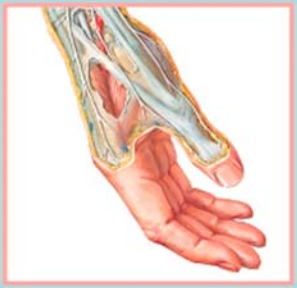
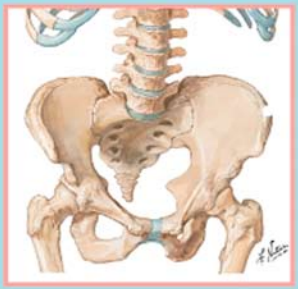
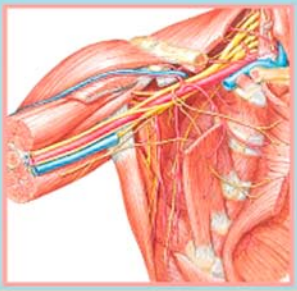
Netter's
Musculoskeletal Flash Cards

Jennifer A. Hart
Mark D. Miller
University of Virginia

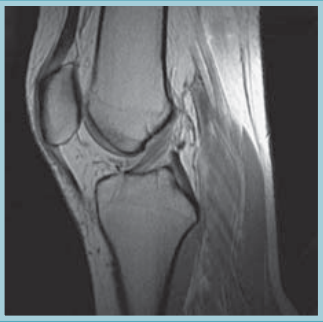
About the pagination of this eBook

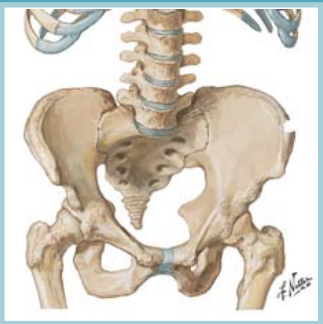
Due to the unique page numbering scheme of this book, the electronic pagination of the eBook does not match the pagination of the printed version. To navigate the text, please use the electronic Table of Contents that appears alongside the eBook or the Search function.

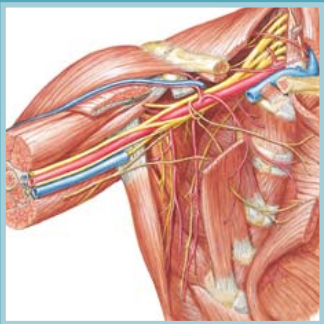
For citation purposes, use the page numbers that appear in the text.

Netter's

Musculoskeletal Flash Cards







Jennifer Hart, PA-C, ATC

Mark D. Miller, MD

University of Virginia

SAUNDERS

ELSEVIER

This page intentionally left blank

Preface

In a world dominated by electronics and gadgetry, learning from flash cards remains a reassuringly "tried and true" method of building knowledge. They taught us subtraction and multiplication tables when we were young, and here we use them to navigate the basics of musculoskeletal medicine. Netter illustrations are supplemented with clinical, radiographic, and arthroscopic images to review the most common musculoskeletal diseases. These cards provide the user with a steadfast tool for the very best kind of learning—that which is self directed.

"Learning is not attained by chance, it must be sought
for with ardor and attended to with diligence."
—Abigail Adams (1744–1818)

"It's that moment of dawning comprehension I live for!"
—Calvin (Calvin and Hobbes)

Jennifer Hart, PA-C, ATC
Mark D. Miller, MD

SAUNDERS
ELSEVIER

1600 John F. Kennedy Blvd.
Ste 1800
Philadelphia, PA 19103-2899

NETTER'S MUSCULOSKELETAL FLASH CARDS ISBN: 978-1-4160-4630-1

Notice
Knowledge and best practice in this field are constantly changing. As new research and experience broaden our knowledge, changes in practice, treatment, and drug therapy may become necessary or appropriate. Readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of the practitioner, relying on his or her own experience and knowledge of the patient, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions. To the fullest extent of the law, neither the Publisher nor the Authors assume any liability for any injury and/or damage to persons or property arising out of or related to any use of the material contained in this book.

The Publisher

ISBN 978-1-4160-4630-1

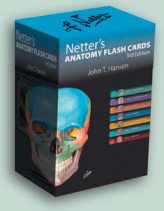
Acquisitions Editor: Elyse O'Grady
Developmental Editor: Marybeth Thiel
Publishing Services Manager: Linda Van Pelt
Design Direction: Steve Stave
Illustrations Manager: Karen Giacomucci
Marketing Manager: Jason Oberacker

Printed in China
Last digit is the print number: 9 8 7 6 5 4

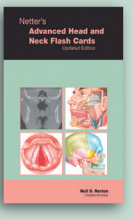
Table of Contents

More exquisitely illustrated sets to help you review!

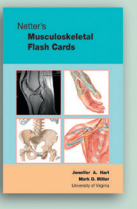
The Netter Flash Cards Series



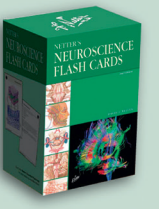
Netter's Anatomy Flash Cards, 3rd Edition (978-1-4377-1675-7)



Netter's Advanced Head and Neck Flash Cards – Updated Edition (978-1-4557-4523-4)



Netter's Musculoskeletal Flash Cards (978-1-4160-4630-1)



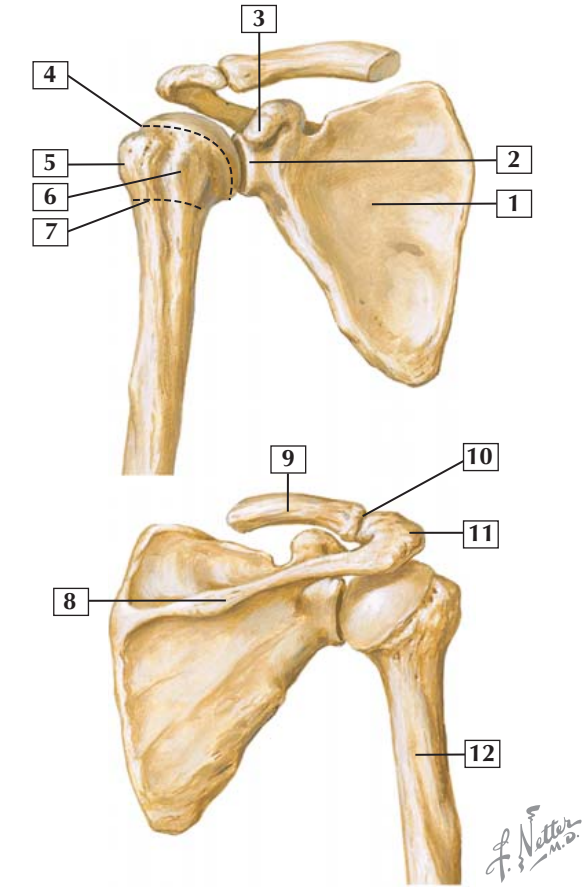
Netter's Neuroscience Flash Cards, 2nd Edition (978-1-4377-0940-7)

Look for these and other great **Netter Flash card sets** at your local medical bookstore or visit www.elsevierhealth.com.

F. H. Netter, M.D.

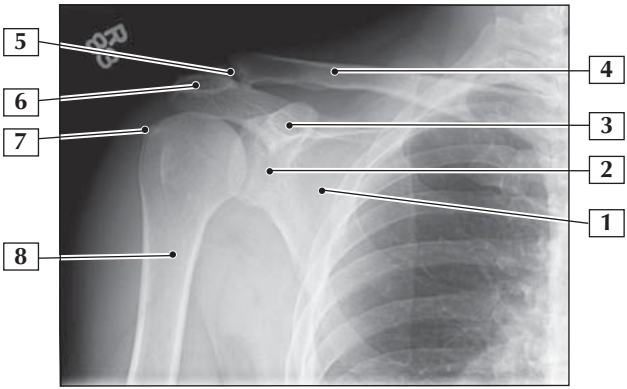
This page intentionally left blank

1 The Shoulder and Upper Arm
Plates 1-1 to 1-22

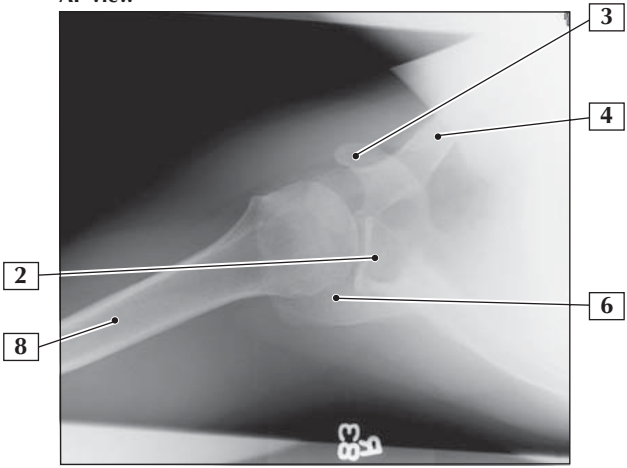

3
4
5
6
7
2
1
9
10
11
8
12
F. Netter M.D.

1. Body of the scapula
2. Glenoid
3. Coracoid process
4. Anatomical neck of the humerus
5. Greater tuberosity of the humerus
6. Lesser tuberosity of the humerus
7. Surgical neck of the humerus
8. Spine of the scapula
9. Clavicle
10. Acromioclavicular (AC) joint
11. Acromion
12. Shaft of the humerus

Comment: The primary articulation of the shoulder joint is between the glenoid of the scapula and the head of the humerus (glenohumeral joint). Other articulations here include the acromioclavicular and the sternoclavicular joints. The bony anatomy does not provide much stability to the shoulder joint.



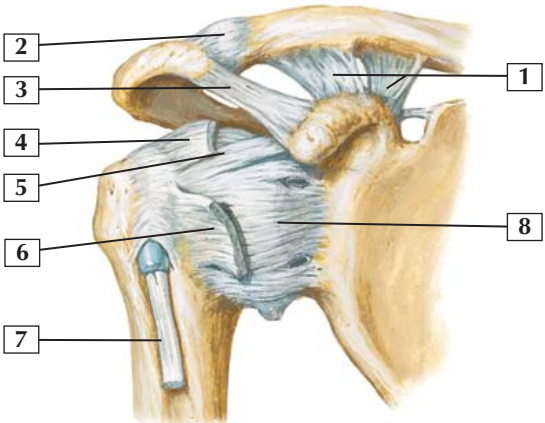
AP view



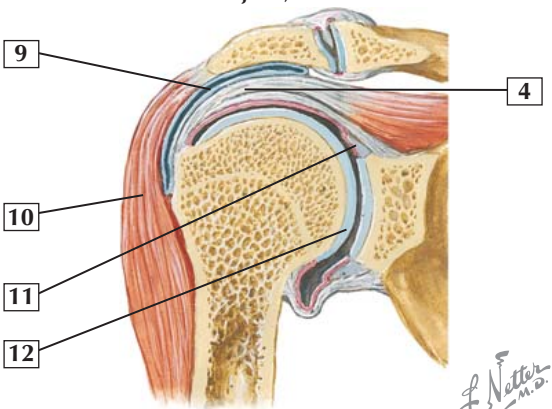
Lateral view

1. Body of the scapula
2. Glenoid
3. Coracoid process
4. Clavicle
5. Acromioclavicular (AC) joint
6. Acromion
7. Greater tuberosity of the humerus
8. Shaft of the humerus

Comment: Anteroposterior and axillary views are the most common views of the shoulder, and both should always be ordered in cases of suspected dislocation.



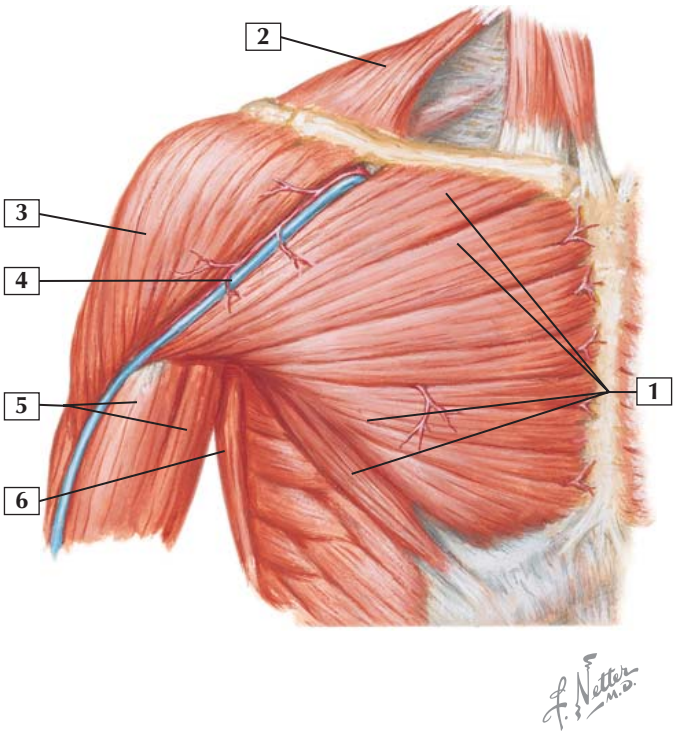
Shoulder joint, anterior view



Coronal section through joint

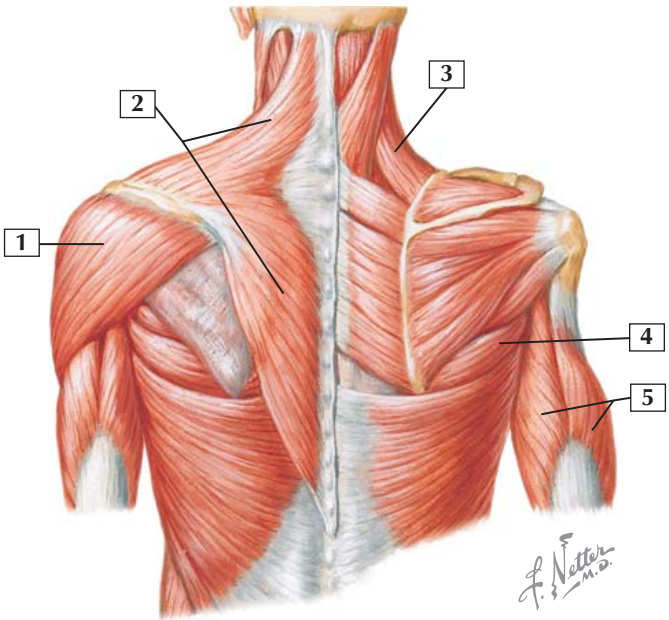
1. Coracoclavicular ligaments (conoid and trapezoid)
2. Acromioclavicular ligament
3. Coracoacromial ligament
4. Supraspinatus tendon
5. Coracohumeral ligament
6. Subscapularis tendon
7. Long head of the biceps tendon
8. Joint capsule
9. Subdeltoid bursa
10. Deltoid muscle
11. Glenoid labrum
12. Articular cartilage

Comment: The secondary stabilizers (ligaments, muscles, and joint capsule) provide most of the stability for the shoulder joint. The glenohumeral ligaments are really just thickenings of the glenohumeral joint capsule.


2
3
4
5
6
1
F. Netter M.D.

1. Pectoralis major muscle
2. Trapezius muscle
3. Deltoid muscle
4. Cephalic vein
5. Biceps brachii muscle
6. Latissimus dorsi muscle

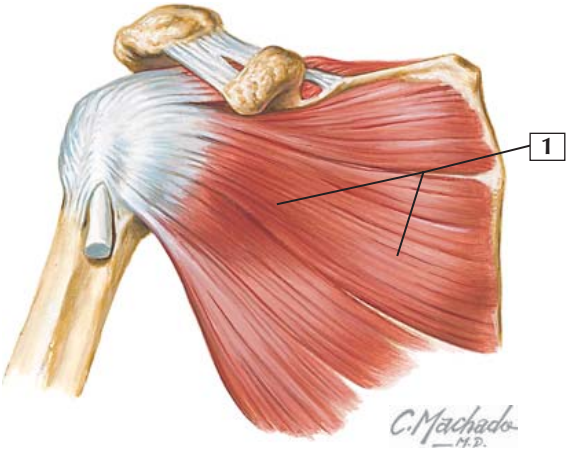
	Deltoid Muscle	Pectoralis Major Muscle	Latissimus Dorsi Muscle
Origin	Clavicle, acromion, scapular spine	Medial clavicle and upper sternum	T6-L5 spinous processes
Insertion	Deltoid tuberosity, humerus	Intertubercular groove of humerus	Intertubercular groove of humerus
Actions	Primarily abduction, flexion, extension	Arm adduction, assists rotation	Shoulder extension, adduction, and internal rotation
Innervation	Axillary nerve (C5-6)	Medial and lateral pectoral nerves (C5-T1)	Thoracodorsal nerve


1
2
3
4
5
F. Netter M.D.

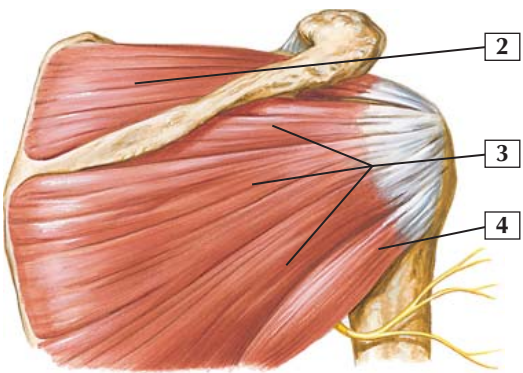
Muscles: Shoulder and Upper Arm (Posterior View)

1. Deltoid muscle
2. Trapezius muscle
3. Levator scapulae muscle
4. Teres major muscle
5. Triceps brachii muscle

	Trapezius Muscle	Teres Major Muscle	Levator Scapulae Muscle
Origin	Occipital bone, ligamentum nuchae, spinous processes C7-T12	Inferior angle of the scapula	Transverse process of C1-4
Insertion	Lateral clavicle, medial acromion, scapular spine	Medial intertubercular groove of humerus	Superior medial scapula
Actions	Primarily scapular rotation	Helps extend, adduct, and medially rotate the arm	Scapular elevation and rotation
Innervation	Spinal accessory nerve (cranial nerve XI)	Lower subscapular nerve (C5-C6, C6-C7)	Third and fourth cervical nerves, dorsal scapular nerve (C5)



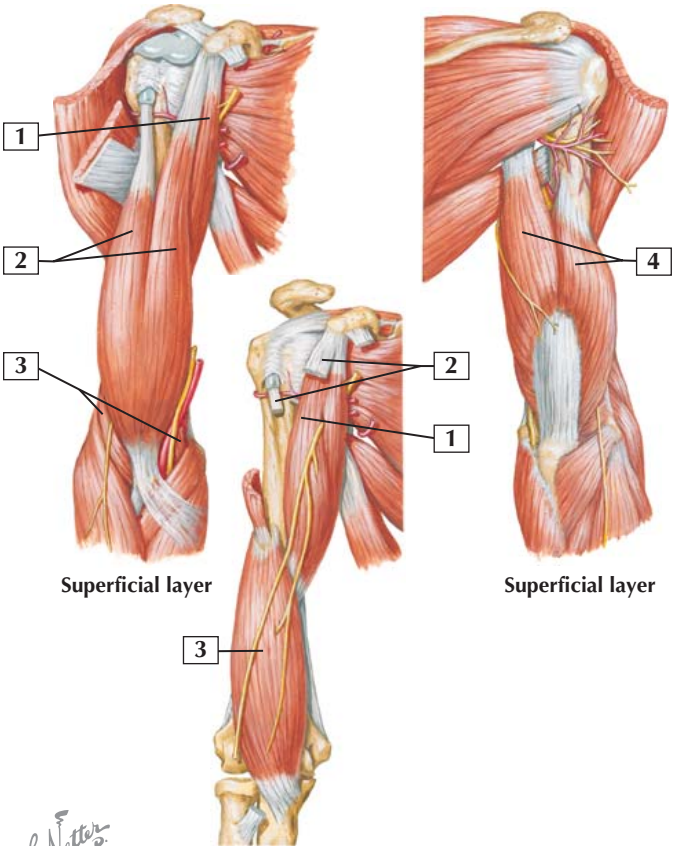
Anterior view



Posterior view

1. Subscapularis muscle
2. Supraspinatus muscle
3. Infraspinatus muscle
4. Teres minor muscle

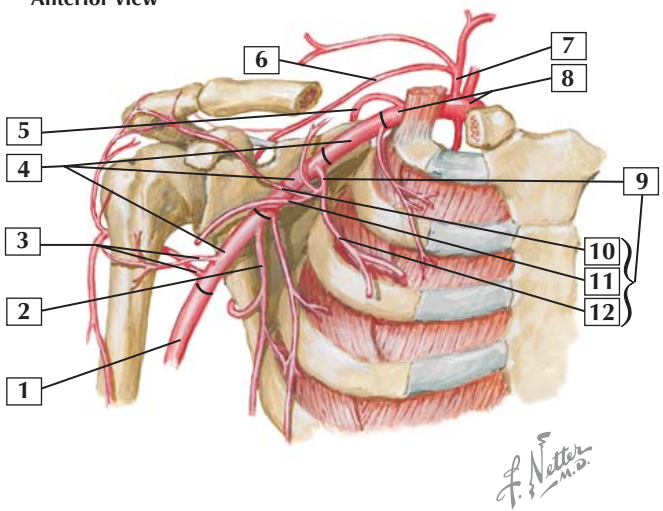
	Supraspinatus Muscle	Infraspinatus Muscle	Teres Minor Muscle	Subscapularis Muscle
Origin	Supraspinous fossa of scapula	Infraspinous fossa of scapula	Lateral border of the scapula	Subscapular fossa and lateral border of scapula
Insertion	Greater tuberosity of humerus	Greater tuberosity of humerus	Greater tuberosity of humerus	Lesser tuberosity of humerus
Actions	Shoulder abduction, external rotation	Shoulder external rotation	Shoulder external rotation and assists with adduction	Shoulder internal rotation and adduction
Innervation	Suprascapular nerve (C5-6)	Suprascapular nerve (C5-6)	Axillary nerve (C5-6)	Subscapular nerves (C5-6)


1
2
3
Superficial layer
2
1
3
Deep layer
4
Superficial layer

1. Coracobrachialis muscle
2. Biceps brachii muscle (long and short heads)
3. Brachialis muscle
4. Triceps brachii muscle (long, lateral)

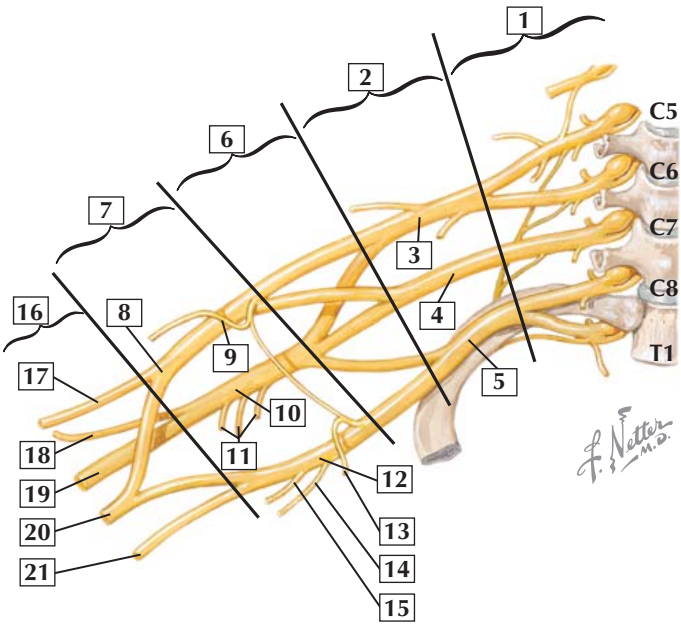
	Biceps Brachii Muscle (Long and Short Heads)	Triceps Brachii Muscle (Long, Lateral, and Medial Heads)	Coracobrachialis Muscle	Brachialis Muscle
Origin	Coracoid process (short head); supraglenoid tubercle of scapula (long head)	Infraglenoid tubercle of scapula (long head), posterior humerus (lateral head), posterior humerus inferior to radial groove (medial head)	Coracoid process of scapula	Distal anterior humerus
Insertion	Radial tuberosity	Posterior proximal olecranon	Medial aspect of midshaft of humerus	Tuberosity and anterior coronoid process of ulna
Actions	Flexion and supination at elbow	Extension at the elbow	Shoulder flexion and adduction	Elbow flexion
Innervation	Musculocutaneous nerve (C5-6)	Radial nerve (C7-8)	Musculocutaneous nerve (C6-7)	Musculocutaneous nerve (C5-6), branch of radial nerve (C7)

Anterior view



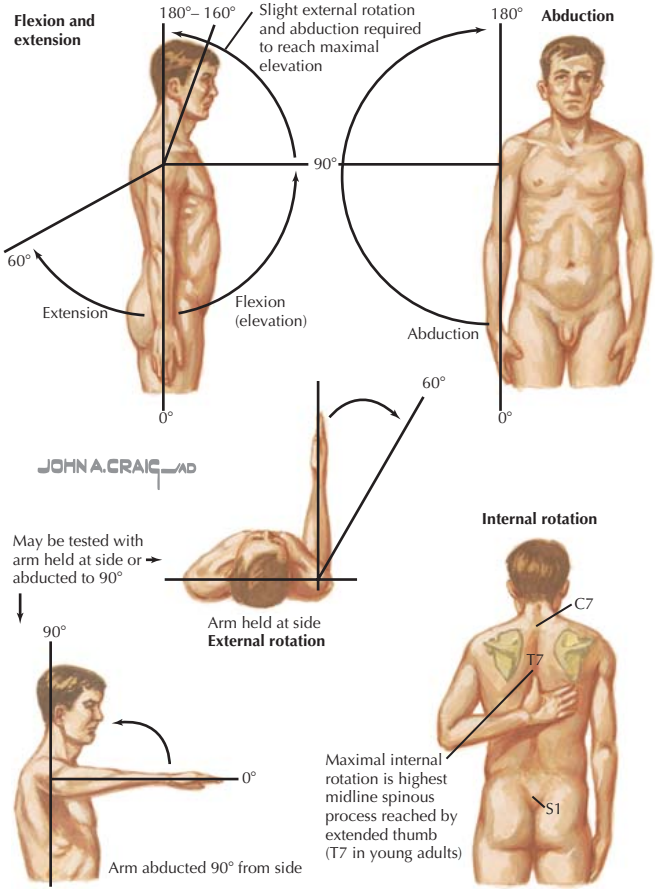
1. Brachial artery
2. Subscapular artery
3. Posterior and anterior humeral circumflex artery
4. Axillary artery
5. Dorsal scapular artery
6. Suprascapular artery
7. Thyrocervical trunk
8. Subclavian artery
9. Thoracoacromial artery
10. Acromial branch
11. Deltoid branch
12. Pectoral branch

Comment: The subclavian artery becomes the axillary artery as it passes underneath the clavicle and later becomes the brachial artery at the inferior border of the teres major muscle. The brachial artery divides in the arm into the radial and ulnar arteries. The main blood supply to the humeral head is provided by the anterior humeral circumflex artery.


1
2
6
7
3
4
5
16
8
9
17
10
18
11
12
19
13
20
14
21
15
C5
C6
C7
C8
T1
F. Netter M.D.

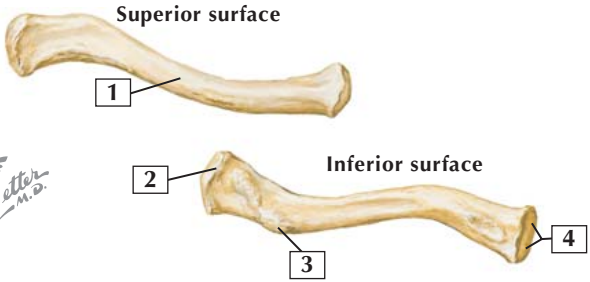
1. Roots
2. Trunks
3. Superior trunk
4. Middle trunk
5. Inferior trunk
6. Divisions (posterior and anterior)
7. Cords
8. Lateral cord
9. Lateral pectoral nerve
10. Posterior cord
11. Upper, middle, and lower subscapular nerves
12. Medial cord
13. Medial pectoral nerve
14. Medial brachial cutaneous nerve
15. Medial antebrachial cutaneous nerve
16. Terminal branches
17. Musculocutaneous nerve
18. Axillary nerve
19. Radial nerve
20. Median nerve
21. Ulnar nerve

Comment: The brachial plexus is formed by the nerve roots of C5, C6, C7, C8, and T1. Injuries typically occur when the plexus is stretched while the shoulder is depressed and the neck is laterally flexed to the opposite side. A helpful mnemonic for the arrangement of the plexus (*r*oots, *t*runks, *d*ivisions, *c*ords, *b*ranches) is "*R*ob *T*aylor *d*rinks *c*old *b*eer."

