is useful for removing in situ calcified disc material from the vertebral canal includes a Buck ear curette, Ball burnisher, tartar scraper, double-ended curette, Iris spatula, and small bone curette.

## PREPARATION AND POSITIONING

Position the animal in sternal recumbency, and prepare the back from the mid-thoracic region to the lower lumbar area. Support the animal with sandbags on each side of the abdomen, or use a vacuum-activated surgical positioning system.§ If needed, further secure the animal in position with white tape to prevent malposition during surgery. Perfect positioning and alignment assist in the approach and ensure proper orientation; however, some surgeons prefer that the patient be rotated slightly, with the operated side being most dorsal.

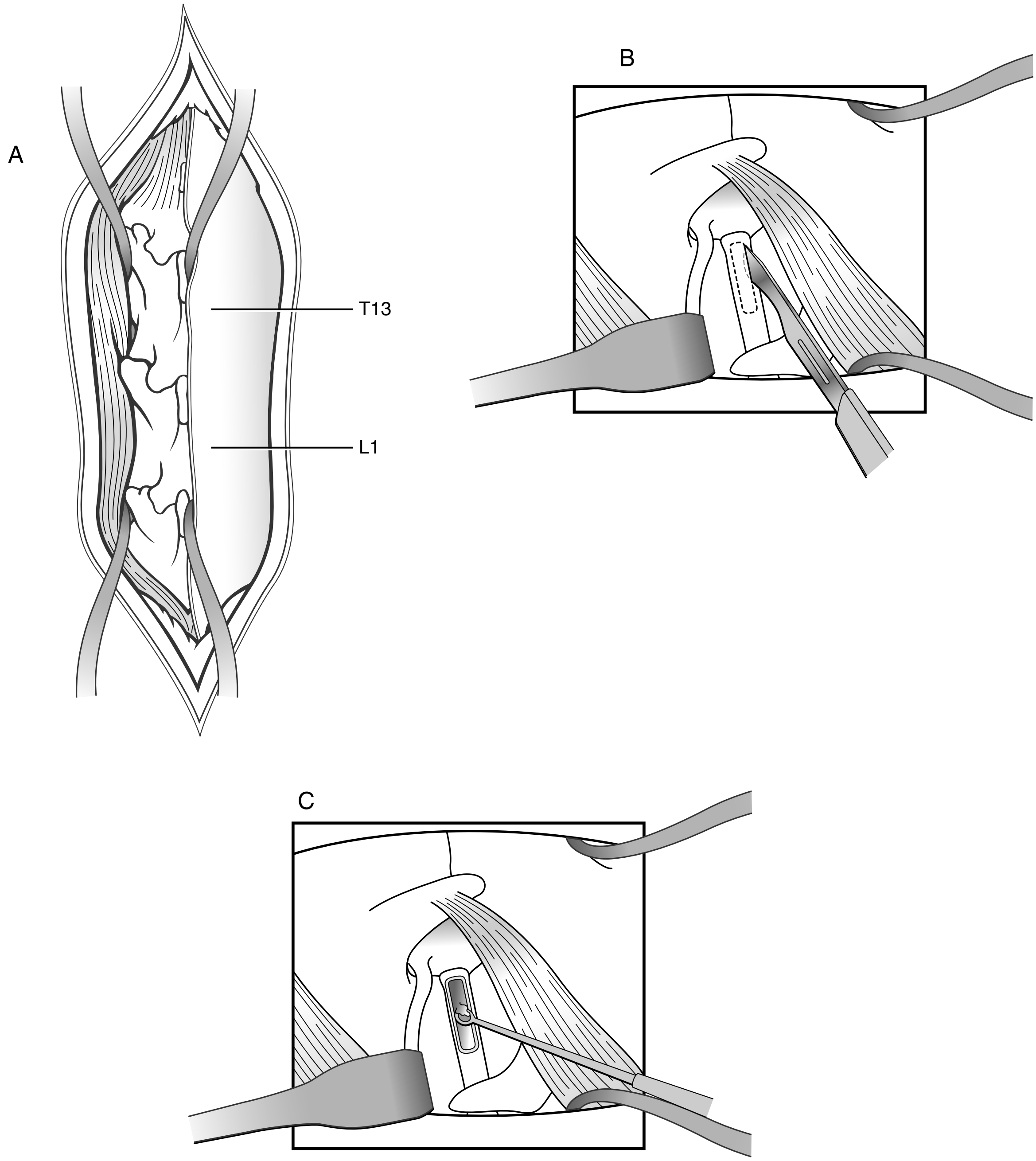
## PROCEDURE

**Thoracolumbar Fenestration:** After performing the hemilaminectomy via a dorsal approach (Plate 86A) (see Chapter 85), locate the intervertebral disc site(s) to be fenestrated. Craniolaterally retract the spinal nerve and artery, demarcating the intervertebral disc site to reveal the lateral aspect of the annulus fibrosis (Plate 86B). With a no. 11 scalpel blade, resect a rectangular section of the lateral annular wall that is large enough to allow access to and removal of the calcified nucleus pulposus (see Plate 86B). With a tartar scraper, buck ear curette, or a neurologic instrument of choice, remove as much of the calcified disc material as possible (Plate 86C). To avoid damage to the peridisc neurovascular structures, maintain the neurologic instrument at a perpendicular angle to the longitudinal and transverse axis of the spine. Lavage and remove the retractors from the epaxial musculature. Suture the epaxial muscular fascia in a simple continuous pattern with absorbable suture. Close the subcutaneous tissues and skin in a routine fashion.

*Continued*

*Bone wax, Ethicon, Johnson & Johnson, Somerville, New Jersey.
†Gelfoam, Pharmacia and Upjohn, Kalamazoo, Michigan.
‡Avitene, Davol, Cranston, Rhode Island.
§Hug-U-Vac, South Salem, Oregon.

# PLATE 86



## CAUTIONS[5,6]

Fenestration of the disc space alone is not an appropriate treatment in animals with neurologic deficits (e.g., significant ataxia or loss motor function) because it does not ameliorate spinal cord compression stemming from disc extrusion. Animals that display more advanced dysfunction associated with spinal cord compression (e.g., paresis or paralysis) are candidates for decompression via hemilaminectomy.