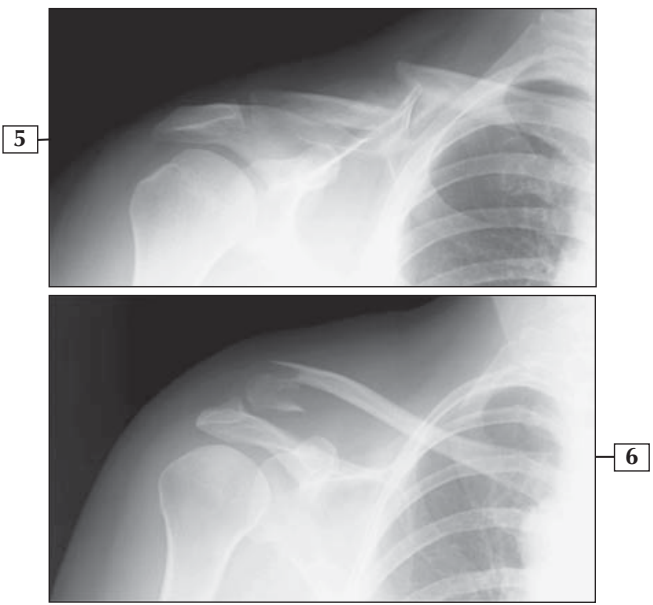

Flexion and extension
180°– 160°
Slight external rotation and abduction required to reach maximal elevation
180°
Abduction
90°
60°
Extension
Flexion (elevation)
Abduction
0°
0°
JOHN A. CRAIG, MD
60°
May be tested with arm held at side or abducted to 90°
Arm held at side
External rotation
Internal rotation
C7
T7
90°
0°
Maximal internal rotation is highest midline spinous process reached by extended thumb (T7 in young adults)
S1
Arm abducted 90° from side

Type of Movement	Normal Range of Motion
Flexion	160-180 degrees
Extension	45-60 degrees
Abduction	160-180 degrees
External rotation	40-60 degrees
Internal rotation	Midthoracic: 55 degrees

Test/Sign	Reason for Evaluation
Apprehension/relocation	Shoulder instability
Sulcus sign	Inferior shoulder instability
Impingement sign (Neer and Hawkins)	Impingement/bursitis
Supraspinatus stress test External rotation strength	Rotator cuff tear
Drop arm sign	Massive rotator cuff tear
Lift off test Belly press test	Subscapularis tear
Speed test Yergason test	Bicipital tendinitis
O'Brien test (active compression)	Superior labrum anterior to posterior (SLAP) tear
Jerk test	Posterior labral tear
Wall push-up	Scapular winging
Cross-body adduction test	Acromioclavicular (AC) joint arthritis/osteolysis



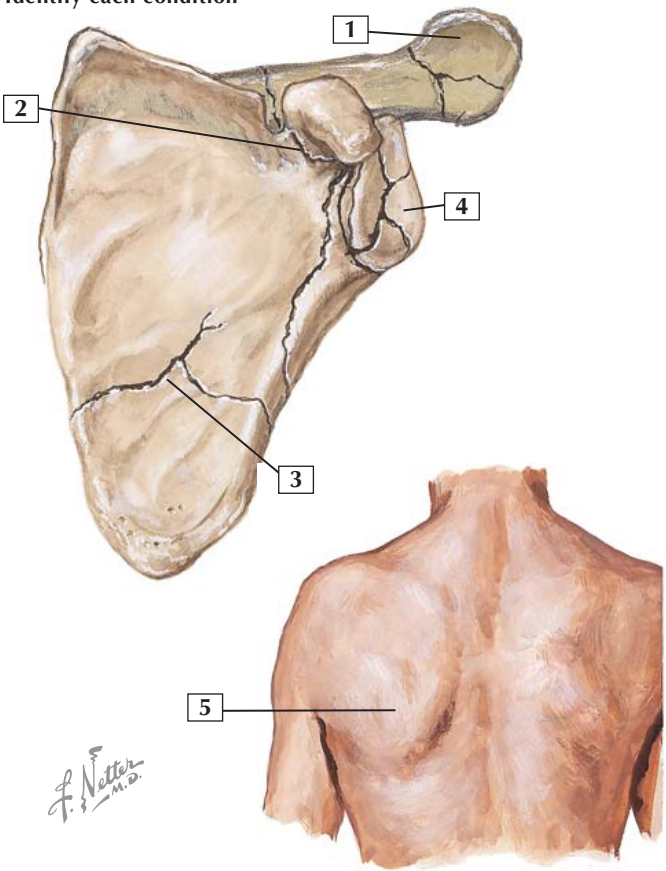
Identify each condition



1. Shaft
2. Acromial facet
3. Conoid tubercle
4. Sternal facet
5. Midshaft clavicle fracture
6. Distal clavicle fracture

	Clavicle Fractures
Mechanism	Fall onto "point" of shoulder
Diagnosis	Pain, tenderness, deformity
Imaging	Plain radiographs Computed tomography to determine nonunion if necessary
Treatment	Generally conservative
Surgical Indications	Excessive shortening Skin compromise (tenting) Distal fracture Medial fracture Nonunion after 6 months

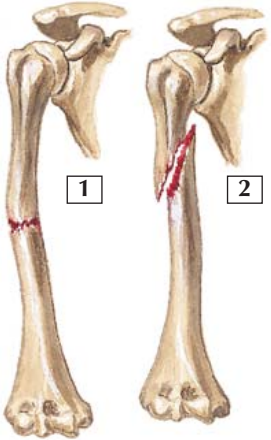
Identify each condition



1. Acromion fracture
2. Coracoid process fracture
3. Scapular body fracture
4. Glenoid fracture
5. Scapular winging

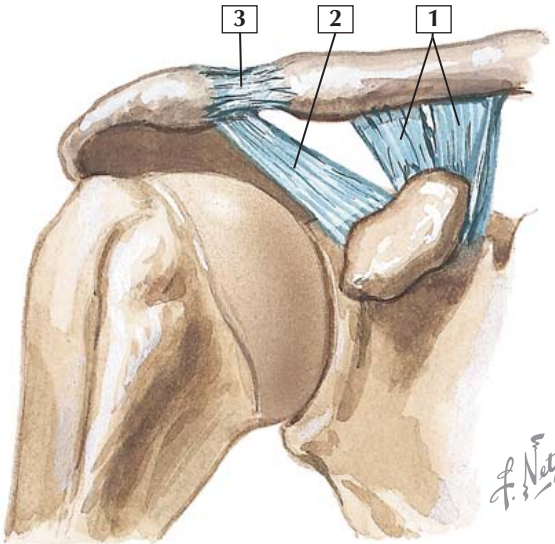
	Scapular Fracture	Scapular Winging
Mechanism	Direct trauma	Injury to the long thoracic nerve or cranial nerve XI
Diagnosis	Anteroposterior, axillary, scapula Y radiographs, computed tomographic scan to further define fracture pattern if necessary	Winging apparent with wall push-ups (weak serratus anterior) Electromyography confirms nerve injury
Classification	By area of involvement	Primary, secondary, voluntary
Treatment	Usually conservative Surgical open reduction and internal fixation (ORIF) indicated in cases of severely displaced fractures or "floating shoulder" (associated clavicle fracture)	Depends on cause of nerve injury, but winging frequently resolves spontaneously

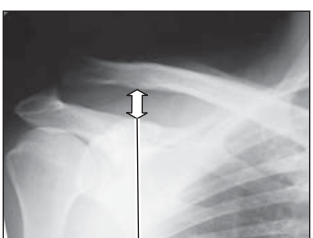
Identify each condition



1. Transverse midshaft humerus fracture
2. Oblique midshaft humerus fracture
3. Comminuted midshaft humerus fracture
4. Radiographic appearance of oblique midshaft humerus fracture
5. Displaced proximal humerus fracture (anteroposterior [AP] view)

	Midshaft Humerus Fracture	Proximal Humerus Fracture
Mechanism	Direct trauma	Fall, direct trauma
Classification	By fracture type (transverse, oblique, comminuted)	By number of parts (greater tuberosity, lesser tuberosity, head, and shaft)
Imaging	AP and lateral radiographs of the humerus	AP and axillary view of the shoulder
Treatment	Conservative with protective brace if angulation <30 degrees	Conservative if one part or displacement <45 degrees
Surgical Indications	Open fracture, associated forearm fracture, severe angulation, or pathological fracture	Surgical treatment is generally open reduction and internal fixation (ORIF) but may include shoulder replacement in older patients with three- or four-part fractures


3
2
1
F. Netter M.D.

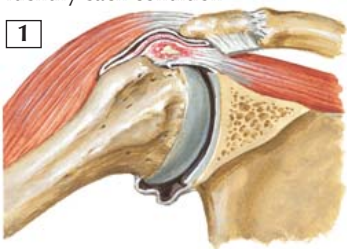

4
5

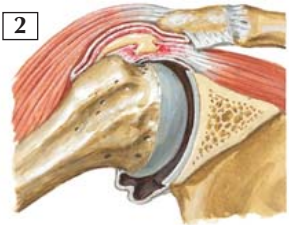

6

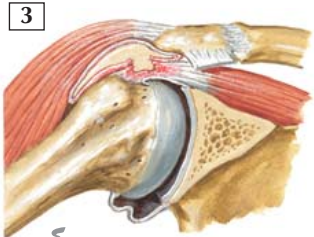
1. Coracoclavicular (CC) ligament
2. Coracoacromial (CA) ligament
3. Acromioclavicular (AC) ligament
4. Type III AC separation
5. Coracoclavicular distance
6. Type IV AC separation

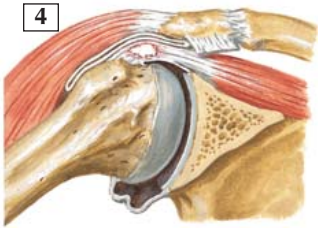
	AC Separations
Mechanism	Fall on "point" of shoulder
Diagnosis	Local tenderness and deformity
Imaging	Bilateral AC joint view, axillary of affected side
Grading	I: AC sprain II: AC tear, intact CC III: AC and CC tear (up to 100% displacement) IV: AC and CC tear (clavicle displaced posteriorly) V: AC and CC tear (over 100% displacement) VI: AC and CC tear (inferior displacement of clavicle)
Treatment	Conservative for types I and II Surgical repair or reconstruction for symptomatic types IV, and V Treatment for type III is controversial and depends on individual patient circumstances

Identify each condition

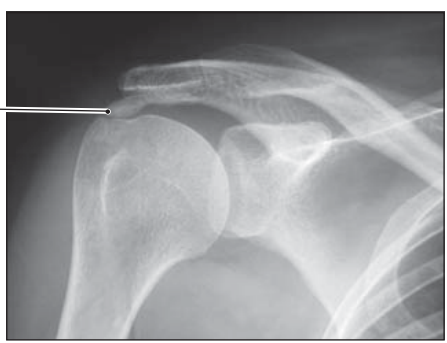






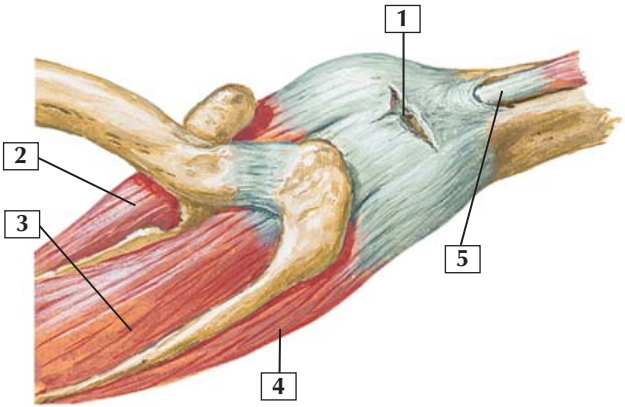


F. Netter M.D.



1. Rotator cuff tendinitis
2. Partial rotator cuff tear
3. Partial rotator cuff tear and subacromial bursitis
4. Calcific tendonitis
5. Radiographic appearance of calcific tendinitis

	Subacromial Bursitis and Rotator Cuff Tendonitis
Mechanism	Overuse/impingement
Diagnosis	Pain with overhead reaching, positive Neer and Hawkins impingement signs
Imaging	Usually not necessary Plain radiographs (anteroposterior, outlet, axillary) may show calcific tendonitis
Treatment	Generally conservative with nonsteroidal antiinflammatory drugs (NSAIDs), subacromial steroid injections, and rotator cuff strengthening Arthroscopic débridement and acromioplasty for refractory cases

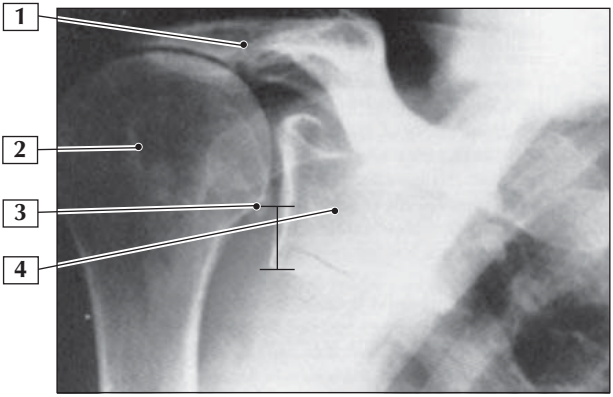


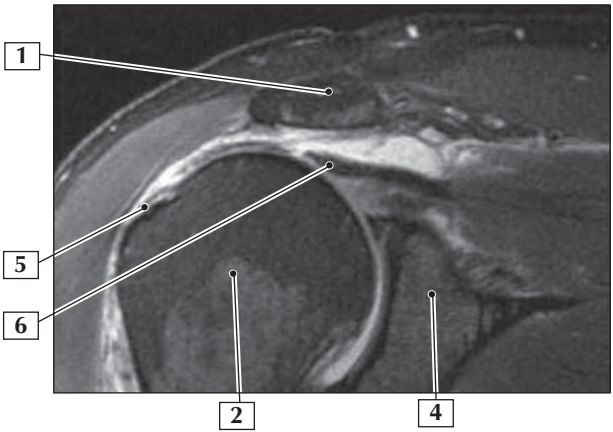
F. Netter M.D.

Identify each condition

1. Rotator cuff tear
2. Subscapularis muscle
3. Supraspinatus muscle
4. Infraspinatus muscle
5. Biceps tendon
6. Arthroscopic view of rotator cuff tear
7. Arthroscopic view of rotator cuff repair

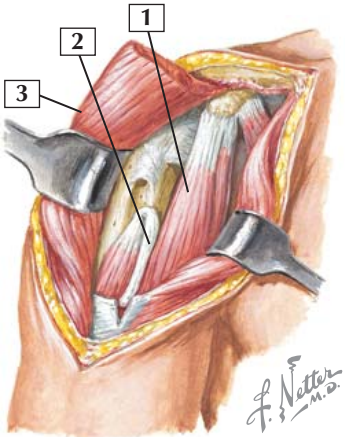
	Rotator Cuff Tears
Mechanism	May be traumatic or degenerative
Diagnosis	Weakness with abduction (supraspinatus muscle), external rotation (infraspinatus muscle), and internal rotation with lift off sign or belly press (subscapularis muscle)
Imaging	Magnetic resonance imaging with arthrogram
Treatment	High grade partial tears (>50% of fibers) and full-thickness rotator cuff tears necessitate surgical repair


1
2
3
4


1
5
6
2
4

1. Acromion
2. Humeral head
3. Proximal migration of the humeral head
4. Glenoid
5. Rotator cuff insertion
6. Rotator cuff tendon (retracted)

	Rotator Cuff Arthropathy
Mechanism	Rotator cuff tears that remain untreated which results in significant retraction and fatty atrophy of the muscles
Diagnosis	Weakness on examination, drop arm test, “horn blowers” sign
Imaging	Plain radiographs show proximal migration of the humeral head, arthrographic magnetic resonance imaging demonstrates retraction and fatty atrophy
Treatment	These tears are not repairable Treatment consists of conservative management initially and later constrained hemiarthroplasty or reverse shoulder prosthesis



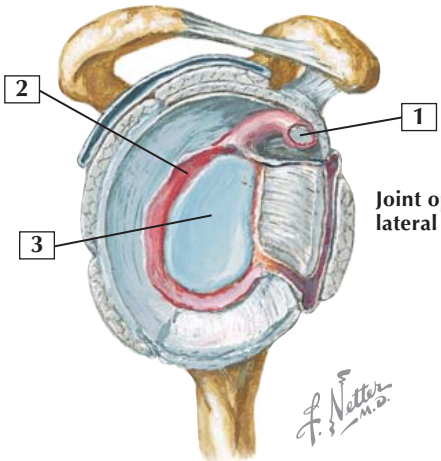
Identify the condition

4

1. Short head of the biceps, intact
2. Long head of the biceps, torn
3. Deltoid, reflected
4. Arthroscopic image of frayed biceps tendon

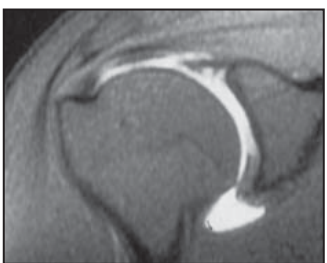
	Rupture of the Long Head of the Biceps	Biceps Tendinitis
Mechanism	Trauma or fraying over time	Overuse
Diagnosis	"Popeye" deformity	Tenderness over the bicipital groove; positive Yergason and Speed tests
Imaging	Not usually necessary	Not necessary
Treatment	Reassurance that this condition is really a cosmetic problem and does not lead to significant strength loss	Initially conservative with injections of the biceps tendon sheath and physical therapy Biceps tenotomy (releasing the long head) or biceps tenodesis (surgical fixation in the groove) if conservative treatment fails

Arthroscopic image from Miller M, Cole B: Textbook of Arthroscopy. Philadelphia: WB Saunders, 2004.



Joint opened: lateral view

Identify each condition

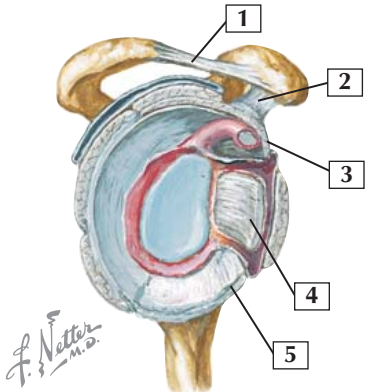


4

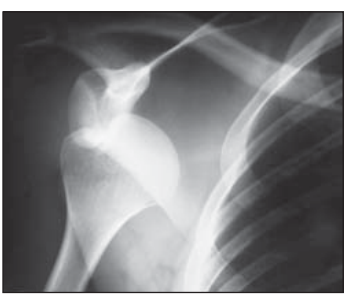
5

1. Biceps tendon (long head)
2. Superior glenoid labrum
3. Glenoid articular cartilage
4. Magnetic resonance imaging (MRI) of superior labrum anterior to posterior (SLAP) tear
5. Arthroscopic view of SLAP tear

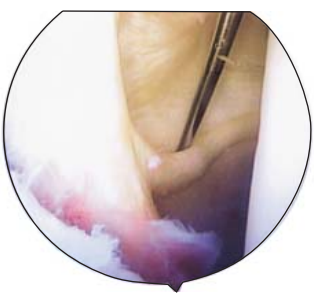
	SLAP Tears
Mechanism	Most often compression, rotation/abduction, or traction on long head of the biceps
Diagnosis	Positive O'Brien test is the classic physical examination finding
Imaging	Arthrogram MRI confirms diagnosis
Treatment	Arthroscopic repair of the tear
Comment	The biceps tendon anchors to the superior part of the glenoid labrum SLAP tears are common in this location and are graded on severity and presence of disruption of the biceps anchor



Identify each condition



6

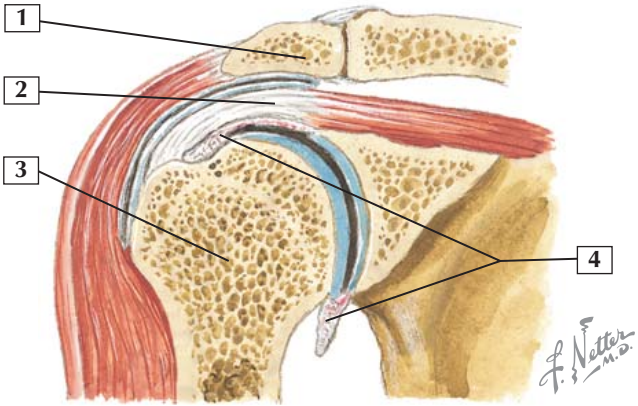


7

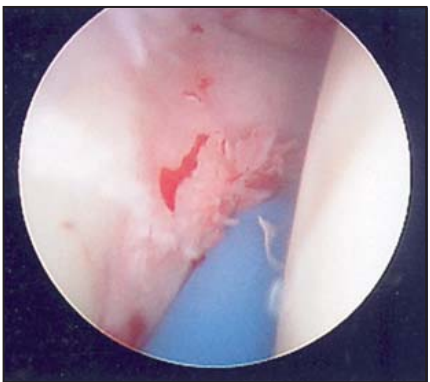
1. Coracoacromial ligament
2. Coracohumeral ligament
3. Superior glenohumeral ligament
4. Middle glenohumeral ligament
5. Inferior glenohumeral ligament
6. Anterior shoulder dislocation (subcoracoid)
7. Arthroscopic view of Bankart tear

	Shoulder Instability
Mechanism	For acute dislocations: trauma with arm in abducted, externally rotated position
Diagnosis	Positive apprehension sign, positive relocation test, positive sulcus sign (may indicate multidirectional instability)
Imaging	Anteroposterior and axillary radiographs for acute dislocation May show bony injury such as Hill-Sachs lesion (impaction fracture of humeral head during relocation) Arthrographic magnetic resonance imaging may show Bankart lesion (classic labral injury of shoulder dislocation)
Treatment	Generally conservative in nontraumatic cases and first-time dislocations Surgical Bankart repair and/or capsulorrhaphy (capsular imbrication and tightening)

Arthroscopic image from Miller M, Howard R, Plancher K: Surgical Atlas of Sports Medicine. Philadelphia: WB Saunders, 2003.



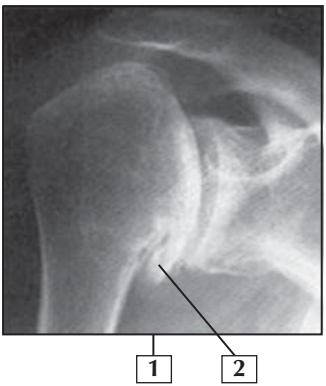
Identify the condition



1. Acromion
2. Rotator cuff tendon (supraspinatus)
3. Humeral head
4. Capsular adhesions
5. Arthroscopic view of shoulder with adhesive capsulitis (note narrowed space and inflamed tissue)

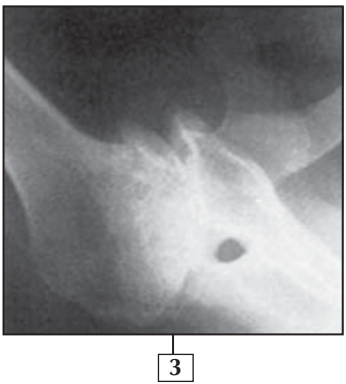
	Adhesive Capsulitis (Frozen Shoulder)
Cause	Thickened fibrotic joint capsule
Mechanism	Unknown but may follow trauma or surgery, or it may occur in patients with autoimmune disorders such as hypothyroidism and diabetes)
Diagnosis	Key physical examination finding is loss of *both* active and passive motion
Imaging	Imaging usually not necessary Arthrographic magnetic resonance imaging may demonstrate decreased capsular volume
Treatment	Physical therapy to emphasize motion is most effective after glenohumeral joint steroid injection Arthroscopic lysis of adhesions and manipulation with anesthesia in refractory cases

Identify each condition



1

2



3

4

5

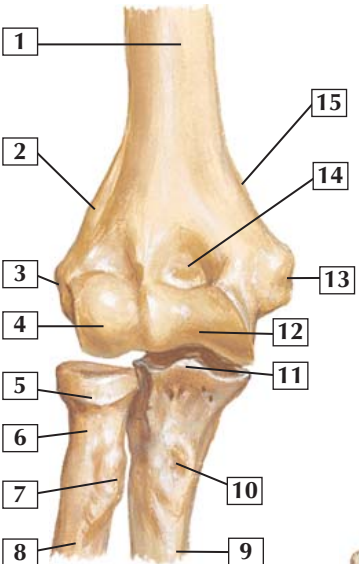
1. Anteroposterior view of glenohumeral arthritis
2. "Goat's beard" deformity (inferior humeral osteophyte)
3. Axillary view of glenohumeral arthritis
4. Anteroposterior view of total shoulder replacement
5. Axillary view of total shoulder replacement

	Shoulder Arthritis
Mechanism	"Wear and tear" over time; can be associated with avascular necrosis, rotator cuff arthropathy, trauma, or prior surgery
Diagnosis	Pain, crepitus, loss of motion
Imaging	Plain radiographs (reveal "goat's beard" deformity, narrowed joint space)
Treatment	Initially conservative with intraarticular steroid injections, nonsteroidal antiinflammatory drugs (NSAIDs), and physical therapy Hemiarthroplasty or total shoulder replacement

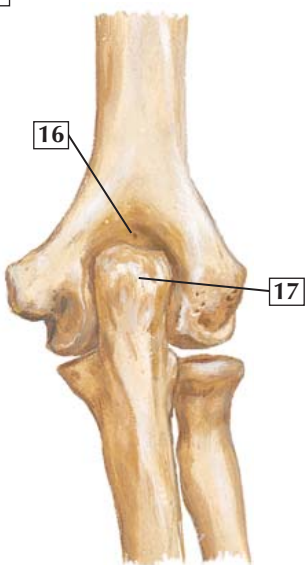
Elbow, Wrist, and Hand
Plates 2-1 to 2-44

Elbow, Wrist, and Hand
Plates 2-1 to 2-44

This page intentionally left blank



In extension: anterior view



In extension: posterior view

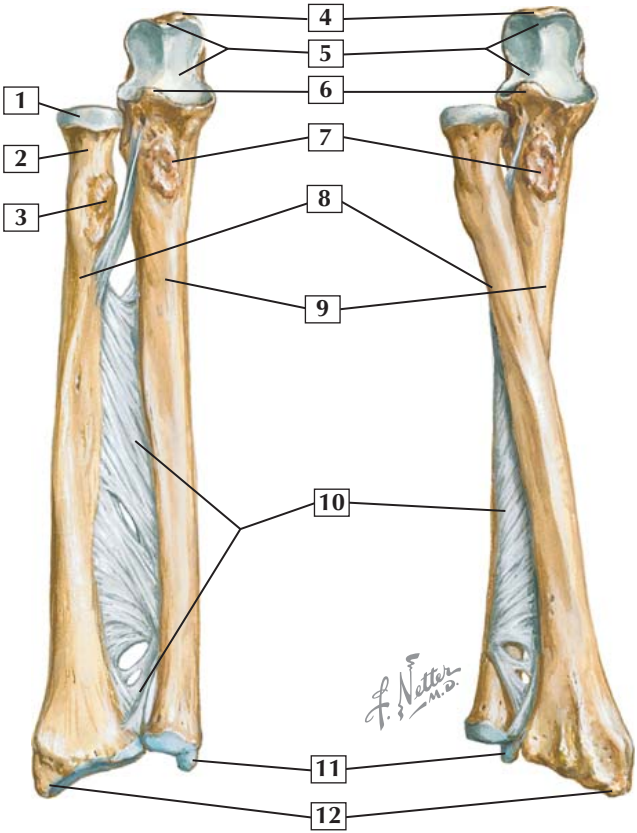
F. Netter M.D.

1. Humerus
2. Lateral supracondylar ridge
3. Lateral epicondyle
4. Capitellum
5. Radial head
6. Radial neck
7. Radial tuberosity
8. Radius
9. Ulna
10. Ulnar tuberosity
11. Coronoid process
12. Trochlea
13. Medial epicondyle
14. Coronoid fossa
15. Medial supracondylar ridge
16. Olecranon fossa
17. Olecranon

Comment: The elbow is made up of three articulations: the humerus and ulna, the humerus and radius, and the ulna and radius. The two articulations with the humerus enable elbow extension; the radioulnar joint enables a degree of rotation.

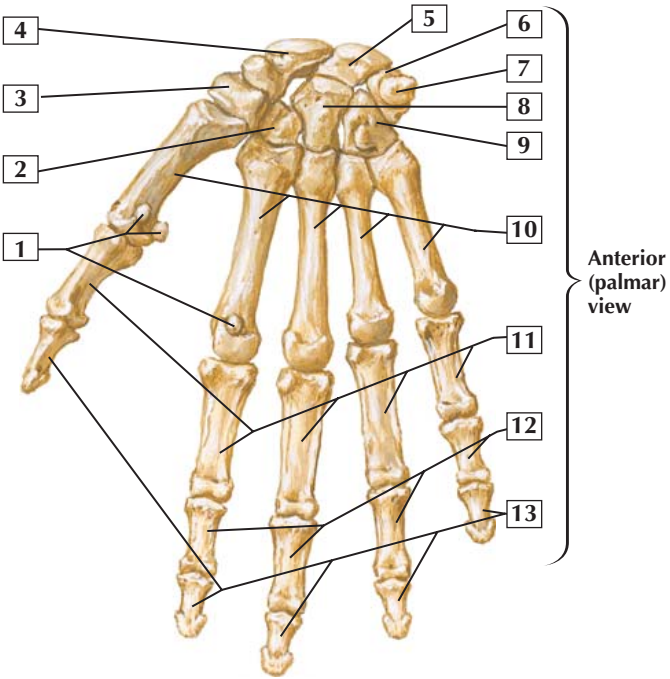
Right radius and ulna in supination: anterior view

Right radius and ulna in pronation: anterior view



1. Radial head
2. Radial neck
3. Radial tuberosity
4. Olecranon
5. Trochlear notch
6. Coronoid process
7. Ulnar tuberosity
8. Radius
9. Ulna
10. Interosseous membrane
11. Styloid process of the ulna
12. Styloid process of the radius

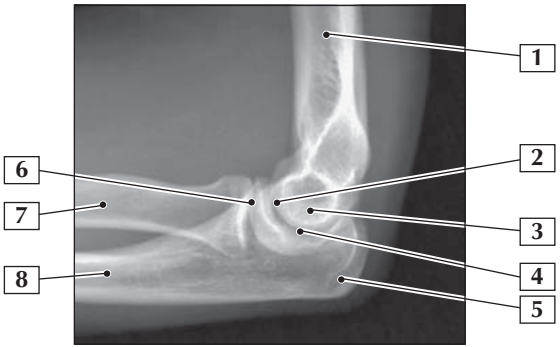
Comment: The ulna is the longer and more medial of the two bones of the forearm. The primary motions that involve the articulation of these two bones are pronation and supination. The two bones are connected by a thick fibrous interosseous membrane. The radius and ulna cross in the pronated position.



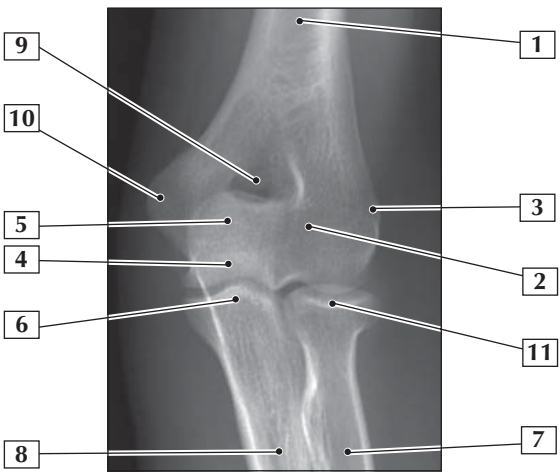
F. Netter M.D.

1. Sesamoids
2. Trapezoid
3. Trapezium
4. Scaphoid
5. Lunate
6. Triquetrum
7. Pisiform
8. Capitate
9. Hamate
10. Metacarpals (1 to 5)
11. Proximal phalanges
12. Middle phalanges
13. Distal phalanges

Comment: The wrist is made of eight carpal bones in two rows. The hand comprises five metacarpals, five proximal phalanges, four middle phalanges (the thumb does not have this bone), and five distal phalanges. A useful mnemonic for remembering the carpal bones (scaphoid, *l*unate, *t*riquetrum, *p*isiform, *t*rapezium, *t*rapezoid, *c*apitate, *h*amate) is "*S*imply *l*earn *t*he *p*arts *t*hat *t*he *c*arpus *h*as."



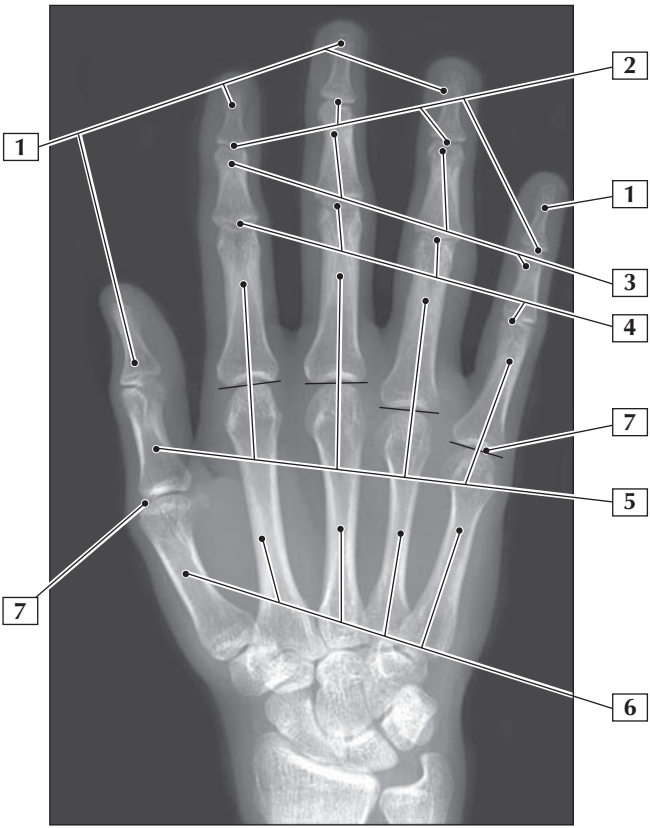
Lateral radiograph



Anteroposterior radiograph

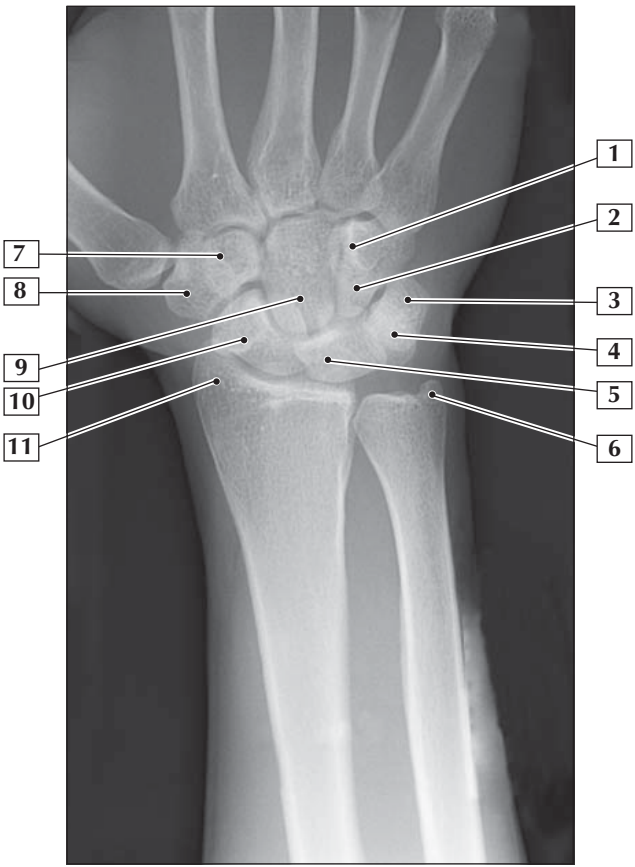
1. Humerus
2. Capitellum
3. Lateral epicondyle of humerus
4. Trochlea
5. Olecranon
6. Coronoid process of ulna
7. Radius
8. Ulna
9. Olecranon fossa
10. Medial epicondyle of humerus
11. Radial head

Comment: The standard elbow radiographs used to detect bony abnormalities of this joint include an anteroposterior (AP) view and a lateral view. Oblique views may also be helpful in identifying loose bodies or avulsion fractures. A useful mnemonic for remembering the ossification order of the bones of the pediatric elbow is *C*aptain *R*oy *M*akes *T*rouble *O*n *L*eave (capitellum, radial head, medial epicondyle, trochlea, olecranon, lateral epicondyle).


2
1
1
3
4
7
5
7
6

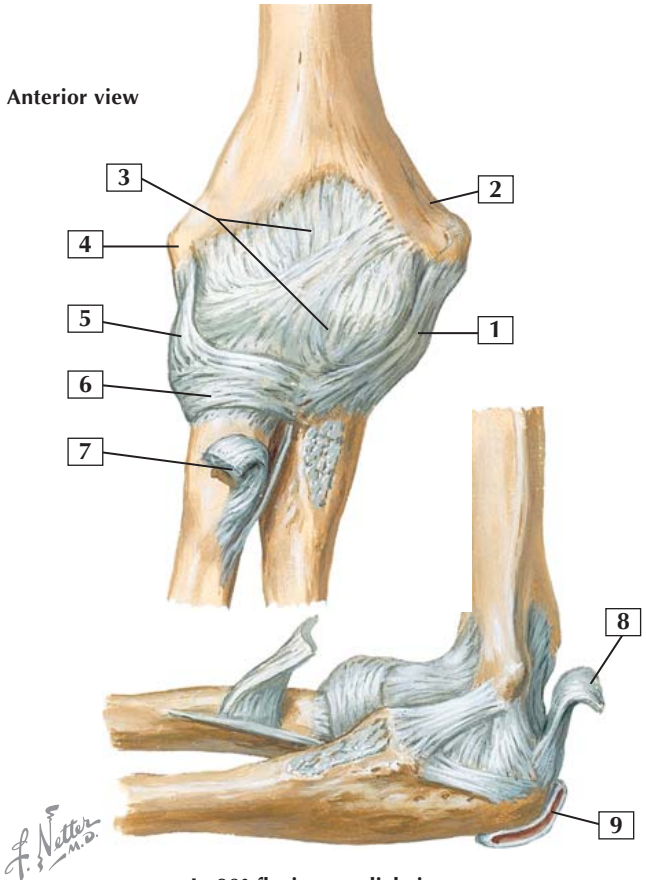
1. Distal phalanges
2. Distal interphalangeal (DIP) joints
3. Middle phalanges
4. Proximal interphalangeal (PIP) joints
5. Proximal phalanges
6. Metacarpal bones
7. Metacarpophalangeal joints

Comment: The anteroposterior (AP) and lateral radiographs are the preferred views for diagnosing pathological processes of the hand.


1
2
3
4
5
6
7
8
9
10
11

1. Hook of the hamate
2. Hamate
3. Pisiform
4. Triquetrum
5. Lunate
6. Styloid process of the ulna
7. Trapezoid
8. Trapezium
9. Capitate
10. Scaphoid
11. Styloid process of the radius

Comment: The anteroposterior (AP) and lateral radiographs are the preferred views for diagnosing pathology of the wrist. Additional helpful views include the carpal tunnel view and the clenched-fist view. The carpal tunnel view provides an axial image of the carpal canal, as well as images of the hook of the hamate and the pisiform. The clenched-fist view is helpful in evaluating widening of the scapholunate interval.

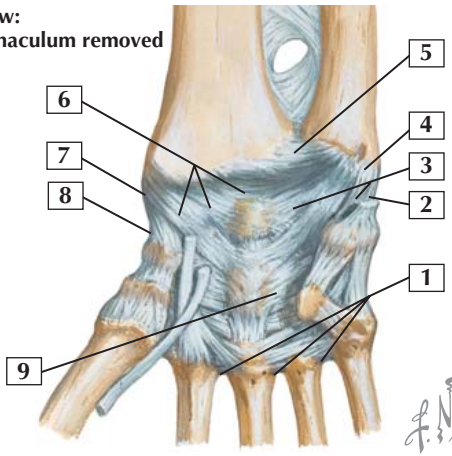


In 90° flexion: medial view

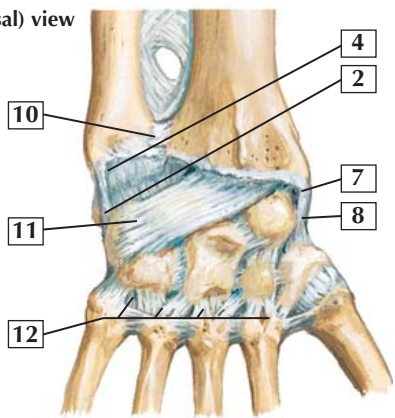
1. Ulnar collateral ligament
2. Medial epicondyle of humerus
3. Joint capsule
4. Lateral epicondyle of humerus
5. Radial collateral ligament
6. Annular ligament
7. Biceps tendon
8. Triceps tendon
9. Olecranon bursa

Comment: The ulnar collateral, radial collateral, and annular ligaments are the most important static stabilizers of the elbow joint. The anterior band of the ulnar collateral ligament is the strongest and resists valgus stress at the elbow. The radial collateral ligament is most important in posterolateral elbow stability, whereas the annular ligament is most important in stabilizing the radial head.

Palmar view:
Flexor retinaculum removed

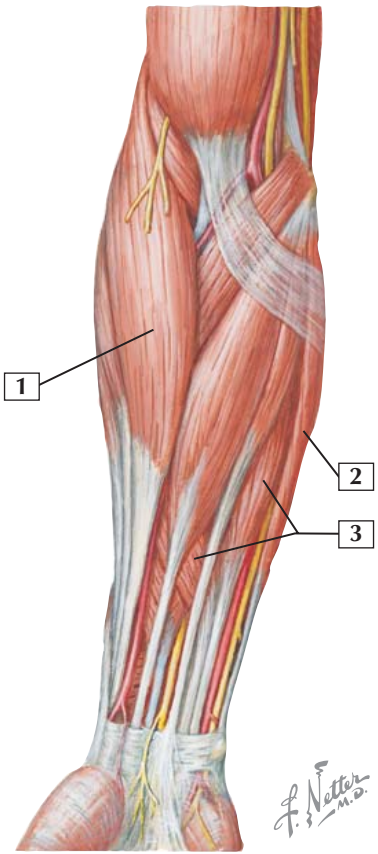


Posterior (dorsal) view



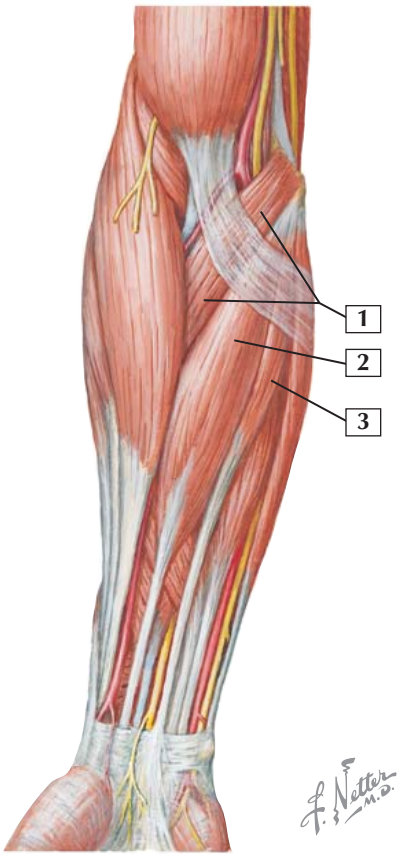
1. Palmar metacarpal ligaments
2. Ulnar collateral ligament
3. Palmar ulnocarpal ligament
4. Ulnar styloid
5. Palmar radioulnar ligament
6. Palmar radiocarpal ligament
7. Radial styloid
8. Radial collateral ligament
9. Capitotriquetral ligament
10. Dorsal radioulnar ligament
11. Dorsal radiocarpal ligament
12. Dorsal carpometacarpal ligaments

Comment: The wrist joint comprises articulations between the distal radius and ulna and the first row of carpal bones (scaphoid, lunate, and triquetrum). Dorsal and palmar ligaments support these articulations. Wrist arthroscopy allows a unique view of injuries to the ligaments and carpal bones.


1
2
3
F. Netter M.D.

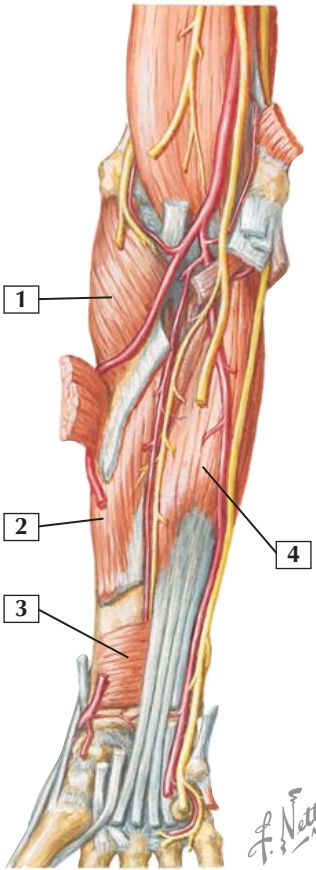
1. Brachioradialis muscle
2. Flexor carpi ulnaris muscle
3. Flexor digitorum superficialis muscle

	Brachioradialis Muscle	Flexor Digitorum Superficialis Muscle	Flexor Carpi Ulnaris Muscle
Origin	Lateral aspect of the supracondylar ridge of the humerus	Medial epicondyle of humerus, ulnar collateral ligament, and coronoid process of ulna; superoanterior radius	Humeral head from medial epicondyle of humerus; ulnar head from medial border of olecranon and posterior ulna
Insertion	Lateral aspect of the distal radius	Middle phalanges of the four fingers	Pisiform bone primarily but also the hook of the hamate and the base of the fifth metacarpal
Actions	Flexion of the elbow	Proximal interphalangeal (PIP) joint flexion; assistance in flexion of the elbow, wrist, and metacarpophalangeal (MCP) joints	Wrist flexion and ulnar deviation
Innervation	Radial nerve (C5-7)	Median nerve (C7, C8, and T1)	Ulnar nerve (C7-8)


1
2
3
F. H. Netter M.D.

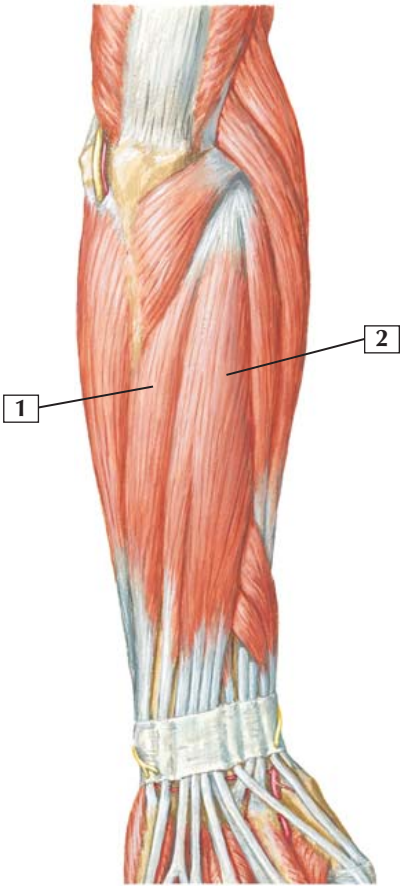
1. Pronator teres muscle
2. Flexor carpi radialis muscle
3. Palmaris longus muscle

	Pronator Teres Muscle	**Flexor Carpi Radialis Muscle**	**Palmaris Longus Muscle**
Origin	Humeral head from just proximal to medial epicondyle; ulnar head from medial aspect of coronoid process of ulna	Medial epicondyle of humerus	Medial epicondyle of humerus
Insertion	Lateral midshaft of radius	Base of the second metacarpal	Anterior aspect of flexor retinaculum and palmar aponeurosis
Actions	Pronation of forearm; assistance in elbow flexion	Flexion of the wrist; assistance in radial deviation	Wrist flexion and tightening of palmar aponeurosis
Innervation	Median nerve (C6-7)	Median nerve (C6-7)	Median nerve (C6-7)


1
2
3
4
F. H. Netter M.D.

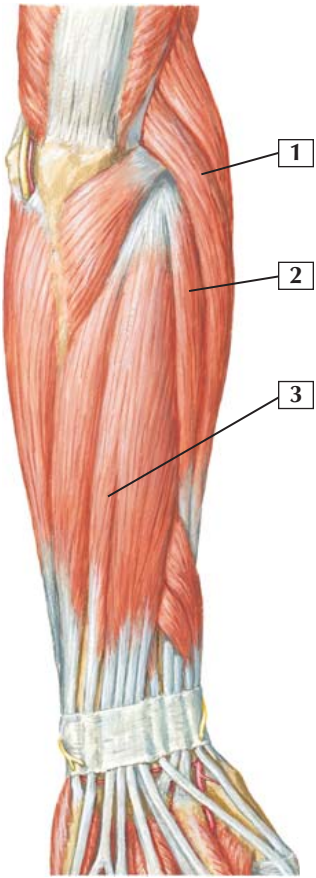
1. Supinator muscle
2. Flexor pollicis longus muscle
3. Pronator quadratus muscle
4. Flexor digitorum profundus muscle

	Supinator Muscle	Flexor Pollicis Longus Muscle	Pronator Quadratus Muscle	Flexor Digitorum Profundus Muscle
Origin	Lateral epicondyle of humerus, radial collateral ligament, annular ligament of radioulnar joint, supinator fossa, and crest of the ulna	Anterior aspect of the radius	Anteromedial distal ulna	Anteromedial part of proximal three fourths of the ulna
Insertion	Anterior, lateral, and posterior proximal radius	Base of the distal phalanx of the thumb	Distal part of the anterolateral radius	Bases of the distal interphalangeal (DIP) joints of the four fingers
Actions	Supination	Flexion of the thumb	Pronation	Flexion of the DIP joints of the fingers
Innervation	Radial nerve (C5-6)	Median nerve (C8-T1)	Median nerve (C8-T1)	Medial part by the ulnar nerve (C8-T1); lateral part by the anterior interosseus branch of the median nerve (C8-T1)


1
2
F. Netter M.D.

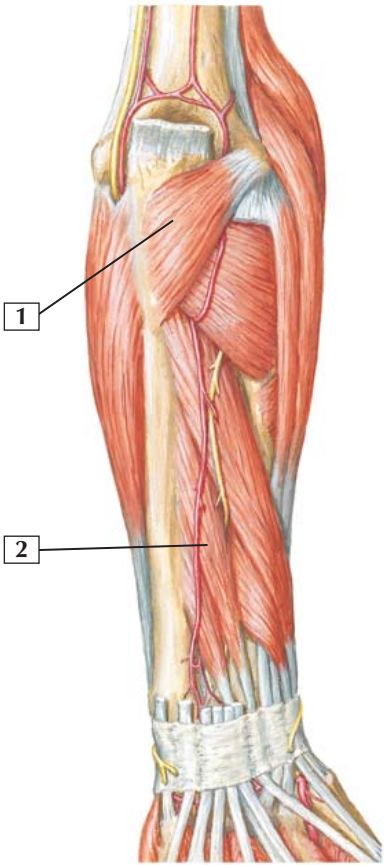
1. Extensor carpi ulnaris muscle
2. Extensor digitorum muscle

	Extensor Carpi Ulnaris Muscle	Extensor Digitorum Muscle
Origin	One head from the lateral epicondyle of the humerus; the other from the posterior aspect of the ulna	Lateral epicondyle of the humerus
Insertion	Medial aspect of the base of the fifth metacarpal	Extensor expansions of the four fingers
Actions	Extension and adduction of the wrist	Extension of the metacarpophalangeal (MCP) and interphalangeal (IP) joints; assistance with wrist extension
Innervation	Posterior interosseous branch of the radial nerve (C7-8)	Posterior interosseous branch of the radial nerve (C7-8)


1
2
3
F. Netter M.D.

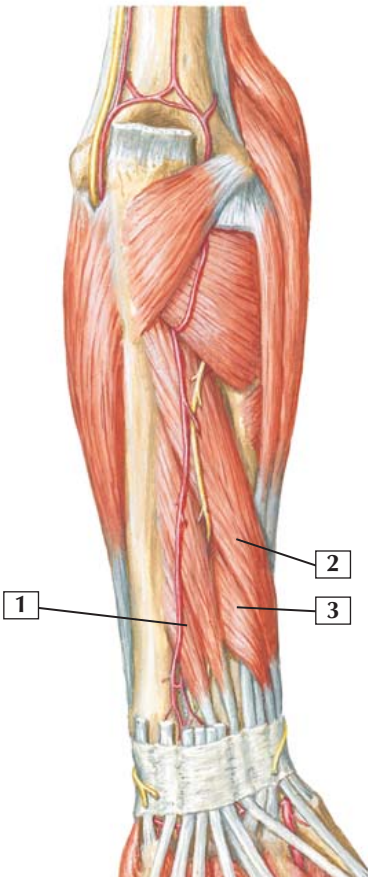
1. Extensor carpi radialis longus muscle
2. Extensor carpi radialis brevis muscle
3. Extensor digiti minimi muscle

	Extensor Carpi Radialis Longus Muscle	Extensor Carpi Radialis Brevis Muscle	Extensor Digiti Minimi Muscle
Origin	Lateral aspect of the supracondylar ridge of humerus	Lateral epicondyle of humerus	Lateral epicondyle of the humerus
Insertion	Base of the second metacarpal	Base of the third metacarpal	Extensor expansion of the fifth finger
Actions	Extension and abduction of the wrist	Extension and abduction of the wrist	Extension of the fifth metacarpophalangeal (MCP) and interphalangeal (IP) joints; assistance with wrist extension
Innervation	Radial nerve (C6-7)	Deep branch of the radial nerve (C7-8)	Posterior interosseous branch of the radial nerve (C7-8)


1
2
F. Netter M.D.

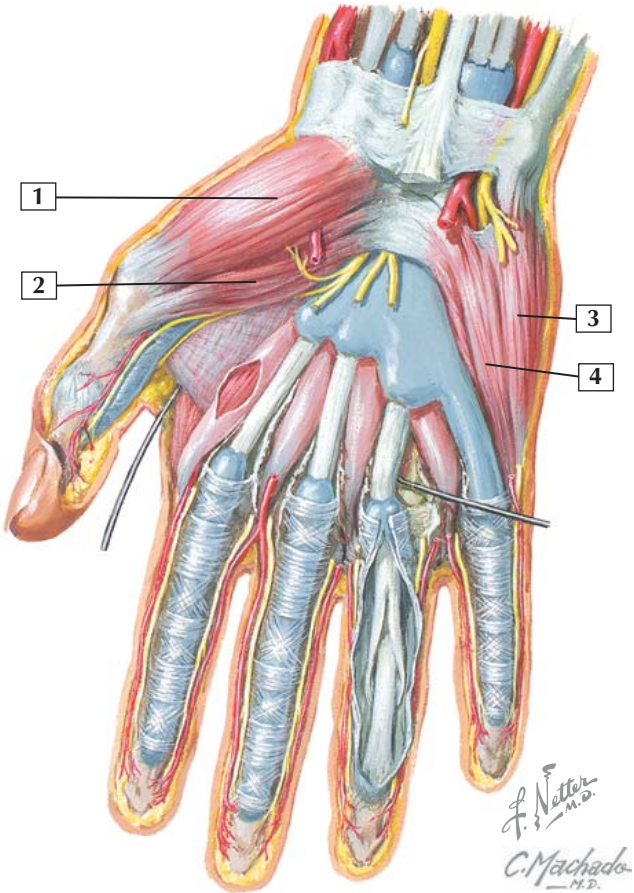
1. Anconeus muscle
2. Extensor pollicis longus muscle

	Anconeus Muscle	Extensor Pollicis Longus Muscle
Origin	Lateral epicondyle of the humerus	Posterior aspect of midshaft of the ulna
Insertion	Lateral aspect of the olecranon and posterosuperior ulna	Base of the distal phalanx of the thumb
Actions	Abduction of ulna during pronation	Extension of the distal phalanx of the thumb; assistance in thumb abduction
Innervation	Radial nerve (C7-T1)	Posterior interosseous branch of the radial nerve (C7-8)


1
2
3

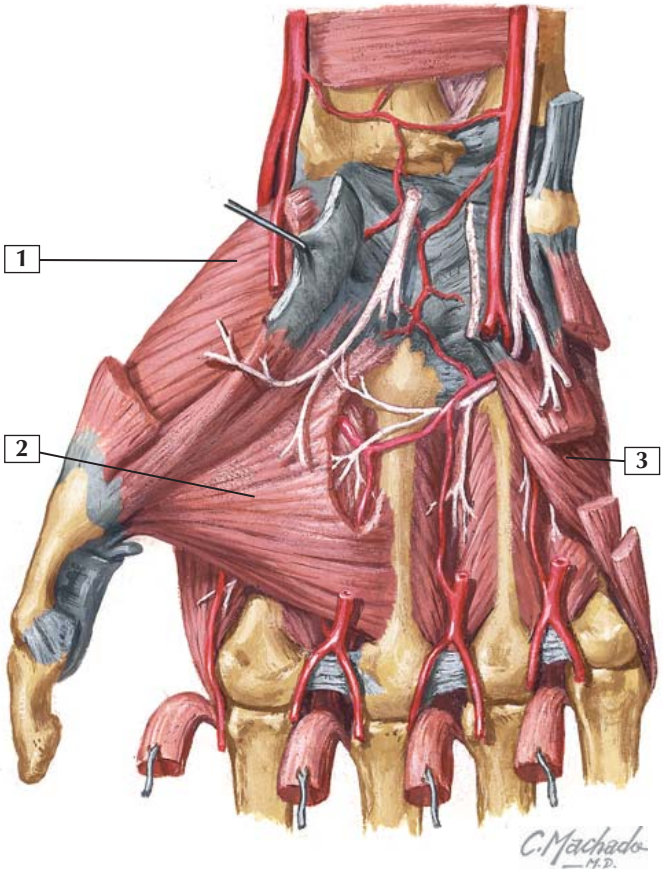
1. Extensor indicis muscle
2. Abductor pollicis longus muscle
3. Extensor pollicis brevis muscle

	Extensor Indicis Muscle	Abductor Pollicis Longus Muscle	Extensor Pollicis Brevis Muscle
Origin	Posterior ulna just distal to the extensor pollicis longus origin	Posterior radius and ulna	Posterior radius
Insertion	Extensor expansion of index finger	Base of the first metacarpal	Base of the proximal phalanx of the thumb
Actions	Extension of the index finger; assistance in wrist extension	Abduction, extension, and rotation of the thumb; assistance in abduction of the wrist	Extension of the proximal phalanx of the thumb
Innervation	Posterior interosseous branch of the radial nerve (C7-8)	Posterior interosseous branch of the radial nerve (C7-8)	Posterior interosseous branch of the radial nerve (C7-8)


1
2
3
4
F. Netter M.D.
C. Machado M.D.