## POSTOPERATIVE EVALUATION[3,5–8]

The neurologic status of the patient should be serially evaluated upon recovery from anesthesia and surgery. Neurologic deterioration associated with thoracolumbar fenestration has been reported in the literature and is thought to be caused by residual disc material herniating into the canal. Postoperative radiographs or ancillary imaging (computed tomography or magnetic resonance imaging) of the thoracolumbar vertebrae is usually not indicated.

## POSTOPERATIVE CARE

General supportive care and pain management are indicated in all neurosurgery patients. Clean, dry, soft, padded bedding is important for patients that are nonambulatory or weakly ambulatory. Maintenance fluid therapy is routine for the first 24 to 48 hours or until the animal is able to eat and drink without assistance. Urine output and quantitation should be closely monitored for the first 24 to 48 hours, and bladder expression and catheterization (or both) should be provided in those patients not urinating on a voluntary basis. Rehabilitation may be implemented as soon as the acute postoperative pain has subsided (usually after 24 hours). Depending on the level of neurologic dysfunction, therapy may consist of massage, assisted standing, proprioceptive exercises, and controlled therapeutic exercise.

## EXPECTED OUTCOME[1,6]

The prognosis varies depending on the level of neurologic dysfunction. Most animals improve following surgical intervention, given an adequate convalescent period.

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# CHAPTER 87 Dorsal Laminectomy of L7-S1

## INDICATIONS[1–4]

Surgical candidates for a lumbosacral dorsal laminectomy are those animals that have exhibited multiple bouts of lumbosacral pain and that are nonresponsive to conservative treatment of rest and nonsteroidal anti-inflammatory drugs or those animals that exhibit loss of voluntary motor function and urinary or fecal incontinence and that, ideally, have been diagnosed with compression of the cauda equina via epidurography, computed tomography, or magnetic resonance imaging.

## OBJECTIVES[1–6]

- Lumbosacral dorsal laminectomy is performed for exposure to and is indicated for decompression of the cauda equina

Lumbosacral dorsal laminectomy is often performed in combination with foraminotomy to relieve individual nerve root impingement.