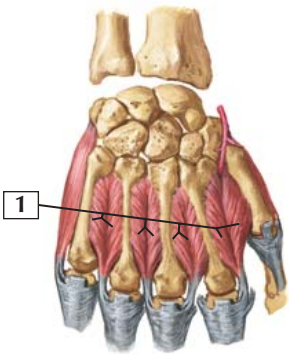
1. Abductor pollicis brevis muscle
2. Flexor pollicis brevis muscle
3. Abductor digiti minimi muscle
4. Flexor digiti minimi brevis muscle

	Abductor Pollicis Brevis Muscle	Flexor Pollicis Brevis Muscle	Abductor Digiti Minimi Muscle	Flexor Digiti Minimi Brevis Muscle
Origin	Flexor retinaculum, scaphoid, trapezium	Superficial head from flexor retinaculum and trapezium; deep head from floor of the carpal canal overlying the trapezoid and capitate	Pisiform and flexor carpi ulnaris muscle	Flexor retinaculum and hook of the hamate
Insertion	Lateral aspect of the base of the proximal phalanx of the thumb	Lateral aspect of first metacarpal and base of proximal phalanx	Medial aspect of the base of the proximal phalanx of the fifth finger	Medial aspect of the base of the proximal phalanx of the fifth finger
Actions	Abduction of thumb	Flexion of the proximal phalanx of the thumb	Abduction of the fifth finger	Flexion of the proximal phalanx of the fifth finger
Innervation	Recurrent branch of the median nerve (C8-T1)	Recurrent branch of the median nerve (C8-T1)	Deep branch of the ulnar nerve (C8-T1)	Deep branch of the ulnar nerve (C8-T1)

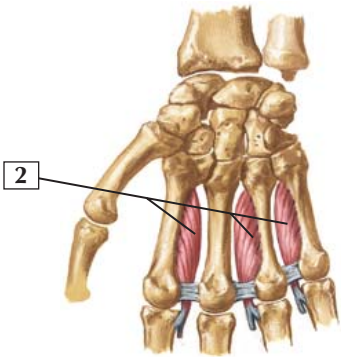

1
2
3
C. Machado, M.D.

1. Opponens pollicis muscle
2. Adductor pollicis muscle
3. Opponens digiti minimi muscle

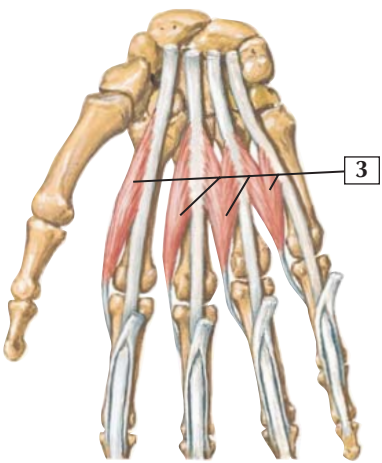
	Opponens Pollicis Muscle	Adductor Pollicis Muscle	Opponens Digiti Minimi Muscle
Origin	Flexor retinaculum and trapezium	Oblique head from the bases of second and third metacarpals and the capitate; transverse head from anterior aspect of the third metacarpal	Flexor retinaculum and hook of the hamate
Insertion	Lateral aspect of the first metacarpal	Base of the proximal phalanx of the thumb	Palmar surface of fifth metacarpal
Actions	Rotation of thumb to oppose fingers	Adduction of the proximal phalanx of the thumb	Abduction, flexion, and rotation of the fifth metacarpal
Innervation	Recurrent branch of the median nerve (C8-T1)	Deep branch of the ulnar nerve (C8-T1)	Deep branch of the ulnar nerve (C8-T1)



Posterior (dorsal) view



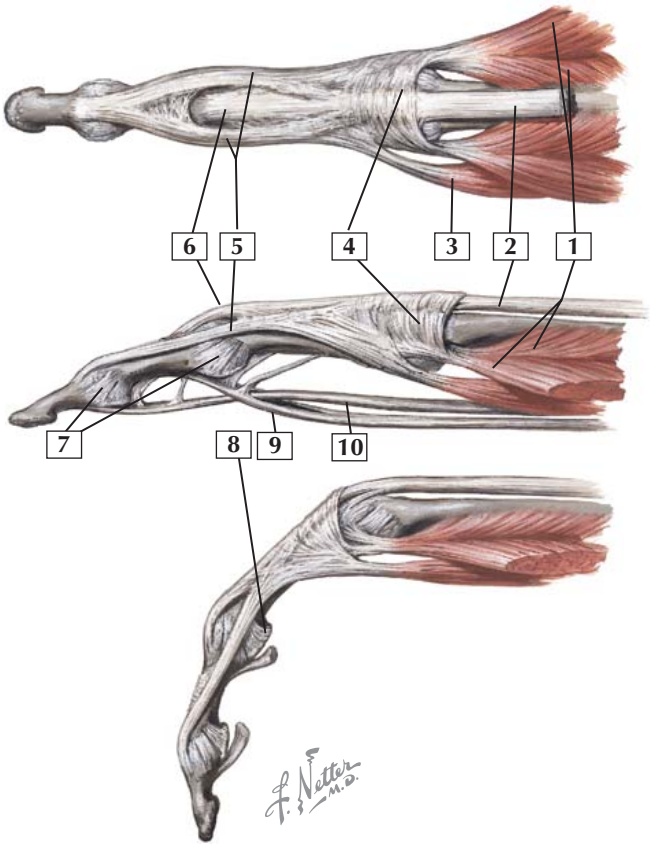
Anterior (palmar) view



C. Machado, M.D.

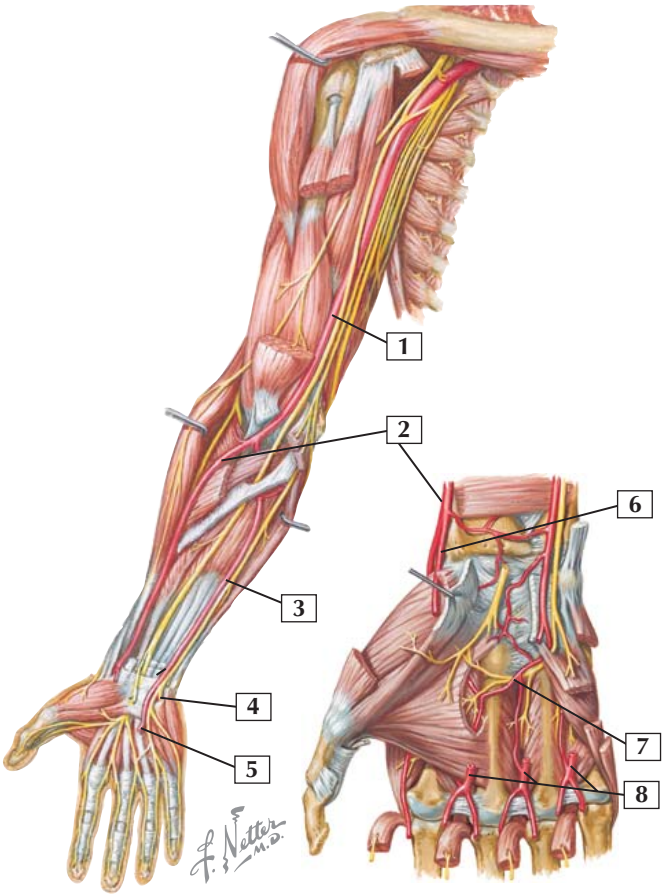
1. Dorsal interosseous muscles
2. Palmar interosseous muscles
3. Lumbrical muscles

	Dorsal Interosseous Muscles (Four)	Palmar Interosseous Muscles (Three)	Lumbrical Muscles
Origin	One head from each side of the metacarpal	Palmar aspects of the second, fourth, and fifth metacarpals	Tendon of the flexor digitorum profundus (lumbricales 1 and 2 from the lateral two tendons, and lumbricales 3 and 4 from the medial three tendons)
Insertion	Base of the proximal phalanx and extensor expansion of fingers 2 to 4	Extensor expansions and bases of proximal phalanges of fingers 2, 4, and 5	Lateral aspect of the extensor expansions of fingers 2 to 5
Actions	Finger abduction; assistance with flexion at the metacarpophalangeal (MCP) joints; assistance with extension at the interphalangeal (IP) joints	Finger adduction; assistance with flexion at the MCP joints; assistance with extension at the IP joints	Flexion of the MCP joints; extension of the IP joints
Innervation	Deep branch of the ulnar nerve (C8-T1)	Deep branch of the ulnar nerve (C8-T1)	Fingers1 and 2 by the median nerve (C8-T1); 3 and 4 by a deep branch of the ulnar nerve (C8-T1)


6
5
4
3
2
1
7
8
9
10
F. H. Netter M.D.

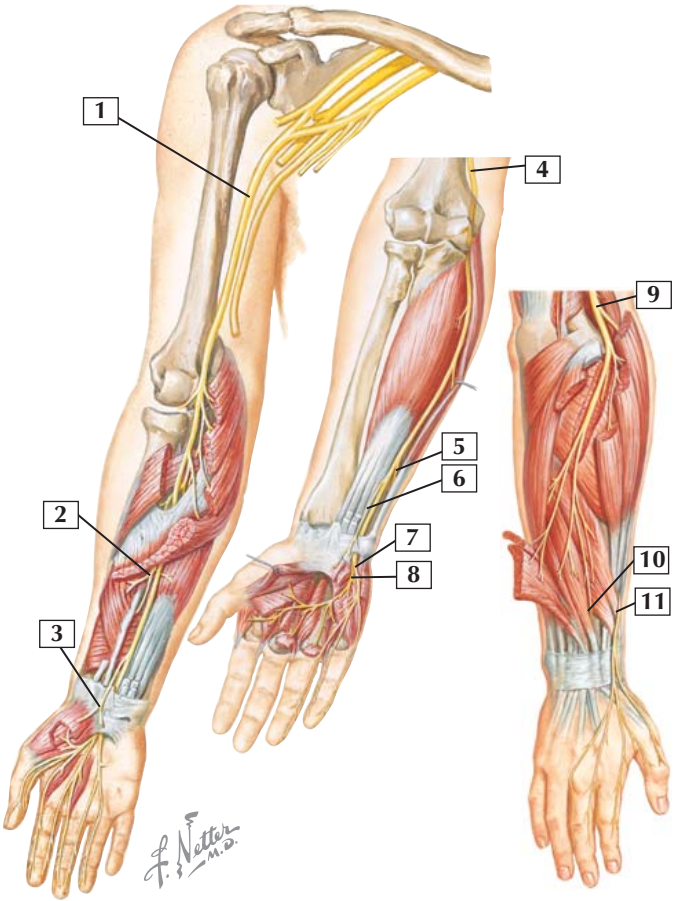
1. Interosseous muscles
2. Extensor digitorum longus tendon
3. Lumbrical muscle
4. Extensor expansion (hood)
5. Lateral bands
6. Central band
7. Collateral ligaments
8. Palmar ligament (plate)
9. Flexor digitorum superficialis muscle
10. Flexor digitorum profundus muscle

Comment: Finger flexion and extension occur through a complex system of pulleys, bands (sagittal and lateral), a central slip, a volar plate, and retinacular ligaments. The pulleys are really thickenings of the flexor sheath and are important biomechanically to prevent "bowstringing" of the tendons.


1
2
3
4
5
6
7
8
F. Netter M.D.

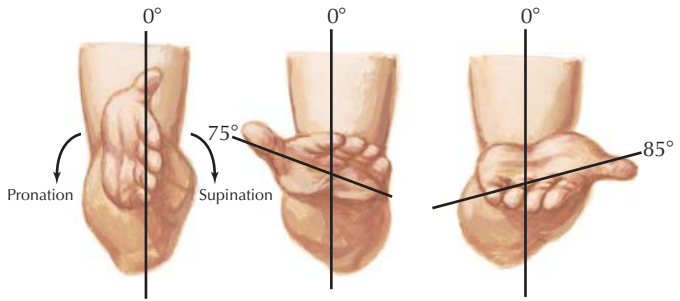
1. Brachial artery
2. Radial artery
3. Ulnar artery
4. Deep palmar branch of ulnar artery
5. Superficial palmar arch (cut)
6. Superficial palmar branch of radial artery
7. Deep palmar arch
8. Common palmar digital arteries

Comment: The radial artery passes over the pronator teres muscle and under the brachioradialis muscle. Distally, it separates into the palmar carpal, dorsal carpal, and superficial branches. It forms the deep palmar arch distally. The ulnar artery crosses between the flexor digitorum superficialis and profundus muscles and forms four branches distally: the palmar and dorsal carpal branches, the deep palmar branch, and the superficial palmar arch.


1
2
3
4
5
6
7
8
9
10
11
F. Netter M.D.

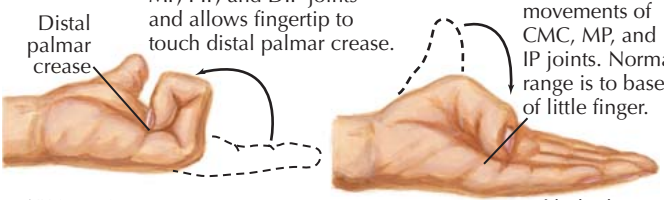
1. Median nerve
2. Anterior interosseous nerve
3. Palmar branch of median nerve
4. Ulnar nerve
5. Dorsal branch of ulnar nerve
6. Palmar branch of ulnar nerve
7. Superficial branch of ulnar nerve
8. Deep branch of ulnar nerve
9. Radial nerve
10. Posterior interosseous nerve
11. Superficial branch of the radial nerve

Comment: The median nerve (C5-T1) passes anteriorly and centrally through the elbow to supply the anterior compartment of the forearm; then it passes into the hand through the carpal tunnel, where it provides innervation to the thumb, index, and middle fingers. The ulnar nerve (C7-T1) arises from the medial cord of the brachial plexus, passes the elbow just posterior to the medial epicondyle, and moves into the wrist through the Guyon canal. It supplies the flexor digitorum profundus and carpi ulnaris muscles. It also has both motor and sensory supplies to the ulnar aspect of the palm. The radial nerve (C5-T1) divides into superficial and deep branches at the elbow and innervates the wrist extensors and sensation to the posterior forearm and dorsal hand (thumb, index finger, middle finger, and half of the ring finger).



Normal finger flexion is composite of flexion of MP, PIP, and DIP joints and allows fingertip to touch distal palmar crease.

Normal thumb opposition is composite of movements of CMC, MP, and IP joints. Normal range is to base of little finger.



JOHN A. CRAIG, MD

Limitations of thumb opposition may be quantified by measuring distance from tip of thumb to base of little finger.

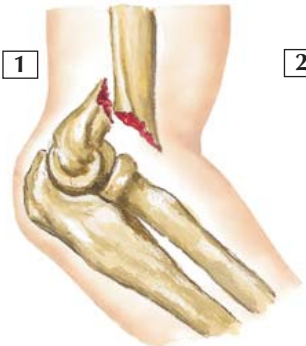
Limitation of finger flexion may be quantified by measuring distance from fingertip to distal palmar crease.

Movement	Normal Range of Motion
Elbow flexion	135-145 Degrees
Elbow extension	0 Degrees
Supination	85-90 Degrees
Pronation	80-90 Degrees
Wrist flexion	80 Degrees
Wrist extension	70 Degrees
Radial deviation	20 Degrees
Ulnar deviation	30-45 Degrees
Finger (MCP) flexion	90 Degrees
Finger (MCP) extension	30-45 Degrees
Thumb (MCP) flexion	50 Degrees
Thumb (MCP) extension	0 Degrees
Thumb abduction	70 Degrees
Thumb adduction	0 Degrees

Test/Sign	Reason for Evaluation
Valgus stress test	Ulnar collateral ligament (UCL) tear
Varus stress test	Lateral collateral ligament (LCL) tear
Tinel sign (elbow)	Ulnar nerve dysfunction
Phalen test Tinel sign (wrist)	Carpal tunnel syndrome
Finkelstein test	DeQuervain tendonitis
Allen test	Radial and ulnar artery function

Identify each condition

1



2

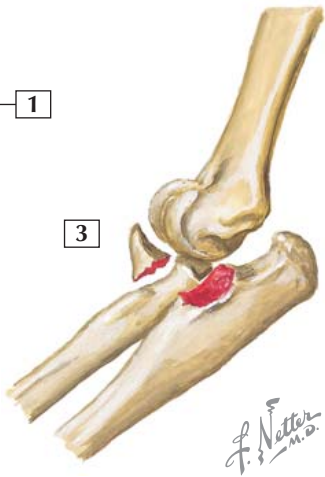
3

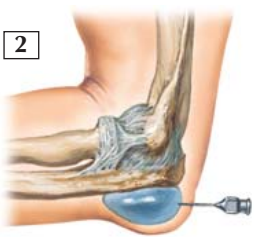
4

1. Supracondylar fracture of the humerus, extension type (more common)
2. Supracondylar fracture of the humerus, flexion type
3. Lateral radiograph of extension type supracondylar fracture
4. Bicolumn intraarticular fracture of the distal humerus

	Supracondylar Humerus Fracture (in Children)	Adult Distal Humerus Fractures
Mechanism	Fall on outstretched hand	Fall on outstretched hand; high-energy trauma
Signs and Symptoms	Focal pain, deformity, swelling; more common in children	Pain, deformity, elbow effusion
Imaging	Anteroposterior (AP), lateral, and oblique radiographs (fat pad sign in occult fracture)	AP and lateral radiographs; computed tomography for evaluation of joint surface
Treatment	Type I: posterior splint, 3 weeks Type II: reduce, cast, or percutaneous pinning Type III: reduce, percutaneous or open pinning	Single-column or nondisplaced fractures: splint in supination (lateral condyle) or pronation (medial condyle) Displaced or bicolumn fractures: ORIF

Identify each condition

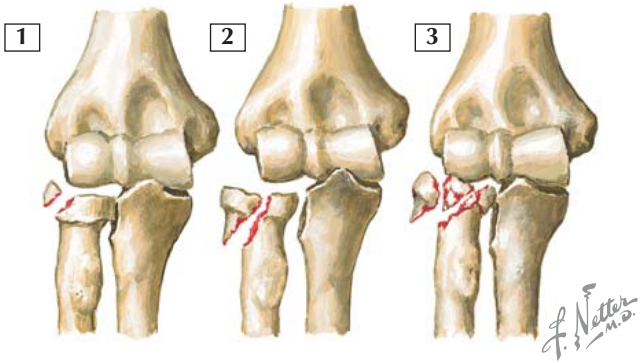




1. Olecranon fracture
2. Olecranon bursitis
3. Coronoid fracture
4. Monteggia fracture

	Olecranon Fracture	Olecranon Bursitis	Coronoid Fracture	Monteggia Fracture
Mechanism	Direct fall on elbow	Usually direct trauma to the olecranon	Often associated with a posterior elbow dislocation	Direct blow or fall on the outstretched hand
Signs and Symptoms	Focal pain, swelling, deformity	Painless localized swelling over the olecranon	Pain, elbow deformity, joint effusion	Pain, tenderness, deformity
Imaging	Anteroposterior (AP), lateral, oblique radiographs	Plain AP and lateral radiographs to evaluate for olecranon fracture	AP, lateral, oblique radiographs	AP/lateral of forearm, wrist, and elbow shows proximal ulna fracture and radial head dislocation
Treatment	Nondisplaced fractures: cast in flexion for 3 weeks, then begin range-of-motion exercises Displaced fractures: open reduction, internal fixation (ORIF) with tension band construct	Conservative with padding and compressive sleeve Aspiration may speed recovery; an infected bursa necessitates surgical incision and drainage (I&D)	Types I and II fractures: hinged brace More severe cases: ORIF	ORIF of ulna and reduction (closed or open) of the radial head

Identify each condition



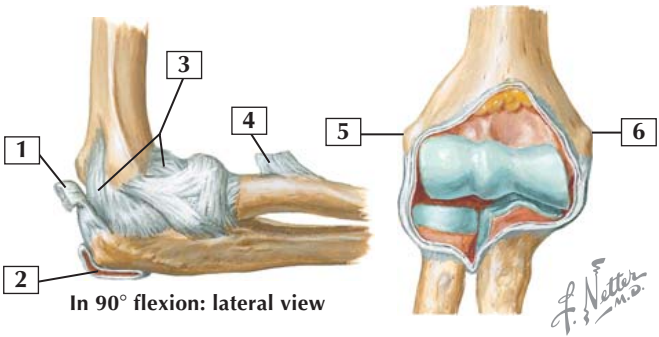
4

5

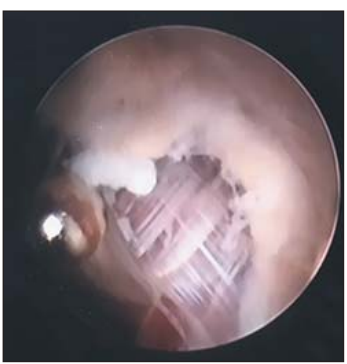
1. Radial head fracture, type I: nondisplaced
2. Type II: displaced
3. Type III: comminuted
4. Type IV: radial head fracture with associated elbow dislocation
5. Radial head subluxation (nursemaid's elbow)

	Radial Head Fractures	Radial Head Subluxation (Nursemaid's Elbow)
Mechanism	Fall on outstretched hand	Pulled or swung by hand.
Signs and Symptoms	Focal tenderness, swelling	Patients aged 2 to 4 years refuse to use arm; arm remains in flexed/pronated position
Imaging	Anteroposterior (AP), lateral, oblique radiographs (fat pad sign in occult fracture)	AP and lateral radiographs to rule out fracture
Treatment	Displaced less than 3 mm or involving one third of the bone: splint and early range-of-motion exercises More severe or comminuted fracture: open reduction, internal fixation (ORIF) or radial head excision	Reduce by supinating and flexing elbow

Radial head subluxation image from DeLee J, Drez D, Miller M: DeLee & Drez's Orthopaedic Sports Medicine. Philadelphia: WB Saunders, 2002.



In 90° flexion: lateral view



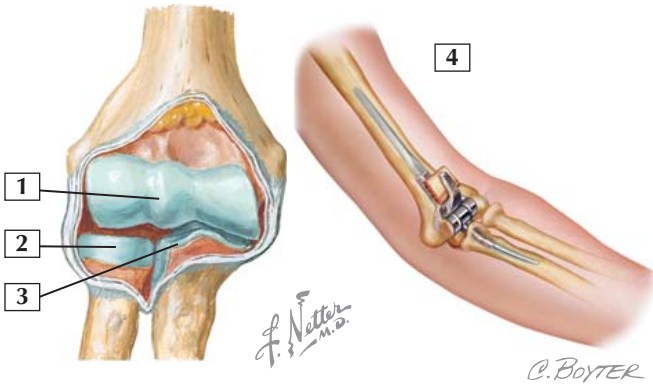
7

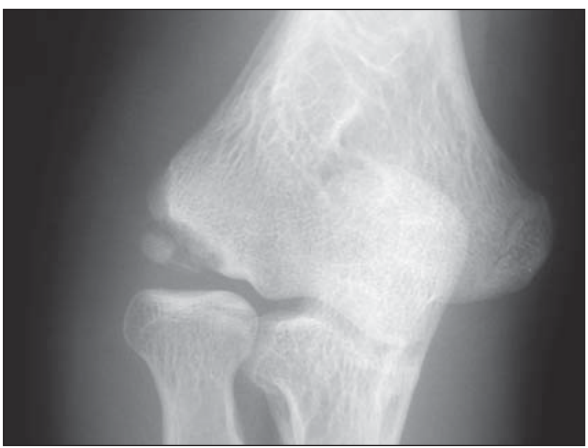
8

1. Triceps brachii tendon (cut)
2. Olecranon bursa
3. Joint capsule
4. Biceps brachii tendon (cut)
5. Lateral epicondyle
6. Medial epicondyle
7. Arthroscopic image of extensor carpi radialis brevis tear in case of lateral epicondylitis
8. Lateral radiograph of triceps tendon avulsion injury

	Distal Biceps Rupture	Distal Triceps Tendon Avulsion	Lateral Epicondylitis (Tennis Elbow)	Medial Epicondylitis (Golfer's Elbow)
Mechanism	Forceful eccentric overload of the biceps tendon	Deceleration force at the elbow; associated with chronic olecranon bursitis	Overuse commonly; may be associated with trauma	Overuse; may be associated with trauma
Signs and Symptoms	Pop, pain, deformity, loss of flexion and supination strength	Posterior pain, palpable defect, weakness with elbow extension	Lateral epicondyle tenderness and pain with wrist extension	Medial epicondyle tenderness and pain with wrist flexion and resisted pronation
Imaging	Not usually necessary, but magnetic resonance imaging (MRI) helpful if diagnosis is in question	Plain anteroposterior (AP) and lateral radiographs	Not necessary unless history of trauma or suspicion of loose bodies	Not necessary unless history of trauma or suspicion of loose bodies
Treatment	Surgical repair of the tendon	Surgical repair of the avulsion	Generally conservative with nonsteroidal antiinflammatory drugs (NSAIDs), activity modification, elbow strap, and steroid injections Surgery is reserved for refractory cases	Same as lateral epicondylitis

Arthroscopic image from Miller M, Cole B: Textbook of Arthroscopy. Philadelphia: WB Saunders, 2004. Radiograph from Miller M, Sekiya J: Core Knowledge in Orthopaedics: Sports Medicine. Philadelphia: WB Saunders, 2006.





5

1. Articular cartilage of the capitellum and trochlea
2. Articular cartilage of the radial head
3. Articular cartilage of the proximal ulna
4. Total elbow replacement
5. Anteroposterior (AP) radiograph showing osteochondritis dissecans of the capitellum

	Panner's Disease	Osteochondritis Dissecans	Osteoarthritis
Mechanism	Idiopathic osteochondrosis	Focal vascular insufficiency	Posttraumatic or age-related wear
Signs and Symptoms	Pain in a child aged 4 to 8 years	Pain, catching, and/or locking in a child aged 13 to 16 years	Primarily pain, but patient may complain of catching or locking sensation
Imaging	Anteroposterior (AP) and lateral radiographs show involvement of entire capitellum	AP and lateral radiographs show lesion of the capitellum Magnetic resonance imaging (MRI) to evaluate stability of fragment	AP and lateral radiographs show joint space narrowing and osteophytes
Treatment	Conservative with rest and activity modification, self-limited	If fragment is stable: conservative If fragment if unstable or condition is refractory to other treatment: surgical débridement or fixation	Initially conservative, with nonsteroidal antiinflammatory drugs (NSAIDs), activity modification, steroid injections Surgical treatment includes arthroscopic débridement or elbow arthroplasty

Arthroscopic image from Miller M, Cole B: Textbook of Arthroscopy. Philadelphia: WB Saunders, 2004.

Identify each condition

1

2

3

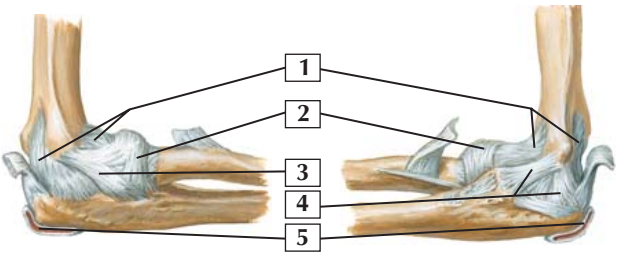
F. H. Netter, M.D.

4

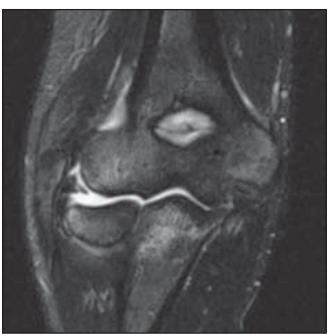
5

1. Posterior elbow dislocation
2. Divergent elbow dislocation
3. Lateral elbow dislocation
4. Medial elbow dislocation
5. Lateral radiograph of posterolateral elbow dislocation

	Elbow Dislocation
Mechanism	Fall, high-energy trauma; more common in pediatric patients
Signs and Symptoms	Pain, deformity, loss of ability to flex at elbow
Imaging	Anteroposterior (AP), lateral, and oblique radiographs; rule out associated fractures; arteriography if vascular examination findings are abnormal
Treatment	Reduce immediately; splint 7 days; early range-of-motion exercises; surgery if persistent instability later
Comment	Posterior and posterolateral dislocations are the most common



F. Netter M.D.



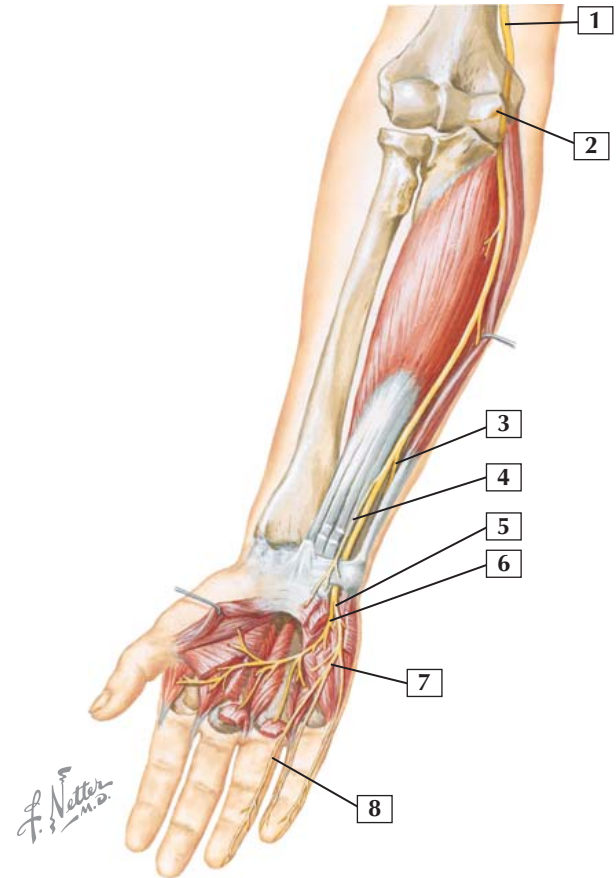
6

7

1. Joint capsule
2. Annular ligament of the radius
3. Radial collateral ligament
4. Ulnar collateral ligament (UCL)
5. Olecranon bursa
6. Ulnar collateral ligament (UCL) tear
7. Lateral collateral ligament (LCL) tear

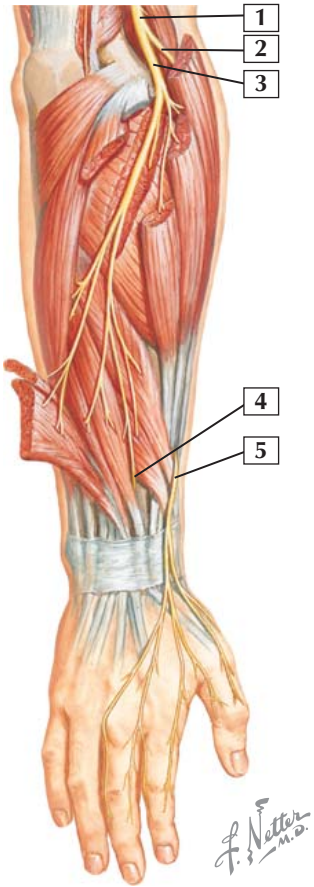
	UCL Injury	LCL Injury
Mechanism	Repetitive valgus stress (baseball pitch)	Often with elbow dislocation
Signs and Symptoms	Medial pain, ulnar neuropathy, valgus instability (although not always present)	Lateral pain, clicking/locking with full extension, posterolateral instability on examination
Imaging	Arthrographic magnetic resonance imaging (MRI)	Arthrographic MRI
Treatment	Conservative initially with ice, nonsteroidal antiinflammatory drugs (NSAIDs), activity modification, and physical therapy Surgical ligament reconstruction for refractory cases or in high-performing athletes	Conservative initially; surgical ligament reconstruction referral for refractory cases

Radiographs from Sanders TG, Miller MD: Imaging of the upper extremities. Clin Sports Med 25(3):395, Fig. 10 (UCL), 398, Fig. 14 (LCL), 2006.


1
2
3
4
5
6
7
8
F. Netter M.D.

1. Ulnar nerve (C7-T1)
2. Articular branch of the ulnar nerve
3. Dorsal branch of the ulnar nerve
4. Palmar branch of the ulnar nerve
5. Superficial cutaneous branch
6. Deep motor branch
7. Common palmar digital nerve
8. Proper palmar digital nerves

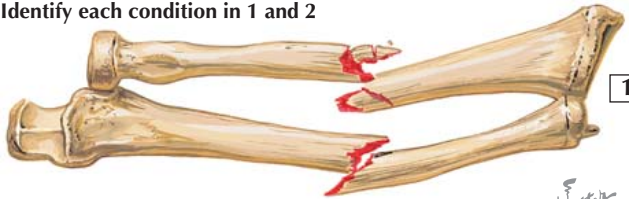
	Cubital Tunnel Syndrome (Ulnar Nerve Entrapment)
Mechanism	Compression of the nerve (usually between the two heads of the flexor carpi ulnaris muscle)
Signs and Symptoms	Medial elbow pain; numbness and tingling palmar and dorsal aspects of the ulnar side of the hand, fifth finger, and medial half of the fourth finger; positive Tinel sign at the medial elbow; decreased pinch and grip strength
Imaging	Electromyography, magnetic resonance imaging (rule out cyst), ultrasonography (ulnar artery thrombosis)
Treatment	Night splinting, nonsteroidal antiinflammatory drugs (NSAIDs), refractory cases should go undergo decompression of the nerve and removal of underlying lesion


1
2
3
4
5
F. Netter M.D.

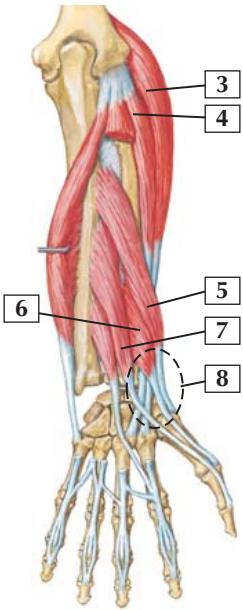
1. Radial nerve
2. Superficial branch of the radial nerve
3. Deep branch of the radial nerve
4. Posterior interosseus nerve
5. Superficial branch of the radial nerve

	Posterior Interosseous Nerve (PIN) Syndrome
Mechanism	Compression of the radial nerve at the proximal border of the supinator muscle (radial head fracture, ganglion)
Signs and Symptoms	Weakness of the thumb, finger extensors, extensor carpi ulnaris muscle; tenderness 5 cm distal to the lateral epicondyle
Imaging	Electromyography, injection test
Treatment	Surgical decompression of the nerve

Identify each condition in 1 and 2



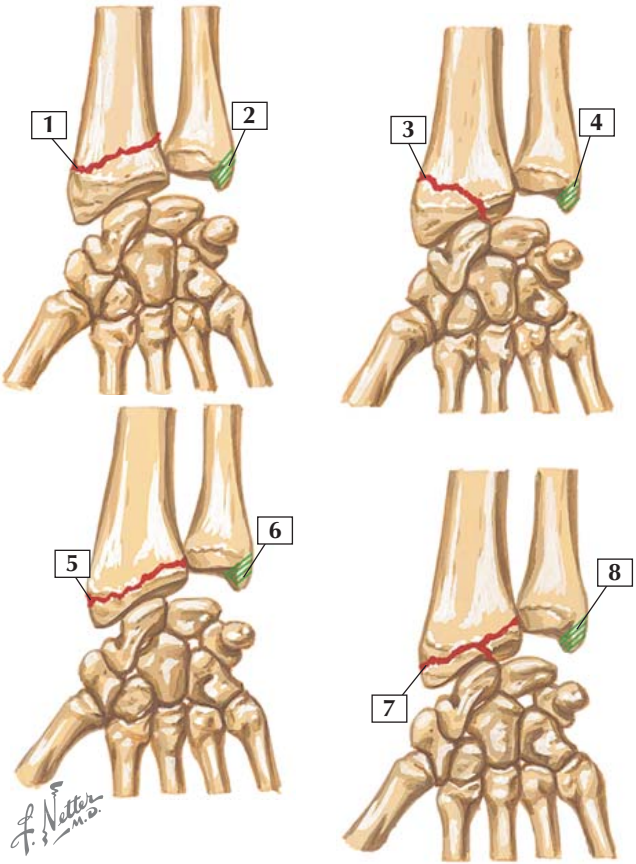
F. Netter M.D.
with
C.A. Luce



1. Radius and ulna fracture ("both bone forearm fracture")
2. X-ray view of both bone forearm fracture
3. Extensor carpi radialis longus muscle
4. Extensor carpi radialis brevis muscle
5. Abductor pollicis longus muscle
6. Extensor pollicis brevis muscle
7. Extensor pollicis longus muscle
8. Intersection syndrome

	Radius and Ulna Fracture	Ulna Fracture ("Nightstick Fracture")	Intersection Syndrome
Mechanism	High-energy trauma/fall	Direct blow to ulnar side of forearm	Overuse causing inflammation of the crossing point between the abductor pollicis longus/ extensor pollicis brevis muscles and the extensor carpi radialis longus and brevis muscles (first and second dorsal compartment)
Signs and Symptoms	Pain, local edema, deformity	Focal pain, deformity less common	Forearm pain, crepitus ("squeakers"), commonly seen in rowers and weight lifters
Imaging	Anteroposterior (AP) and lateral forearm radiographs	AP and lateral forearm radiographs	Not necessary
Treatment	Open reduction, internal fixation (ORIF) with plate and screws on both bones	Usually treated in cast; ORIF for severe displacement	Activity modification, splinting, local steroid injection

Identify each condition

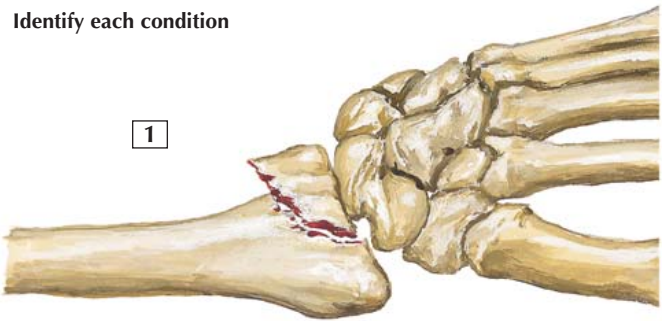


1. Frykman I: Extraarticular radius fracture
2. Frykman II: Extraarticular radius fracture with ulnar styloid fracture
3. Frykman III: Radiocarpal joint fracture
4. Frykman IV: Radiocarpal joint and ulnar styloid fractures
5. Frykman V: Radioulnar joint fracture
6. Frykman VI: Radioulnar joint and ulnar styloid fractures
7. Frykman VII: Radiocarpal and radioulnar joint fractures
8. Frykman VIII: Radiocarpal, radioulnar, and ulnar styloid fractures

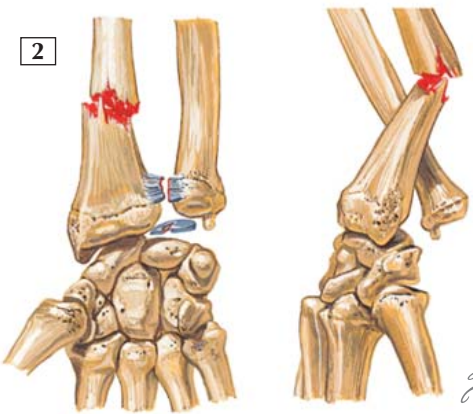
	Colles Fracture
Mechanism	Fall on the outstretched hand, causing dorsal displacement of the distal radius; most common in women older than 50
Signs and Symptoms	Pain, swelling, deformity
Imaging	Posteroanterior (PA) and lateral radiographs
Treatment	For <10-degree change palmar tilt, <2-mm radial shortening, <5-degree change radial angle, >2-mm articular step-off: splint/cast For unacceptable reduction: open reduction, internal fixation (ORIF); also for young patients

Identify each condition

1



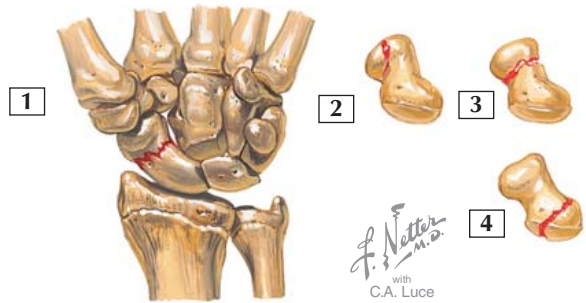
2



1. Barton fracture (dorsal or volar rim fracture)
2. Galeazzi fracture (or Piedmont fracture)

	Barton Fracture (Dorsal or Volar Rim Fracture)	Galeazzi Fracture (or Piedmont Fracture)	Smith Fracture (Reverse Colles Fracture)
Mechanism	Fall on the outstretched hand	Fall on the outstretched hand; pronation (Galeazzi fracture); supination (reverse Galeazzi fracture)	Backwards fall on a flexed wrist with volar displacement of the distal radius
Signs and Symptoms	Pain, swelling, deformity	Pain, swelling, deformity	Pain, swelling, deformity
Imaging	Anteroposterior (AP) and lateral radiographs reveal dorsal or palmar lip fracture with associated subluxation of the carpus	AP and lateral radiographs reveal distal radial shaft fracture with associated radioulnar dislocation	AP and lateral radiographs
Classification	Classification is descriptive (displaced/ nondisplaced, dorsal/volar, angulated, etc)	Based on direction of radial head (BADO): I (anterior), II (posterior), III (lateral), IV (anterior with both bone forearm fracture)	Classification is descriptive (displaced/ nondisplaced, dorsal/volar, angulated, etc)
Treatment	Open reduction, internal fixation (ORIF)	Fracture of necessity: ORIF of radius, reduction of distal radioulnar joint	Closed reduction and splint/cast in supination For unacceptable reduction: ORIF

Identify each condition

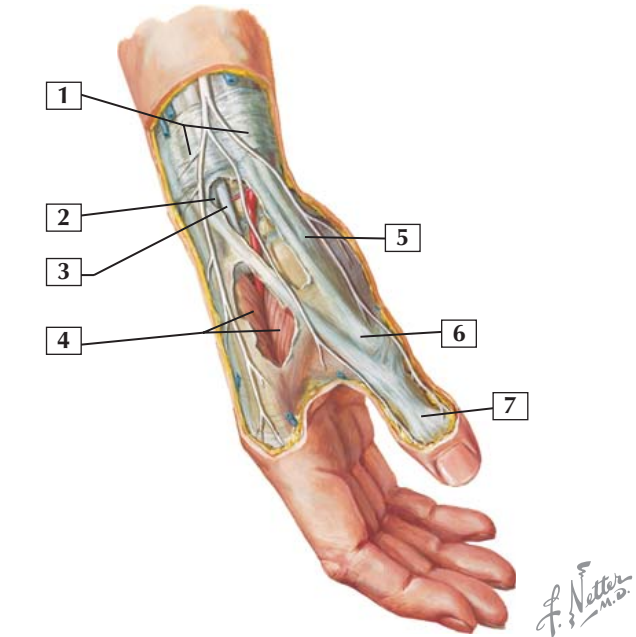


5

6

1. Scaphoid fracture
2. Scaphoid tubercle fracture
3. Fracture of the distal pole of the scaphoid
4. Fracture of the proximal pole of the scaphoid
5. Anteroposterior (AP) radiograph showing sclerosis of the lunate (Kienböck disease)
6. Magnetic resonance imaging (MRI) showing sclerosis and collapse of the lunate (Kienböck disease)

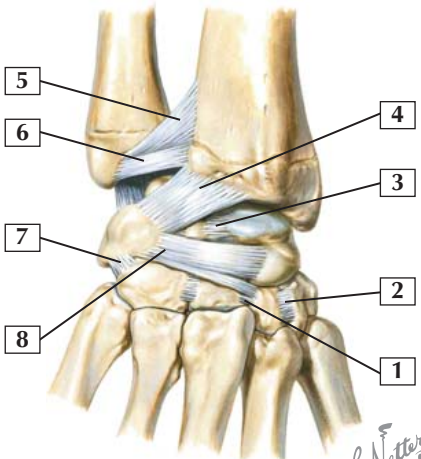
	Scaphoid Fracture	Kienböck Disease (Osteonecrosis of the Lunate)	Hook of the Hamate Fracture
Mechanism	Fall on the outstretched hand	Idiopathic loss of blood supply to the lunate	Repeated direct contact (golfers, baseball batters, lacrosse players)
Signs and Symptoms	Pain, "snuffbox" tenderness	Most common in men aged 20 to 40; insidious onset of wrist pain that is worse with activity; mild swelling	Focal tenderness over hook of the hamate
Imaging	Anteroposterior (AP), lateral, and scaphoid views; if negative, radiographs repeated in 1 week	AP and lateral wrist films; MRI if radiographs are negative	AP, lateral, and carpal tunnel views; computed tomographic scan
Treatment	Thumb spica cast for 6 to 8 weeks; nonunions (resulting from poor blood supply of the proximal fragment) necessitate surgical reduction and fixation; better prognosis with more distal and nondisplaced fracture	Conservative with splinting if no bony collapse; surgery depends on degree of collapse (carpal arthrodesis, resection arthroplasty, wrist arthrodesis, proximal row carpectomy)	Immobilization by cast or surgical excision of the bony hook



8 Identify the condition

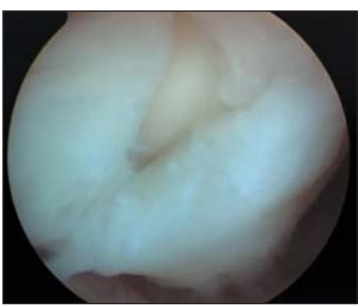
1. Extensor retinaculum
2. Extensor carpi radialis brevis tendon
3. Extensor carpi radialis longus tendon
4. First dorsal interosseous muscle
5. Insertion of the abductor pollicis longus tendon
6. Insertion of the extensor pollicis brevis tendon
7. Insertion of the extensor pollicis longus tendon
8. Dorsal ganglion cyst

	DeQuervain Tendinitis	Ganglion Cysts
Mechanism	Inflammation or tenosynovitis of the abductor pollicis longus and extensor pollicis brevis first dorsal compartment	Occult trauma
Signs and Symptoms	Radius-sided wrist pain, positive Finkelstein test result	Localized nodule on dorsal or volar wrist; transilluminates
Imaging	Not necessary but can exclude other diagnoses	Posteroanterior (PA)/lateral wrist radiographs: negative
Treatment	Conservative with activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), local steroid injections For refractory cases: surgical release	Aspiration, cortisone injection, surgical excision including stalk



Posterior (dorsal) view

9

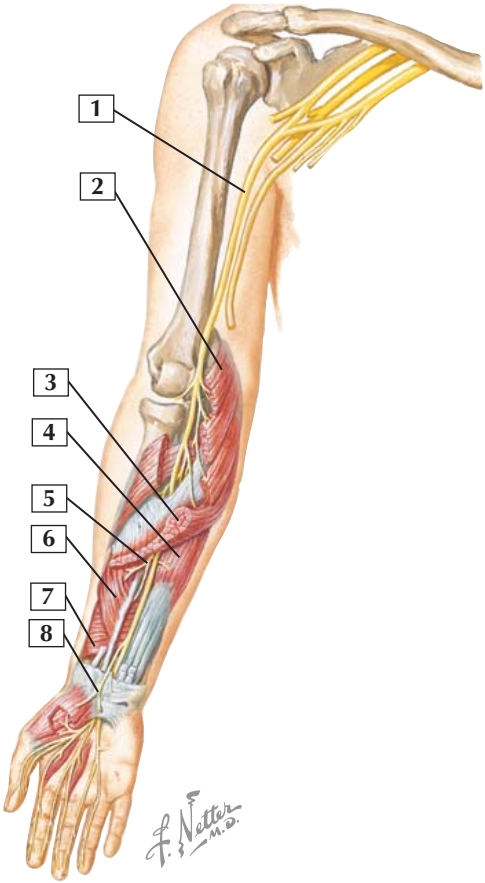


10

1. Trapeziocapitate ligament
2. Trapeziotrapezoid ligament
3. Scapholunate ligament
4. Dorsal radiocarpal ligament
5. Arcuate ligament
6. Dorsal radioulnar ligament
7. Triquetrohamate ligament
8. Dorsal intercarpal ligament
9. Triangular fibrocartilage complex tear
10. Scapholunate ligament tear

	Triangular Fibrocartilage Complex (TFCC) Tears	Scapholunate Ligament Injury	Lunotriquetral Ligament Injury
Mechanism	Fall onto extended, pronated wrist	Usually a fall resulting in hyperextension of a pronated wrist	Fall on outstretched hand
Signs and Symptoms	Ulnar sided wrist pain; tenderness between ulnar styloid and triquetrum ("ulnar snuffbox")	Pain and anatomical "snuffbox" tenderness, positive Watson test result	Ulnar-sided pain worse with ulnar deviation; pain with ballottement of the lunotriquetral joint
Imaging	Arthrographic magnetic resonance imaging (MRI)	Increased scapholunate interval (>2 mm) on posteroanterior (PA) clenched fist radiograph and increased scapholunate angle (>70 degrees) on lateral radiograph	Increased lunotriquetral interval on PA radiographs; lateral radiograph scapholunate angle is normal or <40°
Treatment	Nonsteroidal antiinflammatory drugs (NSAIDS), cortisone injections, splinting for degenerative cases initially Arthroscopic débridement versus repair for degenerative and conservative lesions for which conservative treatment fails	Closed or open reduction and fixation of the scapholunate joint; arthroscopy	Conservative initially For refractory cases: joint débridement

TFCC tear image from Tracy MR, Wiesler ER, Poehling GG: Arthroscopic management of triangular fibrocartilage tears in the athlete. Oper Tech Sports Med 14(2):97, 2006. Scapholunate ligament tear image from Miller M, Cole B: Textbook of Arthroscopy. Phiadelphia: WB Saunders, 2004, p 386, Fig. 39-5.


1
2
3
4
5
6
7
8
F. Netter M.D.

1. The median nerve (C5-T1)
2. Pronator teres muscle
3. Flexor digitorum superficialis muscle
4. Flexor digitorum profundus muscle (lateral)
5. Anterior interosseous nerve
6. Flexor pollicis longus muscle
7. Pronator quadratus muscle
8. Palmar branch of the median nerve

	Carpal Tunnel Syndrome (CTS)	Pronator Syndrome	Anterior Interosseous Nerve (AIN) Compressive Neuropathy
Mechanism	Compression of the median nerve at the carpal tunnel/wrist	Compression of the median nerve at the supracondylar process of the humerus, underneath the pronator teres or flexor digitorum superficialis	Compression of the anterior interosseous branch of the median nerve
Signs and Symptoms	Paresthesias over thumb, index finger, middle finger, and radial ring finger; night symptoms; positive Tinel and Phalen test results	Same as for CTS but no night symptoms	Motor loss but no sensory involvement (radial tendons of the flexor digitorum profundus, flexor pollicis longus, and pronator quadratus muscles)
Imaging	Electromyography	Electromyography but can be normal	Electromyography but can be normal
Treatment	Conservative with night splints, nonsteroidal antiinflammatory drugs (NSAIDs), injections For severe or refractory cases: surgical release	Splinting, NSAIDs, decompression at site	Splinting with elbow in 90 degrees of flexion; surgical decompression

Identify each condition

1

2

F. Netter M.D.

3

4

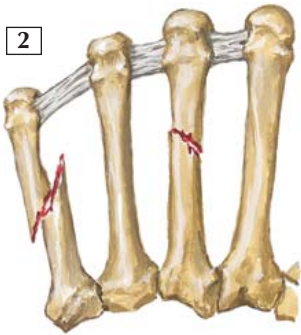
1. Bennett fracture
2. Rolando fracture
3. Stress radiograph of ulnar collateral ligament injury (gamekeeper's thumb)
4. Radiograph of carpometacarpal (CMC) arthritis

	Bennett and Rolando Fractures	Ulnar Collateral Ligament Injury (Gamekeeper's or Skiier's Thumb)	Thumb Carpometacarpal (CMC) Joint Arthritis
Mechanism	Axial load; abductor pollicis longus subluxates main fragment	Forced abduction of the thumb	"Wear and tear," repetitive pinching maneuvers
Signs and Symptoms	Pain and deformity at base of the metacarpal	Pain and tenderness on ulnar side of thumb with opening on stress test	Pain, stiffness, local swelling/ deformity, positive grind test result
Imaging	Anteroposterior (AP) and lateral radiographs; oblique intraarticular fracture (Bennett), Y-shaped intraarticular fracture (Rolando)	Stress radiographs of the thumb	AP and lateral radiographs of the hand
Treatment	Open reduction, internal fixation (ORIF) of displaced fracture or percutaneous pinning	Partial injuries treated with thumb spica splint/cast; complete injures necessitate surgical correction because of adductor pollicis interposition (Stenner's lesion)	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), steroid injections, CMC interposition arthroplasty

Identify each condition

1

2



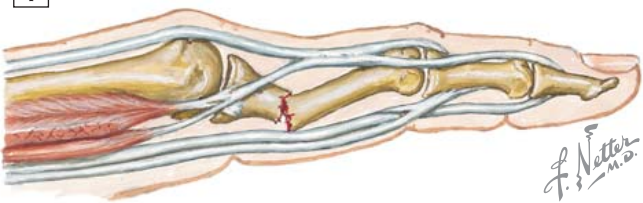
3

1. Fracture of metacarpal neck
2. Midshaft metacarpal fractures
3. Radiographic image of fracture of the base of the fifth metacarpal

	Metacarpal Fractures	Boxer's Fracture (Fracture of the Fifth Metacarpal Neck)
Mechanism	Axial load	Punching hard object
Signs and Symptoms	Pain, rotational deformity (closed fist), local swelling and tenderness	Pain, rotational deformity (closed fist), local swelling and tenderness
Imaging	Anteroposterior (AP) and lateral radiographs of the hand	AP and lateral radiographs of the hand
Treatment	If less than 10 to 15 degrees of angulation: reduction and cast If more angulation or involvement of multiple metacarpals: open reduction, internal fixation (ORIF), or percutaneous pinning	Reduction and ulnar gutter splint/cast with angulation of 40 to 50 degrees

Identify each condition

1

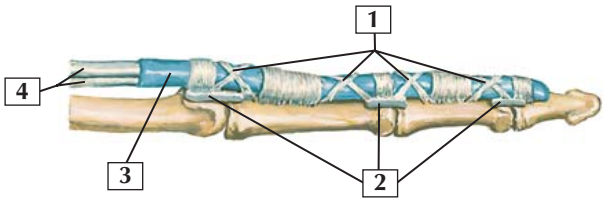


2

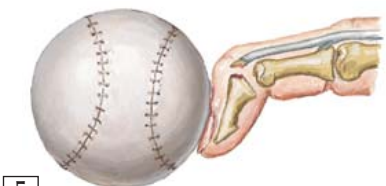
3

1. Fracture of the base of the proximal phalanx
2. Proximal interphalangeal (PIP) joint dislocation
3. Intraarticular fracture of the base of the proximal phalanx

	Fracture of the Phalanx	PIP Joint Dislocation	Osteoarthritis of the PIP and Distal Interphalangeal (DIP) Joints
Mechanism	Axial load, direct trauma	Traction, hyperextension	"Wear and tear"; may be associated with history of trauma
Signs and Symptoms	Pain, crepitus, local swelling, deformity	Pain, tenderness, deformity (Boutonniere: central slip/volar)	Pain, stiffness; Bouchard nodes (PIP joint), Heberden nodes (DIP joint)
Imaging	Anteroposterior (AP) and lateral radiographs of the affected finger	AP and lateral radiographs of the affected finger	AP and lateral radiographs of the affected finger(s)
Classification	Descriptive	Dorsal (volar plate) or volar (central slip)	Mild, moderate, severe
Treatment	For nondisplaced extraarticular fractures: buddy tape For displaced, intraarticular, or comminuted fractures: open reduction, internal fixation (ORIF)	Dorsal: extension block splint for 2-3 weeks Volar: extension splint of PIP joint for 4 to 6 weeks Irreducible dislocation may result from interposed soft tissue and require open reduction	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), joint arthrodesis



Identify each condition



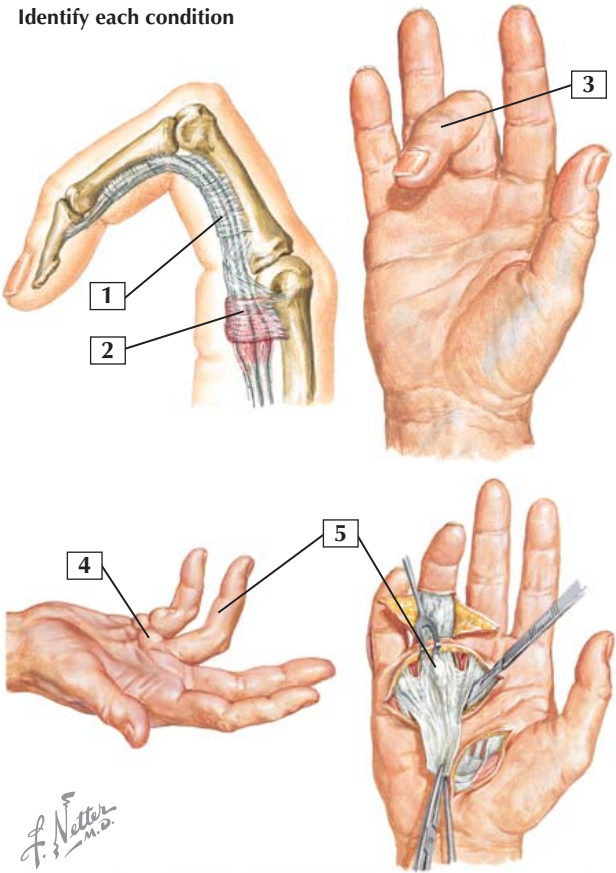
5

6

1. Flexor tendon pulleys
2. Palmar plates
3. Tendon sheath
4. Flexor digitorum tendons
5. Mallet finger
6. Jersey finger

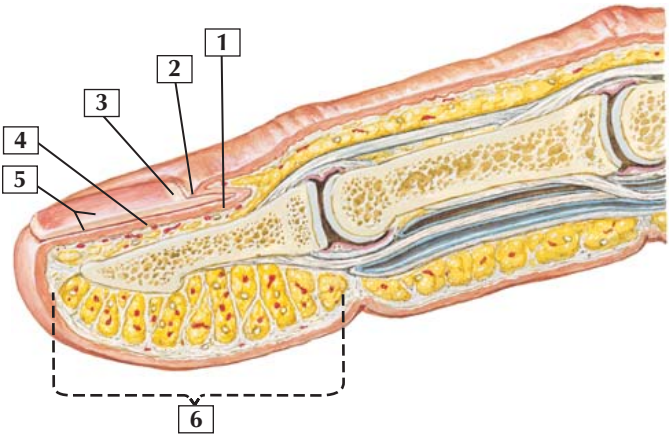
	Mallet Finger	Jersey Finger
Mechanism	Forced flexion of extended finger, causing avulsion of extensor tendon from distal phalanx	Forced extension of flexed finger (caught in jersey on tackle), causing avulsion of flexor digitorum profundus from the base of PIP joint, usually of the ring finger
Signs and Symptoms	Pain, "dropped" distal phalanx (inability to extend at DIP joint)	Pain, inability to flex at the DIP joint
Imaging	Anteroposterior (AP) and lateral radiographs of the finger can show avulsion fracture (bony mallet)	AP and lateral radiographs of the finger to exclude fracture
Treatment	Immobilization in extension (stack splint) for 8 weeks; surgery if this fails	Surgical retrieval and repair of retracted tendon (within 10 days if retracted into palm)