## ANATOMIC CONSIDERATIONS[2]

Because of the differential rate of growth between the bony vertebral column and the spinal cord, the spinal cord terminates between L4 and L6 in the dog. At the end of the spinal cord or conus medullaris, the nerve root segments exit, forming the cauda equina, and then course obliquely and caudally to their respective intervertebral foramina. Specifically, the cauda equina is composed of nerve roots from the seventh lumbar, three sacral, and a varying number of caudal spinal segments. Nerve roots affected by degenerative lumbosacral stenosis or cauda equina syndrome include the sciatic nerve (which arises from the L6 to S1–S2 spinal cord segments), the pudendal and pelvic nerves (which arise from the S1-S3 spinal cord segments), the cranial gluteal nerves (L6-S1), and the caudal gluteal nerve (L7-S1). The femoral nerve, arising from the L4-L6 spinal cord segments, is usually spared from lumbosacral entrapment because of its early exit from the spinal canal at the L6-L7 intervertebral disc space. Degenerative lumbosacral stenosis or cauda equina is a multifactorial disease process, with clinical signs ranging from lumbosacral pain, hind end lameness, and paraparesis and ataxia of the hind end or tail to fecal and urinary incontinence. Degenerative intervertebral disc disease; congenital lumbosacral stenosis, malformation, or malarticulation; and degenerative changes and hypertrophy of the ligamentum flavum, dorsal longitudinal ligament, and articular facet joint capsule have all been associated with this disease process. Regardless of the point of etiology, the disease is caused by nerve root entrapment by either hard or soft tissue.

## EQUIPMENT

- Standard surgical pack, two medium or large Gelpi retractors (depending on the size of the dog), bipolar and unipolar cautery, suction hose and small Frazier suction tip, no. 11 and no. 15 Bard Parker scalpel blades, Freer periosteal elevator, Senn retractors, Lempert rongeur, Kerrison rongeur, pneumatic drill system with burr guard and a variety of sizes of round and oval burrs, DeBakey thumb forceps, bone wax,* gelfoam,† or Avitene Sheets‡ (Microfibrillar Hemostat)

Additional instrumentation that is useful for removing extruded disc material from the vertebral canal includes a Buck ear curette, Ball burnisher, tartar scraper, double-ended curette, Iris spatula, small bone curette, and nerve root retractor.

## PREPARATION AND POSITIONING[7–10]

Position the animal in sternal recumbency, and prepare the lower back and sacrum from the mid-lumbar region to the tail head. Elevate the hind end with sandbags, and position the rear limbs forward, with the hips and stifles flexed. Support the animal with sandbags on each side of the abdomen, or use a vacuum-activated surgical positioning system.§ If needed, further secure the animal in position with white tape to prevent malpositioning during surgery. Perfect positioning and alignment assist in the approach and ensure proper orientation.

## PROCEDURE

**Approach:**[11–13] Incise the skin and subcutaneous tissue on dorsal midline from the L5 dorsal spinous process to the first or second caudal vertebrae. Suture two quarter drapes to the subcutaneous tissue to decrease skin contamination. Incise the lumbosacral and gluteal fascia with a no. 11 scalpel blade, from the L6 dorsal spinous process to the caudal median sacral crest. Bilaterally elevate the sacrocaudalis dorsal medialis muscles away from the dorsal spinous process, pedicle, and lamina to the articular facets of L7-S1 and the intermediate sacral crest, using an Adson or Freer periosteal elevator. Retract the elevated muscles using two Gelpi self-retaining retractors (Plate 87A). Excise the interarcuate ligament between the laminae of L7-S1 with a no. 15 blade to expose the epidural space and the cauda equina.

*Continued*

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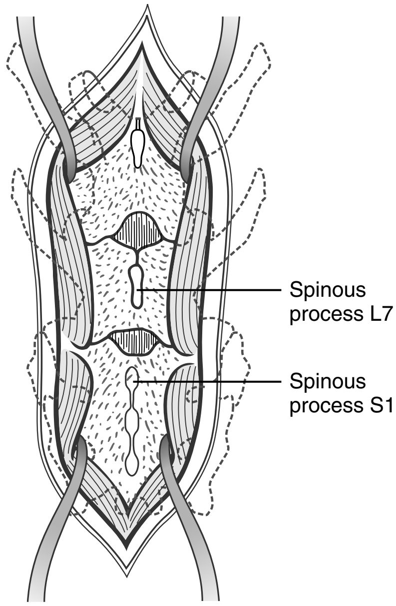
*Bone wax, Ethicon, Johnson & Johnson, Somerville, New Jersey.
†Gelfoam, Pharmacia and Upjohn, Kalamazoo, Michigan.
‡Avitene, Davol, Cranston, Rhode Island.
§Hug-U-Vac, South Salem, Oregon.