Identify each condition



1. Flexor tendon
2. Stenosis of flexor tendon sheath
3. Trigger finger (stenosing tenosynovitis)
4. Dupuytren's nodules
5. Dupuytren contracture

	Trigger Finger (Stenosing Tenosynovitis)	Dupuytren Disease
Mechanism	Thickening of the flexor tendon beneath A1 pulley	Contracture of the palmar fascia; incidence higher in men; genetic predisposition; northern European ancestry
Signs and Symptoms	Pain and catching with finger flexion/extension; nodule in distal palm	Painless nodule in distal palm most common on ulnar side with eventual flexion contracture of the MCP and later proximal interphalangeal (PIP) joints
Imaging	Not necessary	Not necessary
Treatment	Steroid injections in the tendon sheath; surgical release of A1 pulley	Reassurance; surgical release if affects normal activities and prevents finger extension



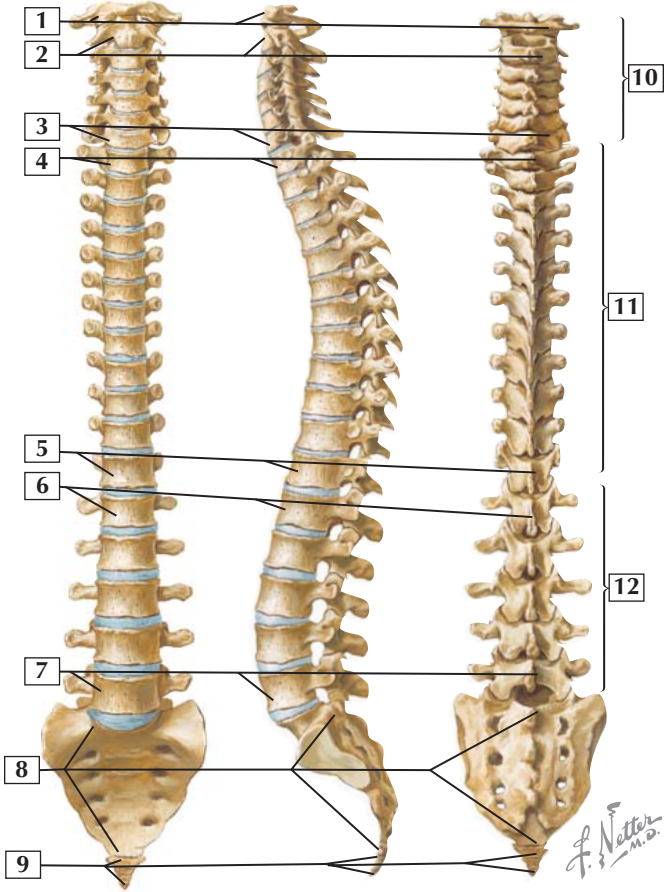
Identify each condition

F. Netter M.D.

1. Nail matrix
2. Eponychium (cuticle)
3. Lunula
4. Nail bed
5. Body of nail
6. Pulp
7. Paronychia
8. Felon
9. Subungual hematoma

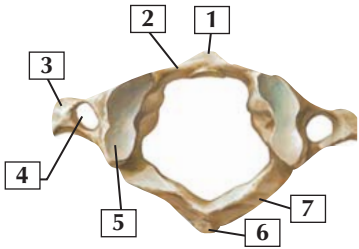
	Soft Tissue Infections of the Fingertip (Felon and Paronychia)	Subungual Hematoma	Nail Bed Injuries
Mechanism	Hangnail, ingrown nail, nail biting, usually *Staphylococcus aureus* infection	Direct trauma to tip of finger	Direct trauma to tip of finger
Signs and Symptoms	Pain, redness, local swelling Felon: palmar pulp Paronychia: sides of nail	Pain, pressure, black discoloration of nail	Pain, deformity of nail
Imaging	Not necessary	Anteroposterior (AP) and lateral radiographs of finger to rule out distal phalanx fracture	AP and lateral radiographs of the affected finger to exclude fracture (occurs 50% of time)
Treatment	Soaks, antibiotics, incision and drainage	Drill small hole through nail to release pressure of hematoma	If nail is avulsed, replace to separate eponychium and nail bed until new nail forms; nail bed repair with nonabsorbable sutures

The Spine
Plates 3-1 to 3-39

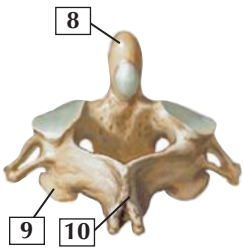

1
2
3
4
5
6
7
8
9
10
11
12
F. Netter M.D.

1. C1 (Atlas)
2. C2 (Axis)
3. C7
4. T1
5. T12
6. L1
7. L5
8. Sacrum
9. Coccyx
10. Cervical vertebrae
11. Thoracic vertebrae
12. Lumbar vertebrae

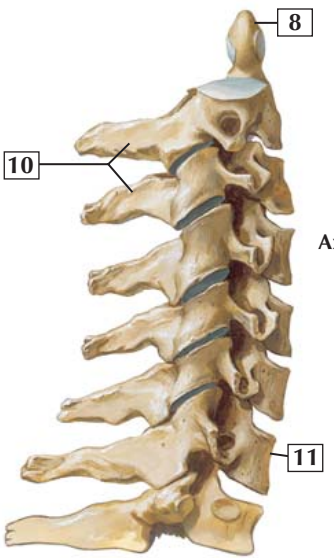
Comment: The vertebral column is divided into the cervical, thoracic, and lumbar sections. The sacrum consists of 5 fused vertebrae. There is a normal kyphotic curve of the thoracic section and a normal lordotic curve of the cervical and lumbar sections.



Atlas (C1): superior view



Axis (C2): posterosuperior view

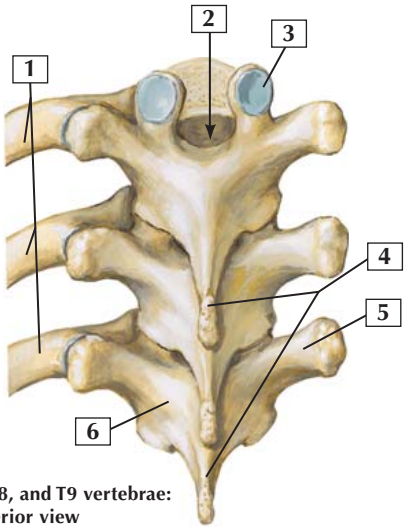


2nd cervical to 1st thoracic vertebrae: right lateral view

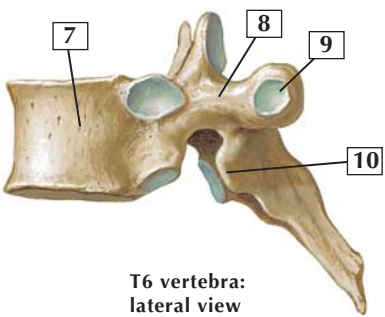
F. Netter M.D.

1. Anterior tubercle
2. Anterior arch
3. Transverse process
4. Transverse foramen
5. Superior articular facet
6. Posterior tubercle
7. Posterior arch
8. Dens
9. Inferior articular facet
10. Spinous process
11. C7

Comment: The cervical section of the spine is made up of 7 vertebrae. C1 (atlas) and C2 (axis) are ring-shaped vertebrae with no vertebral body or intervertebral disc. The other cervical vertebrae have a more standard anatomical appearance, with a body, transverse and spinous processes, pedicles, and laminae. The C7 vertebra is called the *vertebrae prominens* and is easily identified because of its long spinous process.



T7, T8, and T9 vertebrae:
posterior view

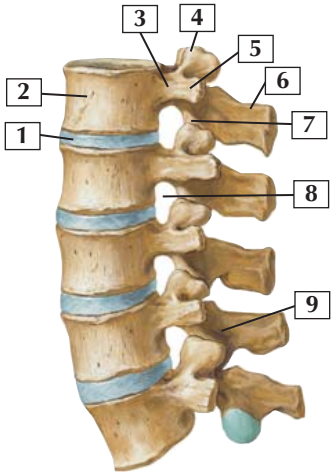


T6 vertebra:
lateral view

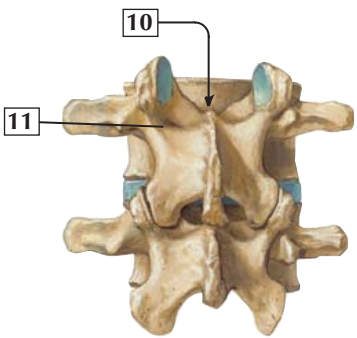
F. Netter M.D.

1. Ribs
2. Vertebral canal
3. Superior articular facet
4. Spinous processes
5. Transverse process
6. Lamina
7. Body
8. Pedicle
9. Transverse costal facet
10. Inferior articular facet

Comment: The thoracic section of the spine is made up of 12 vertebrae. The anatomy is similar to that of the lumbar section; the primary difference is that the vertebral bodies and processes are smaller. Thoracic vertebrae also articulate with the thorax and have superior, inferior, and transverse costal facets for articulation with the ribs at those levels.



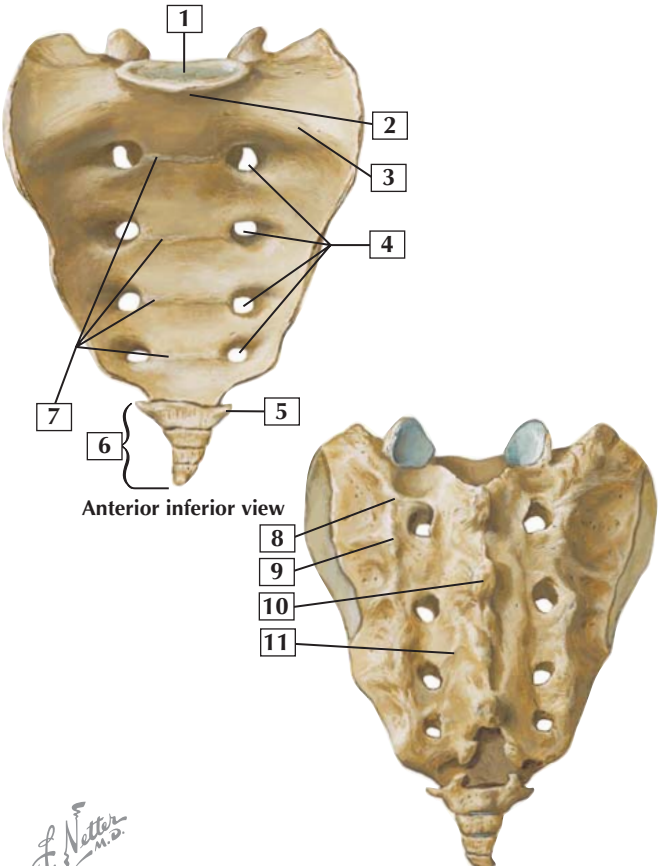
Lumbar vertebrae, assembled: left lateral view



L3 and L4 vertebrae: posterior view

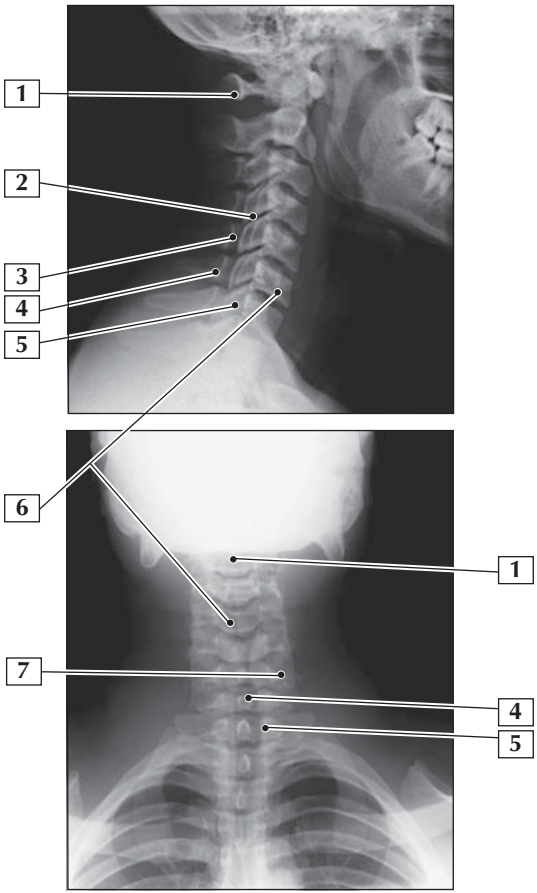
1. Intervertebral disc
2. Vertebral body
3. Pedicle
4. Superior articular process
5. Transverse process
6. Spinal process
7. Inferior articular process
8. Neural foramen
9. Lamina
10. Vertebral canal
11. Pars interarticularis

Comment: The lumbar spine consists of 5 vertebrae with large bodies and processes that serve as attachment sites for the lumbar paraspinal muscles. Each lumbar vertebra is separated by an intervertebral disc, which comprises a softer central nucleus pulposus and a thicker annulus fibrosis (fibrocartilage).


1
2
3
4
5
6
7
Anterior inferior view
8
9
10
11
Posterior superior view

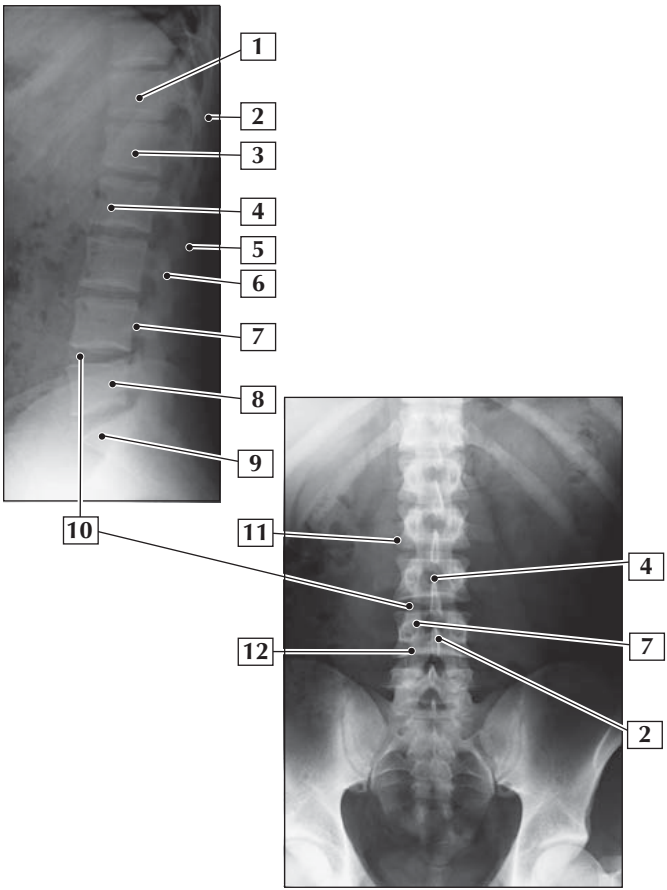
1. Lumbosacral articular surface
2. Sacral promontory
3. Linea terminalis
4. Sacral foramina
5. Transverse process of the coccyx
6. Coccyx
7. Transverse ridges
8. Sacral tuberosity
9. Lateral sacral crest
10. Median sacral crest
11. Intermediate sacral crest

Comment: The sacrum comprises 5 fused sacral vertebrae. Similarly, the coccyx comprises 4 fused coccygeal vertebrae. These structures provide strength and a site for muscle attachments of the spine and pelvis.


1
2
3
4
5
6
1
7
4
5

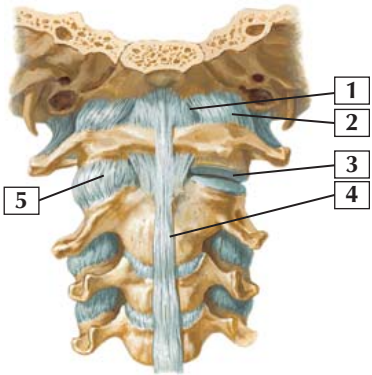
1. C1
2. Superior and inferior articular facets
3. Lamina
4. Spinous process
5. C7
6. Vertebral body
7. Transverse process

Comment: Anteroposterior (AP) and lateral radiographs are the views most commonly used to evaluate abnormalities of the cervical spine. Other views include oblique views, the Water's view (C1 and C2), and flexion/extension lateral views (to evaluate for stability of the cervical spine).

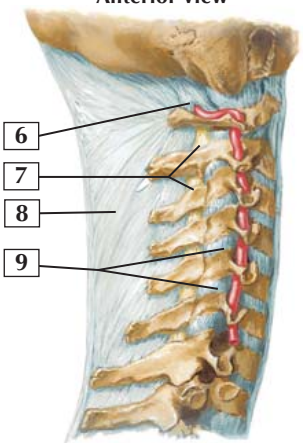

1
2
3
4
5
6
7
8
9
10
11
12
4
7
2

1. T12
2. Spinous process
3. L1
4. Lumbar vertebral body
5. Inferior articular process
6. Superior articular process
7. Pedicle
8. L5
9. S1
10. Intervertebral disc space
11. Transverse process
12. Lamina

Comment: Anteroposterior and lateral radiographs are the views most commonly used to evaluate the spine. Oblique views are also helpful, especially in cases of suspected spondylolysis and spondylolisthesis, because they provide a better view of the pars interarticularis ("neck of the Scotty dog").



Anterior view

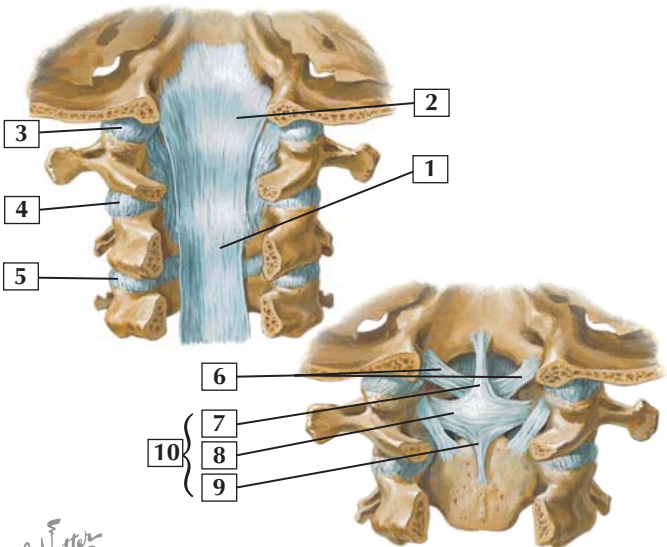


Right lateral view

1. Anterior atlantooccipital membrane
2. Atlantooccipital joint capsule
3. Lateral atlantoaxial joint (capsule removed)
4. Anterior longitudinal ligament
5. Lateral atlantoaxial joint capsule
6. Posterior atlantooccipital membrane
7. Ligamenta flava
8. Ligamentum nuchae
9. Zygapophyseal joints

Comment: The cervical spine comprises multiple joints, including the atlantooccipital joint (C1 and occipital bone), which is an ellipsoid joint; the atlantoaxial joint (C1 and C2), which is a plane and pivot joint; the zygapophyseal joints (facet joints); and the intervertebral joints.

Upper part of vertebral canal with spinous processes and parts of vertebral arches removed: posterior view

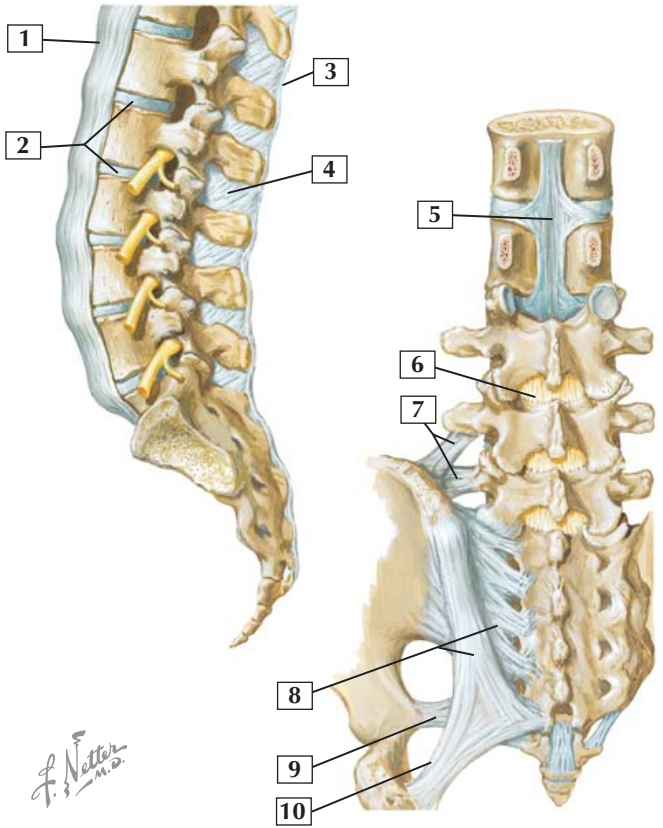


F. Netter M.D.

Principal part of tectorial membrane removed: posterior view

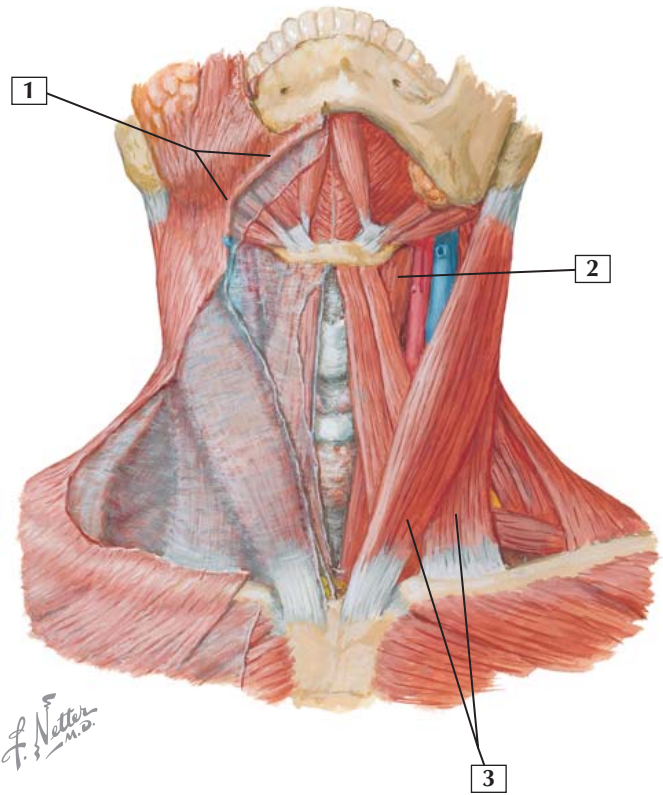
1. Posterior longitudinal ligament
2. Tectorial membrane
3. Atlantooccipital joint capsule
4. Lateral atlantoaxial joint capsule
5. Zygapophyseal joint capsule (C2-3)
6. Alar ligaments
7. Superior longitudinal band
8. Transverse ligament of the atlas
9. Inferior longitudinal band
10. Cruciate ligament

Comment: The atlantoaxial joint (C1-2) is primarily a joint of rotation. The apical, alar, and cruciate ligaments provide stability to the joint. Of these, the transverse ligament of the atlas is biomechanically the strongest.


1
2
3
4
5
6
7
8
9
10
F. Netter M.D.

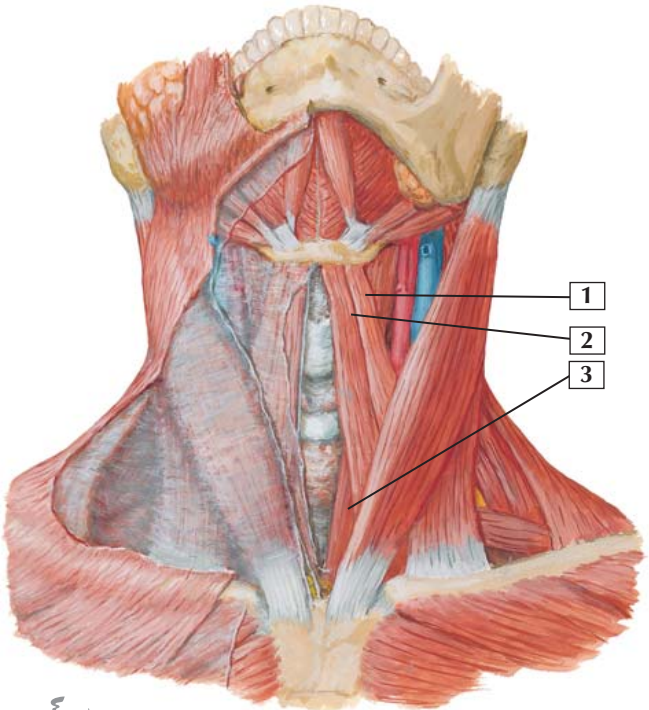
1. Anterior longitudinal ligament
2. Intervertebral discs
3. Supraspinous ligament
4. Interspinous ligament
5. Posterior longitudinal ligament
6. Ligamentum flavum
7. Iliolumbar ligament
8. Dorsal sacroiliac ligament
9. Sacrospinous ligament
10. Sacrotuberous ligament

Comment: The anterior and posterior longitudinal ligaments run along the anterior and posterior vertebral bodies the entire length of the spinal column and prevent excessive extension (anterior) and flexion (posterior) of the spine. The supraspinous and interspinous ligaments run between each pair of spinous processes, and the ligamentum flavum runs between the laminae.


1
2
3
F. Netter M.D.

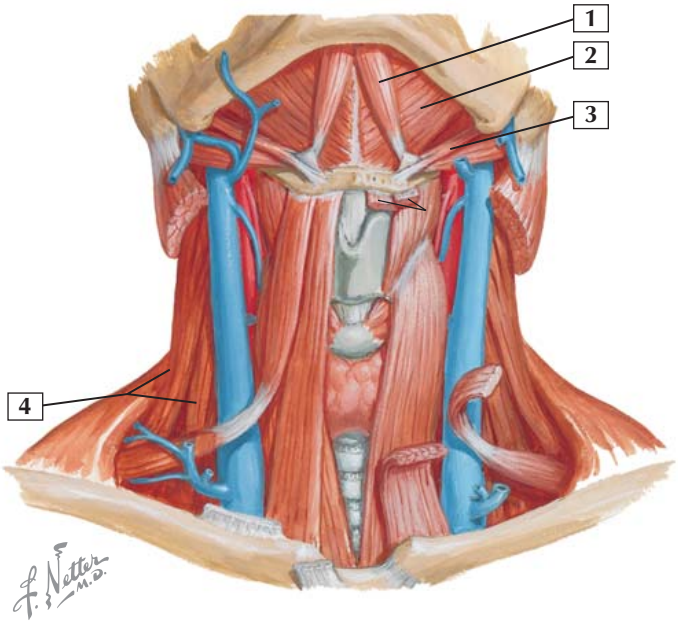
1. Platysma
2. Thyrohyoid muscle
3. Sternocleidomastoid muscle

	Platysma	Thyrohyoid Muscle	Sternocleidomastoid Muscle
Origin	Deltoid and pectoralis major fascia	Thyroid cartilage	Manubrium of sternum (sternal head); medial superior clavicle (clavicular head)
Insertion	Skin and mandible	Inferior hyoid bone	Mastoid process of temporal bone and lateral occipital bone
Actions	Depression of the jaw	Depression of hyoid and larynx	Flexion, rotation, and lateral flexion of the cervical spine
Innervation	Cranial nerve VII	C1 via hypoglossal nerve (cranial nerve XII)	Spinal root of the accessory nerve (cranial nerve XI)


1
2
3

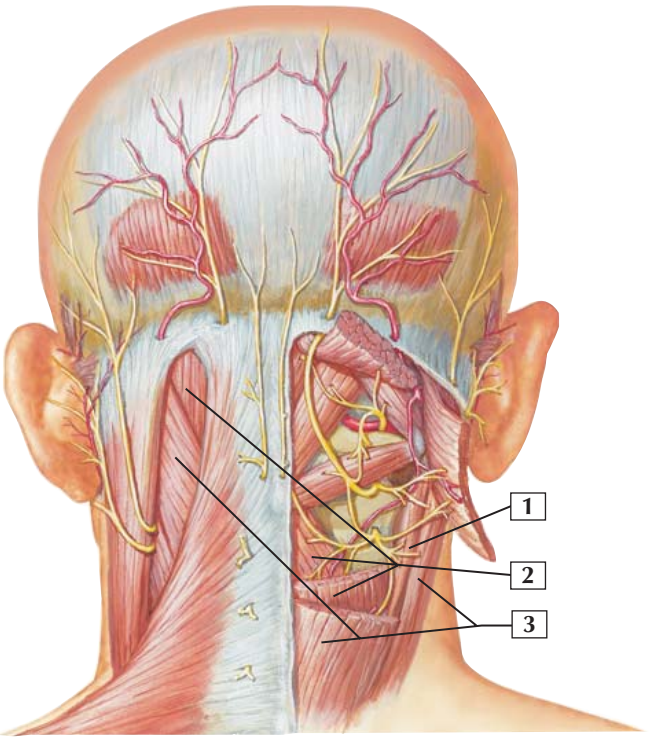
1. Omohyoid muscle
2. Sternohyoid muscle
3. Sternothyroid muscle

	Omohyoid Muscle	**Sternohyoid Muscle**	**Sternothyroid Muscle**
Origin	Superior scapula (suprascapular notch)	Medial clavicle and manubrium of sternum	Posterior manubrium of sternum
Insertion	Inferior hyoid bone	Body of hyoid bone	Thyroid cartilage
Actions	Depression of hyoid	Depression of hyoid	Depression of hyoid and larynx
Innervation	C1-3	C1-3	C1-3


1
2
3
4
F. Netter M.D.

1. Digastric muscle
2. Mylohyoid muscle
3. Stylohyoid muscle
4. Scalene muscles (anterior, middle, posterior)

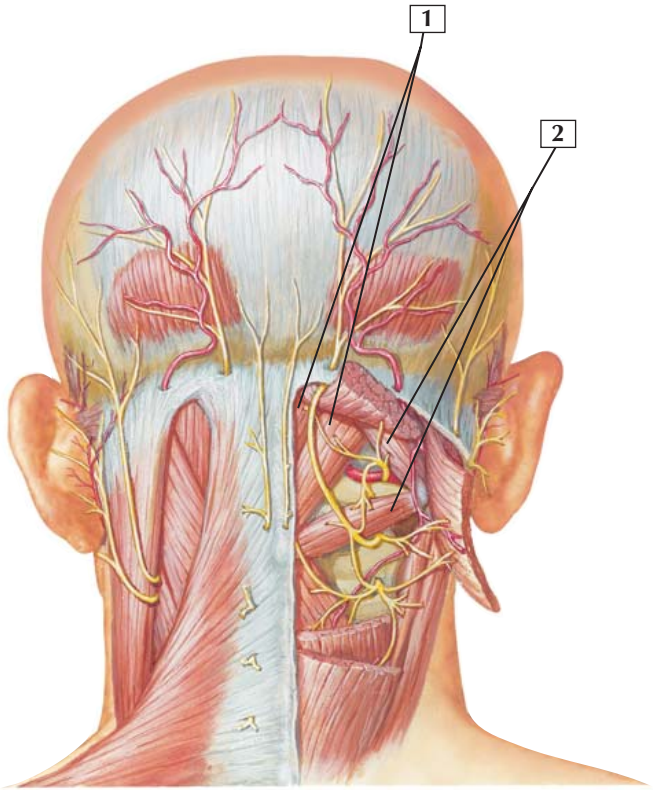
	Digastric Muscle	Mylohyoid Muscle	Stylohyoid Muscle	Scalene Muscles
Origin	Mandible (anterior belly); mastoid (posterior belly)	Mandible	Styloid process	Transverse processes (C2-7)
Insertion	Hyoid bone	Hyoid bone	Hyoid bone	1st and 2nd ribs
Actions	Elevation of the hyoid bone; depression of the jaw	Elevation of the hyoid bone	Elevation of the hyoid bone	Elevation of ribs; flexion, rotation, lateral flexion of cervical spine
Innervation	Anteriorly by cranial nerve V; posteriorly by cranial nerve VII	Cranial nerve V	Cranial nerve VII	Ventral rami (C3-8)



F. Netter M.D.

1. Longissimus capitis
2. Semispinalis capitis and cervicis (thoracis, not pictured)
3. Splenius capitis and cervicis

	Longissimus Capitis	**Semispinalis Capitis and Semispinalis Cervicis**	**Splenius Capitis and Splenius Cervicis**
Origin	Articular processes C4-7 and transverse processes T1-5	Transverse processes	Ligamentum nuchae (capitis) Spinous processes T1-6 (cervicis)
Insertion	Mastoid process	Nuchal ridge (capitis) Spinous processes (cervicis and thoracis)	Mastoid and nuchal line (capitis) Transverse processes C1-4 (cervicis)
Actions	Extension, rotation, lateral flexion of neck	Extension and rotation of the spine	Lateral flexion and rotation of the cervical spine
Innervation	Dorsal rami of cervical nerves	Dorsal primary rami	Dorsal rami of the inferior cervical nerves

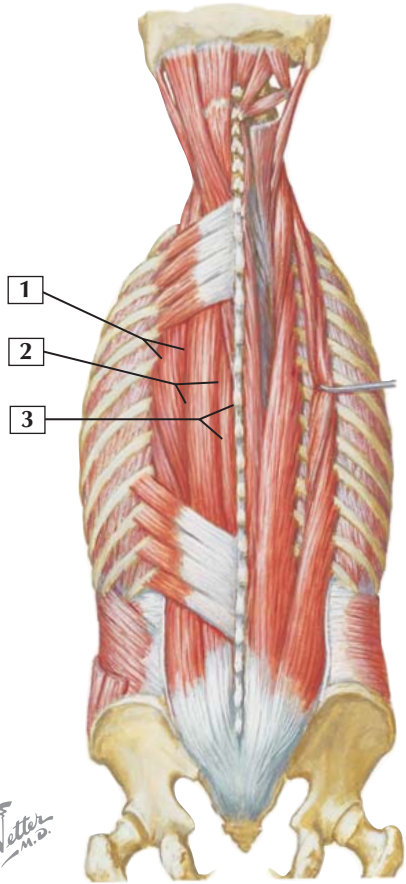


F. Netter M.D.

Muscles: Posterior Neck (Suboccipital Triangle)

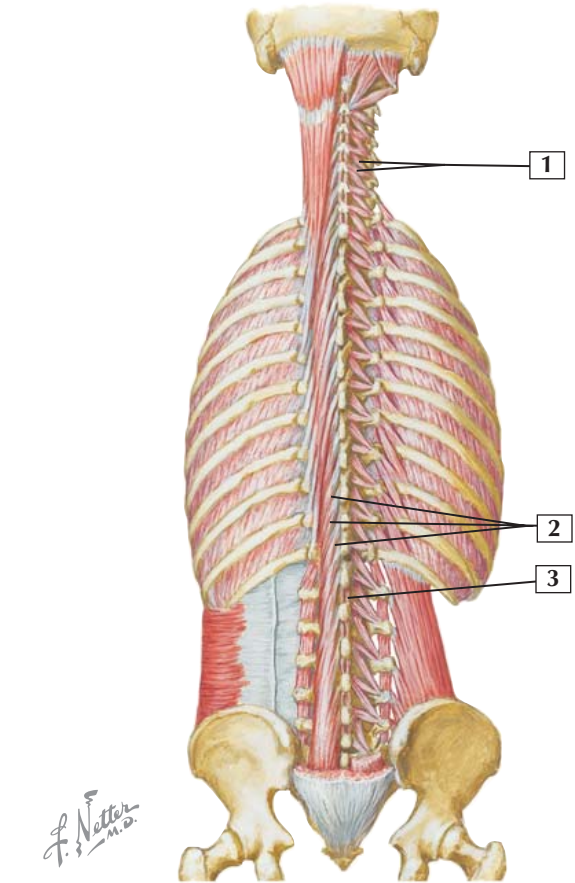
1. Rectus capitis posterior major and minor
2. Obliquus capitis superior and inferior

	Rectus Capitis Posterior Major and Minor	**Obliquus Capitis Superior and Inferior**
Origin	Spine of axis (major) Posterior tubercle of atlas (minor)	Transverse process of atlas (superior) Spine of axis (inferior)
Insertion	Inferior nuchal line (major) Occipital bone (minor)	Occipital bone (superior) Transverse process of atlas (inferior)
Actions	Extension, rotation, and lateral flexion of the cervical spine	Extension, rotation, and lateral flexion of the cervical spine
Innervation	Suboccipital nerve (dorsal ramus of C1)	Suboccipital nerve (dorsal ramus of C1)


1
2
3
F. Netter M.D.

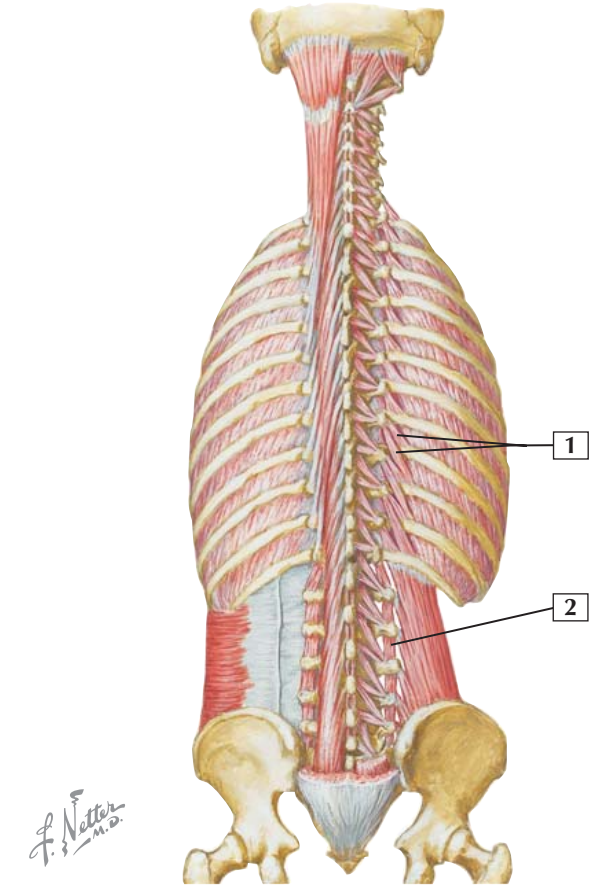
1. Iliocostalis
2. Longissimus
3. Spinalis

	Iliocostalis	Longissimus	Spinalis
Origin	Posterior iliac crest, sacrum, spinous processes of the inferior lumbosacral spine, and the supraspinous ligament	Posterior iliac crest, sacrum, spinous processes of the inferior lumbosacral spine, and the supraspinous ligament	Posterior iliac crest, sacrum, spinous processes of the inferior lumbosacral spine, and the supraspinous ligament
Insertion	Angles of the lower ribs and cervical transverse processes	Ribs, transverse processes of the cervical and thoracic vertebrae, mastoid process of the temporal bone	Midcervical and upper thoracic vertebral spinous processes and the skull
Actions	Vertebral column extension and lateral flexion	Vertebral column extension and lateral flexion	Vertebral column extension and lateral flexion
Innervation	Dorsal rami of the spinal nerves in each region	Dorsal rami of the spinal nerves in each region	Dorsal rami of the spinal nerves in each region
Comment	The iliocostalis, longissimus, and spinalis muscles collectively form the erector spinae muscle group. Each set is separated into 3 groups on the basis of their location in the vertebral column: iliocostalis (cervicis, thoracis, lumborum), longissimus (capitis, cervicis, thoracis), and spinalis (capitis, cervicis, thoracis).		


1
2
3
F. Netter M.D.

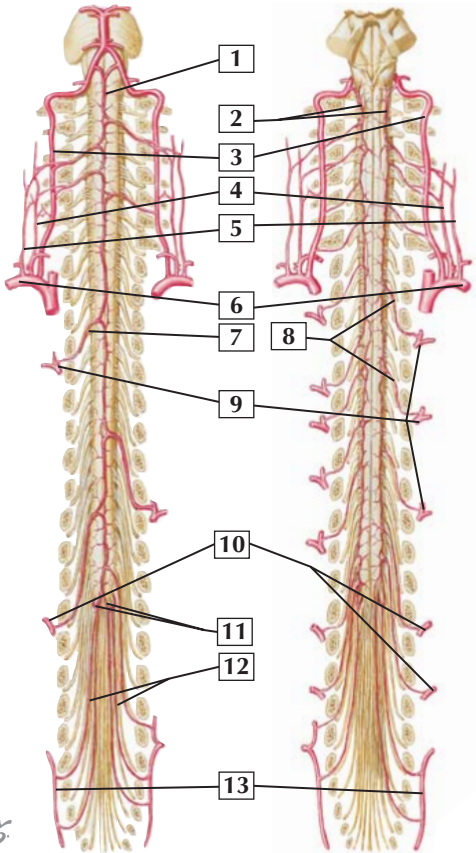
1. Rotatores cervicis
2. Multifidus muscles
3. Interspinales

	Rotatores Cervicis	Multifidus	Interspinales
Origin	Transverse processes	Transverse processes	Spinous process
Insertion	Spinous processes	Spinous processes	Spinous process above
Actions	Rotation of superior vertebrae	Lateral flexion and rotation of the spine	Extension of the spine
Innervation	Dorsal primary rami	Dorsal primary rami	Dorsal primary rami


1
2
F. Netter M.D.

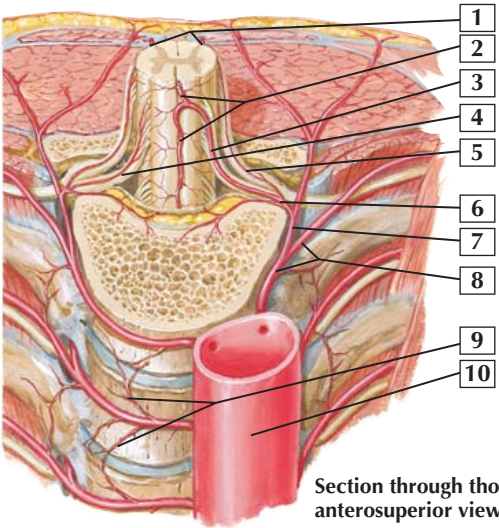
1. Levatores costarum
2. Intertransversarii

	Levatores Costarum	Intertransversarii
Origin	Transverse processes C7-T11	Transverse process
Insertion	Posterior surface and angle of rib below muscle	Transverse process above muscle
Actions	Elevation of ribs	Lateral flexion of the spine
Innervation	Dorsal rami C7-T11	Dorsal primary rami

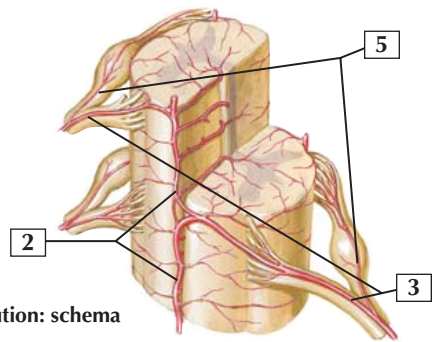

1
2
3
4
5
6
7
8
9
10
11
12
13
F. Netter M.D.
Anterior view
Posterior view

1. Anterior spinal artery
2. Posterior spinal arteries
3. Vertebral artery
4. Ascending cervical artery
5. Deep cervical artery
6. Subclavian artery
7. Anterior segmental medullary artery
8. Posterior segmental medullary arteries
9. Posterior intercostal arteries
10. Lumbar arteries
11. Posterior spinal artery anastomoses
12. Cauda equine arteries
13. Sacral arteries

Comment: The vertebral artery runs through the transverse foraminae from the point where it arises from the subclavian artery. Each nerve root has a corresponding radicular or segmental medullary artery that runs alongside the roots. The segmental medullary arteries supply a segment of the anterior or posterior spinal arteries.



Section through thoracic level: anterosuperior view

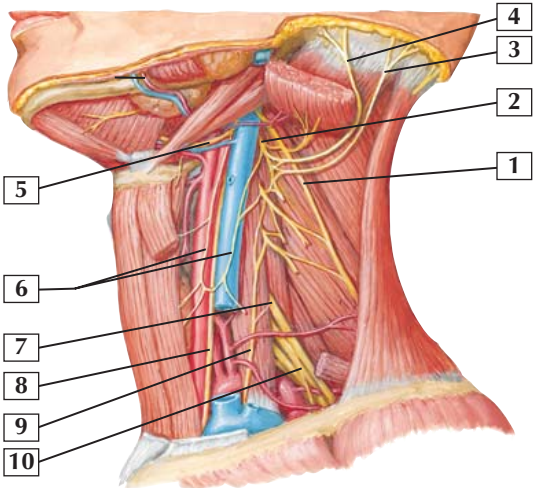


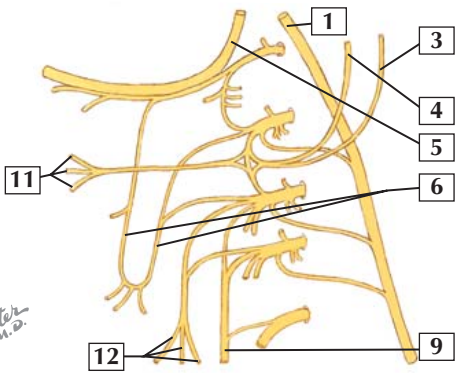
F. Netter M.D.

Arterial distribution: schema

1. Posterior spinal arteries
2. Anterior spinal artery
3. Anterior segmental medullary artery
4. Anterior radicular artery
5. Posterior radicular artery
6. Spinal branch of the posterior intercostal artery
7. Dorsal branch of the posterior intercostal artery
8. Posterior intercostal artery
9. Prevertebral anastomoses
10. Aorta

Comment: Whereas the vertebral artery provides the main blood supply to the cervical spine and cord, the thoracolumbar spine receives its blood supply from branches off the descending aorta. Branches here include the lumbar artery, the anterior and posterior segments of the spinal artery, and the anterior and posterior segmental medullary arteries.



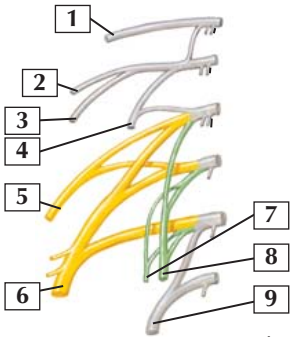


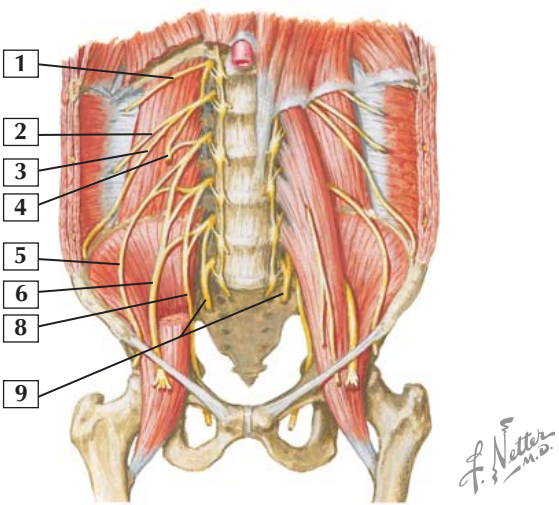
F. Netter M.D.

Nerves of the Spine: Cervical Plexus

1. Accessory nerve (cranial nerve XI)
2. C2 spinal nerve
3. Lesser occipital nerve
4. Great auricular nerve
5. Hypoglossal nerve (cranial nerve XII)
6. Ansa cervicalis
7. C5 spinal nerve
8. Vagus nerve (cranial nerve X)
9. Phrenic nerve
10. Brachial plexus
11. Transverse cervical nerves
12. Supraclavicular nerves

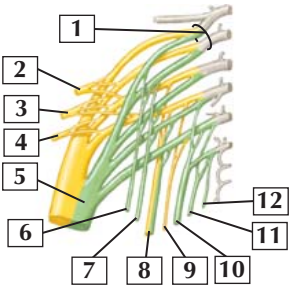
Comment: The cervical plexus (C1-4) comprises the lesser occipital nerve, great auricular nerve, transverse cervical nerve, supraclavicular nerve, ansa cervicalis, and phrenic nerve. The first 4 of these provide only sensory input, whereas the ansa cervicalis provides motor input to the omohyoid, sternohyoid, and sternothyroid muscles. The phrenic nerve innervates the diaphragm.

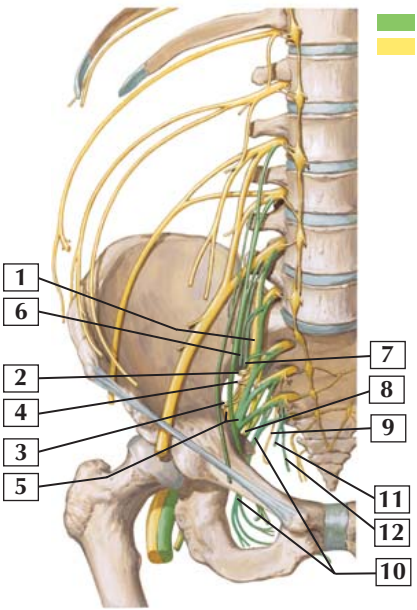

1
2
3
4
5
6
7
8
9
Anterior division
Posterior division


1
2
3
4
5
6
8
9
F. Netter M.D.

1. Subcostal nerve
2. Iliohypogastric nerve
3. Ilioinguinal nerve
4. Genitofemoral nerve
5. Lateral femoral cutaneous nerve
6. Femoral nerve
7. Accessory obturator nerve
8. Obturator nerve
9. Lumbosacral trunk

Comment: The lumbosacral plexus (T12-L5) lies deep to the psoas muscles. It has anterior and posterior divisions. The anterior division comprises the subcostal, iliohypogastric, ilioinguinal, genitofemoral, obturator, and accessory obturator (not always present) nerves. The posterior division comprises the lateral femoral cutaneous and femoral nerves.


1
2
3
4
5
6
7
8
9
10
11
12


Anterior division
Posterior division
1
6
2
4
3
5
7
8
9
11
12
10

F. Netter M.D.

1. Lumbosacral trunk
2. Superior gluteal nerve
3. Inferior gluteal nerve
4. Nerve to the piriformis
5. Sciatic nerve
6. Nerve to quadratus femoris
7. Nerve to obturator internus
8. Posterior cutaneous nerve of the thigh
9. Perforating cutaneous nerve
10. Pudendal nerve
11. Nerve to levator ani and coccygeus muscles
12. Perineal branch

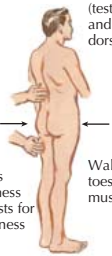
Comment: The sacral plexus comprises nerve roots L4-S5. The anterior division (shown in green on the front) becomes the tibial nerve (L4-S3), the nerve to the quadratus femoris (L4-S1), the nerve to the obturator internus (L5-S2), the pudendal nerve (S2-S4), and the nerve to the coccygeus muscle (S3-S4). The posterior division (shown in yellow on the front) becomes the common peroneal nerve (L4-S2), the superior gluteal nerve (L4-S1), the inferior gluteal nerve (L5-S2), the nerve to the piriformis (S2), and the posterior femoral cutaneous nerve (S1-S3).

Standing

Observe
- body build
- posture
- deformities
- pelvic obliquity
- spine alignment

Palpate for
- m. spasms
- trigger zones
- myofascial nodes
- sciatic n. tenderness

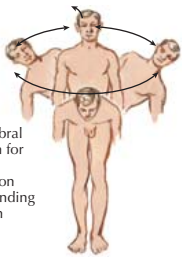
Compress iliac crests for sacroiliac tenderness



Walking on heels (tests foot and great toe dorsiflexion)

Walking on toes (tests calf muscles)

Test vertebral column for
- flexion
- extension
- side bending
- rotation



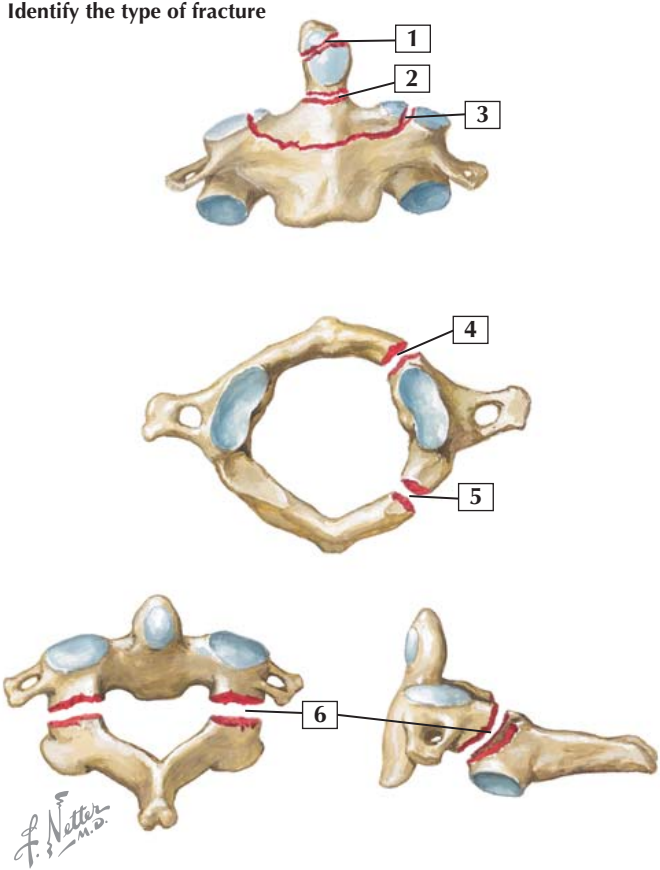
Measurement of rib hump wtih scoliometer

Estimation of rib hump and evaluation of curve unwinding as patient turns trunk from side to side

Movement	Normal Range of Motion
Cervical flexion	Chin within 3-4 cm of chest
Cervical extension	60 degrees
Cervical lateral flexion	30-45 degrees
Cervical rotation	75-80 degrees
Lumbar flexion	60-80 degrees
Lumbar extension	25-40 degrees
Lumbar lateral flexion	40-60 degrees
Lumbar rotation	60-70 degrees

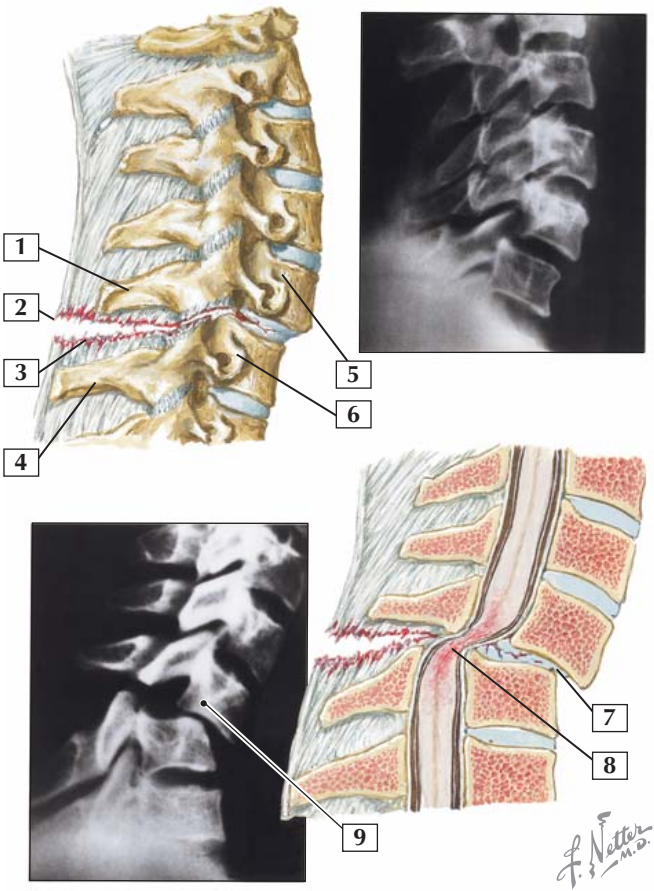
Test/Sign	Reason for Evaluation
Spurling test	Nerve root compression
Straight leg raise	Sciatic nerve irritation
Single leg extension	Spondylolysis/spondylolisthesis
Forward bend/rib hump	Scoliosis
Valsalva test	Space-occupying lesion (disc)

Identify the type of fracture



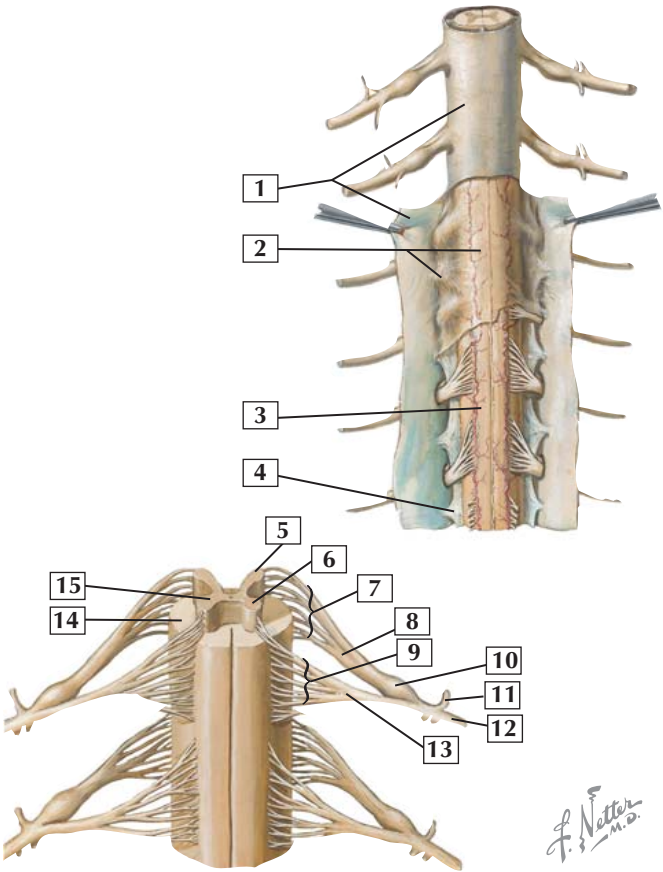
1. Fracture of the tip of the odontoid (type I)
2. Fracture of the base of the odontoid (type II)
3. Fracture involving the C2 body (type III)
4. Jefferson fracture (anterior arch of C1)
5. Jefferson fracture (posterior arch of C1)
6. Hangman fracture

	Jefferson Fracture (C1)	Odontoid Fracture (C2)	Hangman Fracture (C2)
Mechanism	Axial load	MVA or fall	Trauma resulting in extension/axial load and then flexion/distraction
Anatomy	Fracture of the anterior and posterior ring of the atlas	Type I: tip avulsion Type II: base (most common) Type III: body	Disruption of the pars interarticularis of the axis
Imaging	Anteroposterior (AP) and lateral cervical spine radiographs show lateral displacement of the lateral masses	AP and lateral radiographs, computed tomography (CT)	AP and lateral radiographs; CT
Treatment	Stable fractures: hard cervical collar Unstable fractures: halo brace or ORIF	Type I (stable): hard cervical collar Type II: halo brace if <5 mm displacement or 10-degree angulation; open reduction, internal fixation (ORIF) or fusion if greater displacement or angulation Type III (unstable): halo brace, ORIF, or arthrodesis	Displacement <3 mm: hard cervical collar Displacement ≥3 mm: halo brace


1
2
3
4
5
6
7
8
9
F. Netter M.D.