# PLATE 87

A



**Dorsal Laminectomy of L7-S1:[4,12]** Remove the dorsal spinous processes of L7 and S1 with a rongeur (Plate 87B). Drill the proposed laminectomy site with a pneumatic air drill, using a burr of appropriate size (Plate 87C). Slowly trickle warm saline over the burr while drilling to prevent heat transfer from the burr to the laminectomy site. Intermittently lavage the entire laminectomy site to remove bone debris and to keep the tissues moist. The laminectomy site should extend from the cranial aspect of the dorsal spinous process of L7 to the caudal aspect of S1, preserving the articular facets (Plate 87D). Once most of the bone has been removed, a smaller bit can be used to remove the edges of inner cortical bone plate. Control any bone bleeding with bone wax. Once the inner cortex has been removed, use a nerve root probe, ear loop, or tartar scraper to palpate the inner bone and periosteal shelf. When it is thin and pliable, use a probe to gently penetrate the site and create a long window to allow admission of a Kerrison or small Lempert rongeur to remove any remaining bone in the oblong window (Plate 87E). Inspect each nerve root for entrapment or compression from a bulging or extruded intervertebral disc, hypertrophied dorsal longitudinal ligament, or stenotic intervertebral foramina or canal. Trace each nerve root with a nerve root retractor along its path toward its respective intervertebral foramina. Depending on the lesion location, further decompression of a nerve root may be necessary by performing a discectomy (Plate 87F), dorsal longitudinal ligament resection, facetectomy, or foraminotomy. Once the nerve root(s) has been decompressed, gently lavage the laminectomy site, and harvest a fat graft from the subcutaneous region of the back. Place the fat graft over the hemilaminectomy site to prevent fibrous scarring and adhesion. Suture the epaxial muscular fascia in a simple continuous pattern using absorbable suture. Close the subcutaneous tissues and skin in a routine fashion.

## CAUTIONS[14–17]

Every effort should be made to preserve the articular facets of the lumbosacral junction to promote lumbosacral stability. An accurate and thorough identification of each nerve root will improve the postoperative outcome. However, it is often difficult to identify a compressive lesion because of the anatomic complexity of the area. Owner education is very important to the success of the surgery, because small but significant lesions may be missed by ancillary imaging such as magnetic resonance imaging and computed tomography. Therefore, all lumbosacral laminectomies must be approached as exploratory operations, emphasizing the diagnostic and therapeutic significance of the surgery.

## POSTOPERATIVE EVALUATION

The neurologic status of the patient should be serially evaluated upon recovery from anesthesia and surgery. Gentle retraction and manipulation of the nerve roots is often necessary to access the compressive lesion; however, peripheral nerve injury stemming from retraction is usually transient and responsive to appropriate supportive care.

## POSTOPERATIVE CARE

Neurosurgery patients require general supportive care and pain management. Clean, dry, soft, padded bedding is needed for nonambulatory or weakly ambulatory patients. Maintenance fluid therapy is routine for the first 24 to 48 hours or until the animal can eat and drink unaided. Urine output and quantitation are closely monitored for the first 24 to 48 hours, and bladder expression or catheterization (or both) are provided in patients not urinating voluntarily. Rehabilitation may be implemented as soon as the acute postoperative pain has subsided (usually after 24 hours). Depending on the level of neurologic dysfunction, therapy may consist of massage, assisted standing, proprioceptive exercises, and controlled therapeutic exercise. Activity should be restricted for 4 to 6 weeks. Barring extreme paresis or ataxia, normal activity is then slowly reintroduced. For animals with excessive weight, which can impair neurological recovery, a weight loss program may be beneficial.

## EXPECTED OUTCOME[1–6,10,12,18–20]

Most animals with degenerative lumbosacral stenosis have good to excellent prognosis, but expected outcomes vary, depending on the level of neurologic dysfunction. Degree of compression at the time of presentation, as determined by magnetic resonance imaging, has been found to be independent of disease severity and thus should not be used in prognostication. Young animals with mild signs of lumbosacral pain, ataxia, and weakness have a fair to good prognosis for full recovery. Urinary or fecal incontinence and extreme age have been associated with poor or guarded recovery. Most animals improve after surgical intervention, given a reasonable convalescent period (4 to 6 weeks). Recurrence of signs has been reported at a varying rate of 15% to 67% and should be discussed with the owner before surgery.

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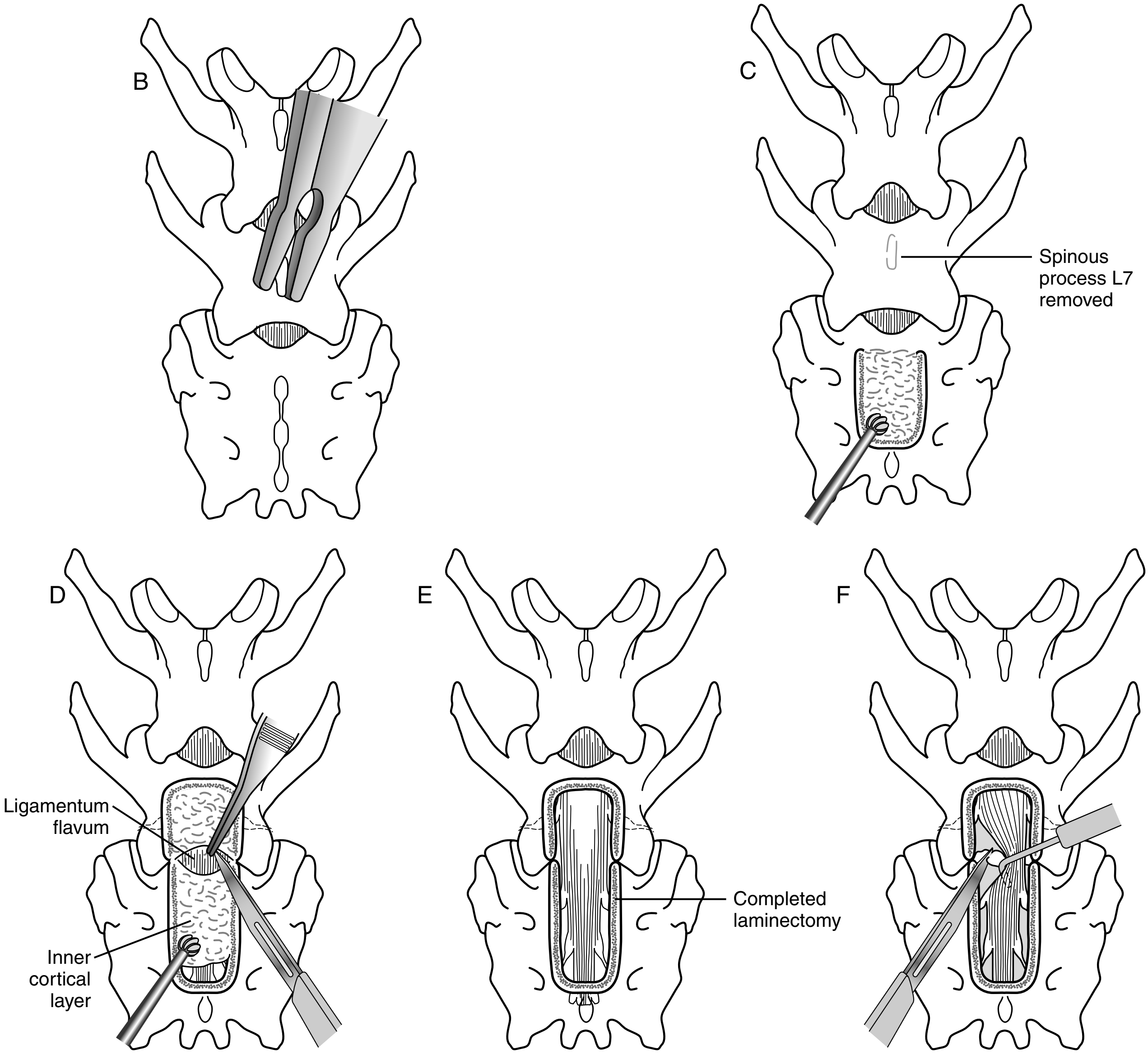
# PLATE 87


B
C
Spinous
process L7
removed
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F
Ligamentum
flavum
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cortical
layer
Completed
laminectomy

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