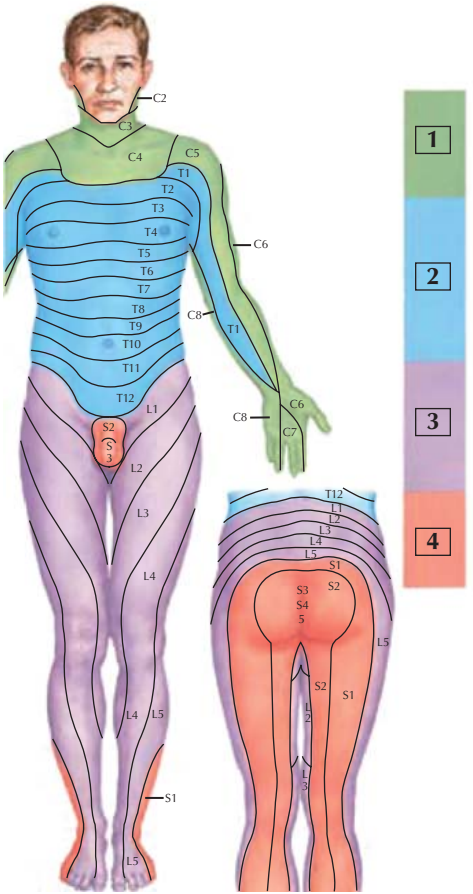
1. Spinous process C6
2. Supraspinous ligament (torn)
3. Interspinous ligament (torn)
4. Spinous process C7
5. Anterior body C6
6. Anterior body C7
7. Step-off C6 vertebral body on C7
8. Cord compression
9. Step-off of more than 3 mm and angulation of more than 11 degrees, indicating instability

	Cervical Sprain/Strain	Cervical Spine Instability
Mechanism	Stretch or whiplash injury to the neck	Traumatic (distraction and flexion of the cervical spine), congenital (Down syndrome), or acquired (rheumatoid arthritis)
Signs and Symptoms	Pain and stiffness, focal tenderness, mild loss of motion, usually not associated with neurological symptoms	Cervical pain post-trauma; may be more insidious in chronic cases
Imaging	Radiographs and magnetic resonance imaging (MRI) as needed to rule out fracture or neurological injury	Anteroposterior (AP), lateral, and odontoid radiographs show >3.5 mm step-off or >11-degree angulation
Treatment	Rest, nonsteroidal antiinflammatory drugs (NSAIDs), activity modification, physical therapy	Careful initial management after trauma; final management may include halo brace or surgical fusion, depending on the cause and severity


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
F. Netter M.D.

1. Dura mater
2. Arachnoid mater
3. Pia mater
4. Denticulate ligament
5. Dorsal horn
6. Ventral horn
7. Filaments of dorsal root
8. Dorsal root
9. Filaments of ventral root
10. Dorsal root ganglion
11. Dorsal ramus of spinal nerve
12. Ventral ramus of spinal nerve
13. Ventral root
14. White matter
15. Gray matter

	Spinal Cord Shock	Spinal Cord Injury
Mechanism	Physiological (not anatomical) reflex depression of spinal function	Anatomical injury from contusion, compression, or transection of cord
Signs and Symptoms	24-72 Hours of paralysis, hypotonia, and areflexia	Varying degree of motor or sensory loss based on level and severity
Imaging	Can be normal	Anteroposterior (AP), lateral, oblique, Water radiographs; computed tomography (CT); magnetic resonance imaging (MRI)
Treatment	Supportive until function begins to restore	Methylprednisolone within 8 hours, immobilization, traction, halo brace, surgical fusion of unstable segment or segments

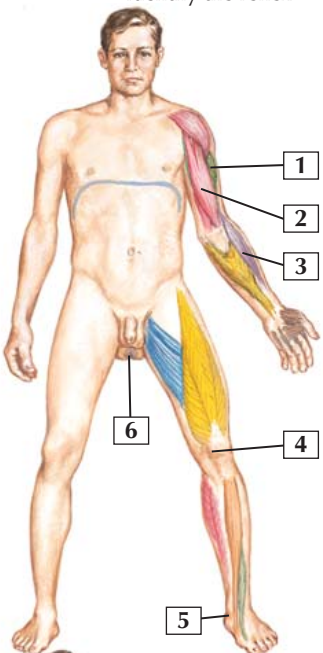

C2
C3
C4
C5
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
5
C6
C7
C8
1
2
3
4

F. Netter M.D.

1. Cervical segments
2. Thoracic segments
3. Lumbar segments
4. Sacral segments

Nerve Root	Dermatome
C1	Top of skull
C2	Temple, occiput
C3	Neck, cheek
C4	Shoulder, axilla
C5	Deltoid patch
C6	Lateral forearm, thumb
C7	Middle finger
C8	Medial arm, small finger
T1	Medial elbow
T2	Axilla, pectoral region
T3-7	Upper thorax (T4, nipple)
T8-12	Abdomen and lower back (T10, umbilicus)
L1	Groin and lateral hip
L2	Anterior thigh
L3	Medial knee and leg
L4	Lateral thigh, medial leg
L5	Posterolateral thigh, lateral leg, dorsum foot
S1	Posterior thigh, leg, and heel
S2	Posterior thigh and leg
S3	Groin, medial thigh
S4	Perineum, genitals

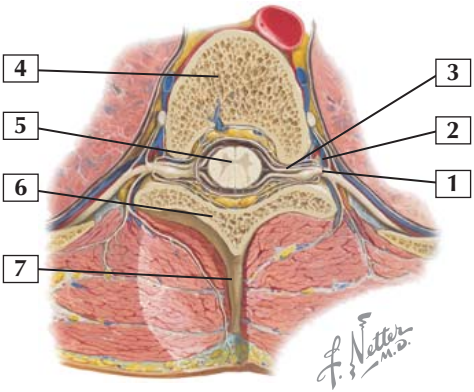
Identify the reflex



F. Netter M.D.

Label	Spinal Level	Reflex
1	C7	Triceps
2	C5	Biceps
3	C6	Brachioradialis
4	L4	Patellar
5	S1	Achilles
6	S2-4	Anal sphincter

Nerve Root	Myotome
C2	Longus colli, sternocleidomastoid
C3	Trapezius, splenius capitis
C4	Trapezius, levator scapulae
C5	Deltoid, biceps
C6	Biceps, wrist extensors
C7	Triceps, wrist flexors
C8	Finger flexors and adductors
L2	Psoas, hip adductors
L3	Quadriceps
L4	Tibialis anterior, extensor hallucis longus
L5	Extensor hallucis longus, peroneal muscles, dorsiflexors
S1	Peroneal muscles, plantar flexors
S2	Hamstrings, plantar flexors
S4	Bladder, rectum

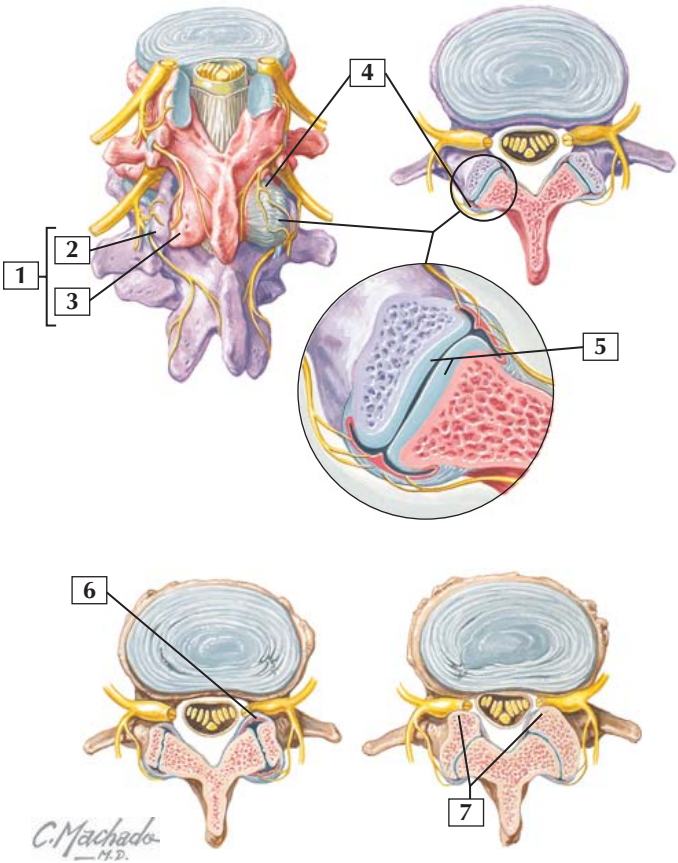


8

1. Spinal nerve
2. Neural foramina, normal
3. Ventral root
4. Vertebral body
5. Spinal canal and cord
6. Lamina
7. Spinous process
8. Magnetic resonance imaging (MRI) appearance of cord changes from central stenosis

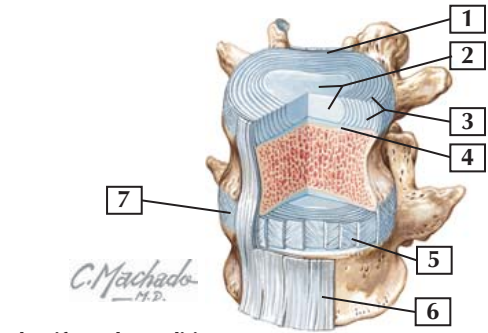
	Central Stenosis	Lateral (Neuroforaminal) Stenosis
Pathophysiology	Congenital, traumatic, or acquired (disc bulge, degenerative spurring) narrowing of the spinal canal	Congenital, traumatic, or acquired narrowing of the neural foramina
Signs and Symptoms	Pain and paresthesias (without dermatomal pattern) worse with activity and relieved by sitting	Radicular pain that is not ameliorated with rest
Imaging	Anteroposterior (AP) and lateral radiographs; MRI; computed tomographic myelography	AP and lateral radiographs; MRI; computed tomographic myelography
Treatment	Activity modification, flexion exercises, nonsteroidal antiinflammatory drugs (NSAIDs), epidural steroid injections, surgical decompression for refractory cases	Activity modification, physical therapy, NSAIDs, nerve root injections, decompression for refractory cases

MRI from Browner B, Jupiter J, Trafton P: Skeletal Trauma. Philadelphia: WB Saunders, 2003.

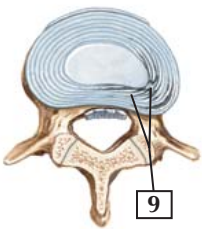

1
2
3
4
5
6
7
C. Machado M.D.

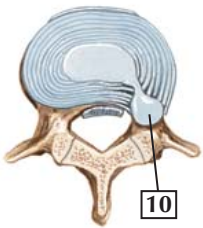
1. Facet (zygapophyseal) joint
2. Superior articular process of vertebra below (purple)
3. Inferior articular process of vertebra above (pink)
4. Facet joint and capsule
5. Articular cartilage of facet joint
6. Synovial inflammation with nerve root impingement
7. Facet arthropathy with large osteophytes causing nerve root impingement

	Facet Syndrome
Pathophysiology	Inflammation or degeneration of facet joints
Mechanism	Acute/injury-related or chronic degenerative process
Signs and Symptoms	Nonspecific pain that may radiate to buttocks, is worse with hyperextension/rotation, is worse in morning and after rest
Imaging	Anteroposterior (AP), lateral, oblique radiographs show facet joint degenerative changes; magnetic resonance imaging (MRI) to rule out other soft tissue injury
Treatment	Activity modification, physical therapy, nonsteroidal antiinflammatory drugs (NSAIDs), facet joint injections; surgery (controversial)



Identify each condition



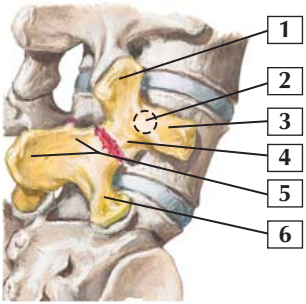


11

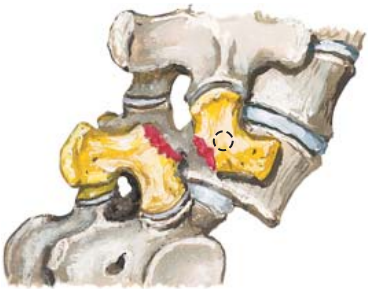
1. Posterior longitudinal ligament
2. Nucleus pulposus
3. Annulus fibrosus
4. Cartilage endplate
5. Collagen lamellae of annulus fibrosus
6. Anterior longitudinal ligament
7. Intervertebral disc
8. Rim tear of annulus fibrosus
9. Annular tear
10. Herniated nucleus pulposus
11. C6-7 herniated disc with cord compression

	Disc Disease
Anatomy	Most common in C5-6, C6-7, L4-5, and L5-S1
Pathophysiology	Tear develops in the annulus pulposus with or without extrusion of the nucleus pulposus and compression of the unilateral nerve root
Mechanism	May be degenerative or traumatic
Signs and Symptoms	Low back pain with or without radicular symptoms
Imaging	Radiographs, which may reveal Schmorl nodes in chronic cases; magnetic resonance imaging (MRI)
Treatment	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), physical therapy for less severe cases Surgical discectomy typically required in cases of nerve root compression

MRI from Browner B, Jupiter J, Trafton P: Skeletal Trauma. Philadelphia: WB Saunders, 2003.



7 Identify the condition shown above

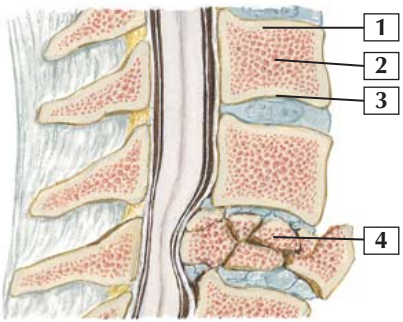


8 Identify the condition shown above

F. Netter M.D.

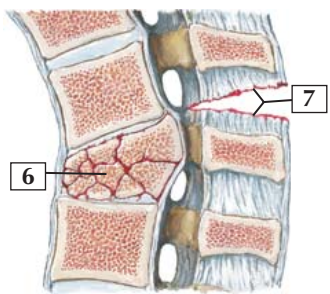
1. Superior articular process
2. Pedicle
3. Transverse process
4. Isthmus
5. Lamina and spinous process
6. Inferior articular processes
7. Spondylolysis
8. Spondylolisthesis

	Spondylolysis	Spondylolisthesis
Pathophysiology	Stress fracture of the pars interarticularis Common in teenagers	Pars defect with anterior slip of superior vertebra Can be degenerative in older patients
Mechanism	Repetitive hyperextension of the spine	Same
Signs and Symptoms	Low back pain worse with extension, positive result of single-leg hyperextension test	Same
Imaging	Anteroposterior (AP), lateral, and oblique radiographs ("Scotty dog with collar" appearance) Single photon emission computed tomographic (SPECT) scan	AP, lateral, and oblique radiographs
Grading	Acute or chronic	Type I: 0-25% displacement Type II: 25-50% displacement Type III: 50-75% displacement Type IV: >75% displacement Type V: 100% displacement (spondyloptosis)
Treatment	Activity modification, flexion exercises, bracing	Types I and II: same Types III, IV, and V: fusion of affected level usually required



F. Netter M.D.

5



8

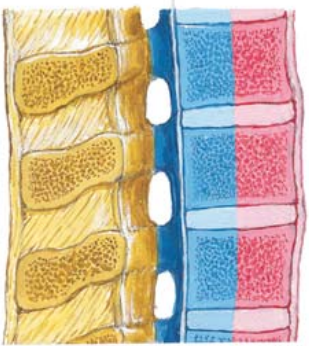
1. Superior endplate
2. Vertebral body
3. Inferior endplate
4. Compression fracture with spinal cord compression
5. Radiographic appearance of compression fracture
6. Burst fracture with anterior collapse
7. Supraspinous and interspinous ligament injury
8. Appearance of burst fracture on computed tomography (CT)

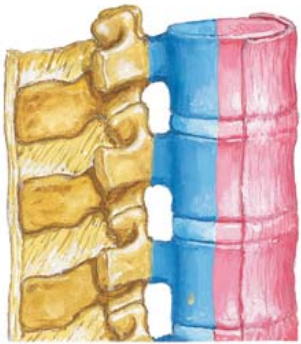
	Compression Fracture	Burst Fracture
Mechanism	Vertebral body collapse from weakened bone (from osteoporosis or metastasis)	Trauma that axially loads spine (fall from a height) Most common in T11-L2 but can occur at any spinal level
Signs and Symptoms	Focal back pain with or without neurological symptoms	Post-traumatic focal pain and tenderness
Imaging	Anteroposterior (AP) and lateral radiographs, dual-energy x-ray absorptiometry (DEXA) (bone density)	AP and lateral radiographs, CT
Classification	Acute, chronic, pathologic	Stable (neurologically intact with loss of <50% of height) or unstable (neurological deficit and ≥50% loss of height)
Treatment	Rest, brace, pain control; surgery if advanced kyphosis or neurological deficit	Brace; if fracture is unstable, surgical decompression and fusion

Radiograph from Browner B, Jupiter J, Trafton P: Skeletal Trauma. Philadelphia: WB Saunders, 2003.

CT image from DeLee J, Drez D, Miller M: DeLee & Drez's Orthopaedic Sports Medicine, 2nd ed. Philadelphia: WB Saunders, 2002.

1 Identify the concept shown





Lateral view

2

3

4

Identify the condition

5

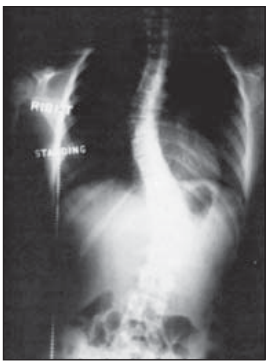
1. Three-column concept of spinal stability (Denis)
2. Posterior column
3. Middle column
4. Anterior column
5. Chance fracture

Comment: The purpose of the three-column system is to determine whether fractures are stable or unstable. A fracture is determined to be stable if there is involvement of only one column. An unstable fracture should be suspected if the middle column is involved and is confirmed by the involvement of all three columns.

- Anterior column: anterior longitudinal ligament (ALL) and anterior 2/3 of vertebral body and annulus
- Middle column: posterior 1/3 of vertebral body and annulus and posterior longitudinal ligament (PLL)
- Posterior column: pedicles, facets, spinous processes, interspinous and supraspinous ligaments

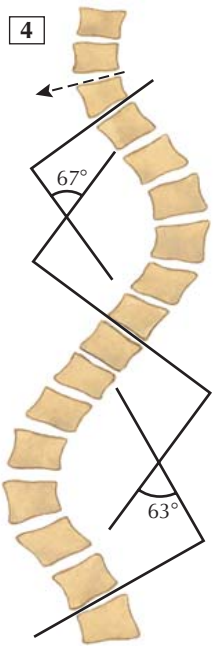
	Chance Fracture
Mechanism	Flexion/distraction injury Common in motor vehicle accidents
Anatomy	Transverse fracture through spinous process into vertebral body; ALL is intact and acts as a hinge
Imaging	Anteroposterior (AP) and lateral radiographs, computed tomography (CT)
Treatment	Reduction and immobilization in thoracolumbosacral orthosis (TLSO) brace; surgery (rare)

1 Identify the conditon shown



5

4



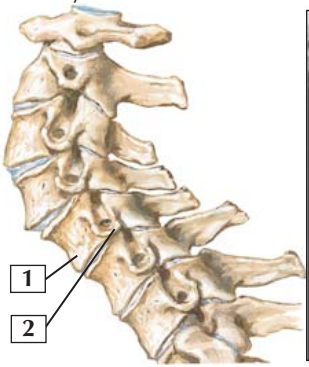
1. Scoliosis, classic appearance
2. Rib hump
3. Decreased vertebral height on concave side
4. Cobb angle
5. Radiographic appearance of scoliosis

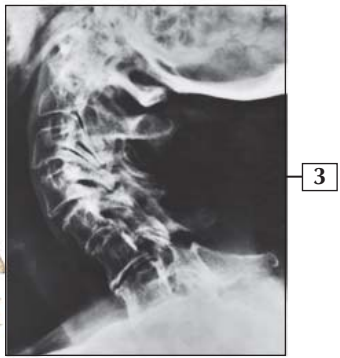
	Scoliosis
Pathophysiology	Congenital, acquired, or degenerative lateral curvature of the spine of at least 10 degrees
Signs and Symptoms	Not typically painful; deformity (rib hump) is a classic finding
Imaging	Standing full-length anteroposterior (AP) and lateral radiographs (Cobb angle measurement)
Treatment	Depends on severity; observation and bracing (patients are still growing) Surgical fusion if curves >50 degrees

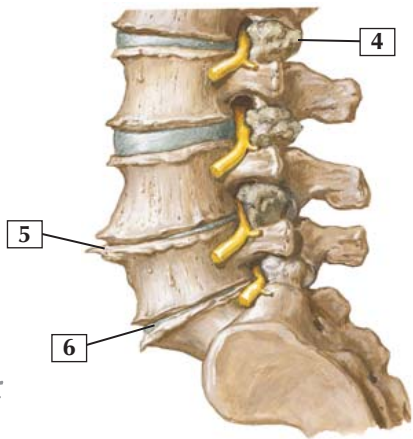
Cobb Angle
Radiographic measurement of curve
Line parallel to superior endplate of highest inclined vertebra
Line parallel to inferior endplate of lowest inclined vertebra
2 Additional lines perpendicular to the first 2
Measure angle created by intersection of the 2 perpendicular lines

Radiograph from DeLee J, Drez D, Miller M: DeLee & Drez's Orthopaedic Sports Medicine, 2nd ed. Philadelphia: WB Saunders, 2002.

Identify each condition



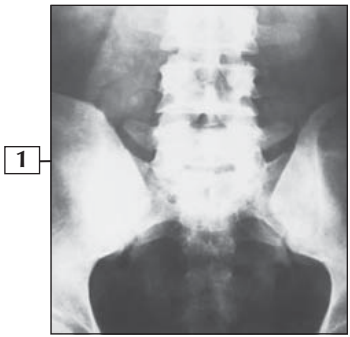


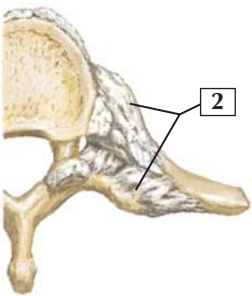


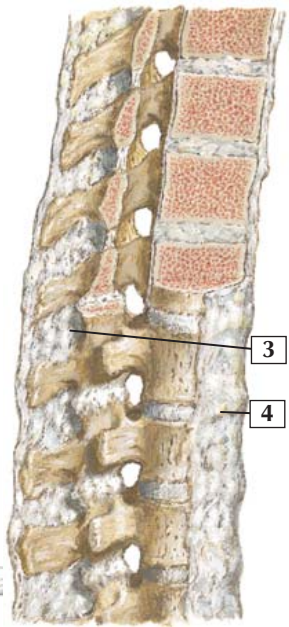
1. Cervical spine degeneration with hyperextension deformity
2. Narrowed neural foramina secondary to degenerative changes
3. Radiographic appearance of cervical spine osteoarthritis
4. Lumbar spine osteoarthritis
5. Anterior osteophytes
6. Disc degeneration

	Osteoarthritis of the Spine	Myelopathy
Mechanism	Degenerative (wear and tear); posttraumatic	Cord compression resulting from osteophytes, disc disease, or facet arthropathy
Signs and Symptoms	Pain that is worse with standing; motion loss may be present Neurological symptoms only with cord or nerve root compression from osteophytes	Pain, neurological symptoms, occipital headaches
Imaging	Anteroposterior (AP), lateral, and oblique radiographs	Radiographs, computed tomographic myelography, and/or magnetic resonance imaging (MRI)
Treatment	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), physical therapy, selective injections	NSAIDs, physical therapy, traction, surgery (discectomy and arthrodesis)

Identify each condition

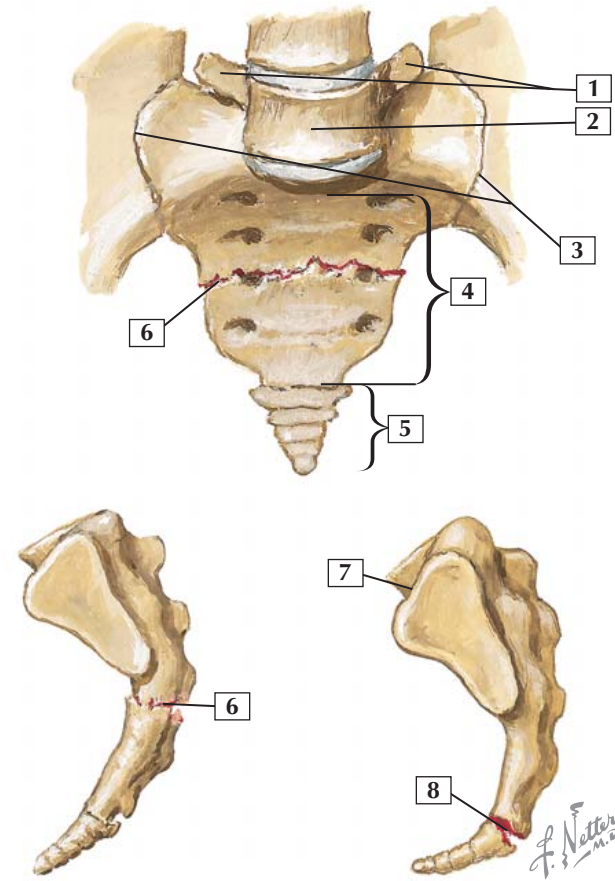






1. Radiograph of bilateral sacroiliitis
2. Calcification of the radiate and costotransverse ligaments in thoracic spine
3. Interspinous ligaments with ossification
4. Anterior longitudinal ligament with ossification

	Ankylosing Spondylitis	Diffuse Idiopathic Skeletal Hyperostosis (DISH) (or Forestier Disease)
Age (Years)	15-35	>50
Sex Predominantly Affected	Male	Male
Pathology	Marginal syndesmophytes	Nonmarginal syndesmophytes
Symptoms	Pain and stiffness	Pain and stiffness
Sacroiliac Joint Involvement	Yes	No
Laboratory Test Findings	Human leukocyte antigen (HLA)–B27 (positive), erythrocyte sedimentation rate (increasing)	—
Imaging	Anteroposterior (AP)/lateral radiograph Bone scan	AP/lateral radiograph
Treatment	Nonsteroidal antiinflammatory drugs (NSAIDs) Physical therapy	NSAIDs Physical therapy
Surgery	Chronic disease: osteotomy/fusion	Not usually indicated


1
2
3
4
5
6
6
7
8
F. Netter M.D.

1. L5 transverse processes
2. L5 vertebral body
3. Sacroiliac joint
4. Sacrum
5. Coccyx
6. Fracture of the body of the sacrum
7. Sacral promontory
8. Fracture of the coccyx

	Sacral Fractures	Sacroiliac Joint Pain
Mechanism	Trauma or stress reaction	Muscle imbalance, postural changes, repetitive activity, trauma
Signs and Symptoms	Localized pain and tenderness, inability to sit	Pain/tenderness localized to joint; positive result of Gaenslen's test
Imaging	Anteroposterior (AP) and lateral radiographs, computed tomography (CT); rule out pelvic ring injury	Not necessary
Treatment	Conservative for nondisplaced traumatic and stress fractures Surgical fixation for fractures displaced >1 cm	Nonsteroidal antiinflammatory drugs (NSAIDs), local injections

4 The Thorax and Abdomen
Plates 4-1 to 4-17

Bony Anatomy

4-1 Bony Anatomy: Thorax

4-2 Bony Anatomy: Abdomen

Radiographic Anatomy

4-3 Radiographic Anatomy: Thorax

Muscles

4-4 Muscles: Anterior Thorax

4-5 Muscles: Anterior Thorax Wall

4-6 Muscles: Anterior Thorax Wall

4-7 Muscles: Superficial Layer of Posterior Thorax

4-8 Muscles: Intermediate Layer of Posterior Thorax

4-9 Muscles: Anterior Abdominal Wall

4-10 Muscles: Posterior Abdominal Wall

Arteries and Nerves

4-11 Intercostal Arteries and Nerves

4-12 Arteries: Thorax and Abdomen

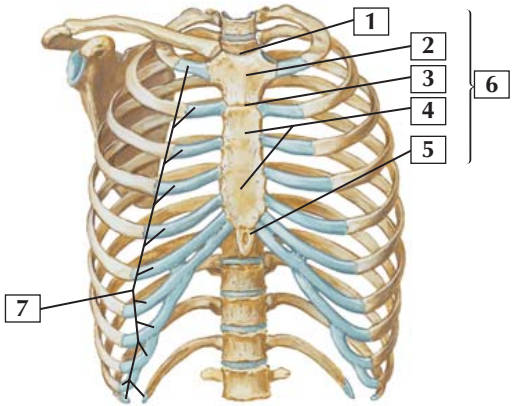
4-13 Nerves: Thorax and Abdomen

Conditions

4-14 Conditions: Sternum

4-15 Conditions: Ribs

The Thorax and Abdomen
Plates 4-1 to 4-17



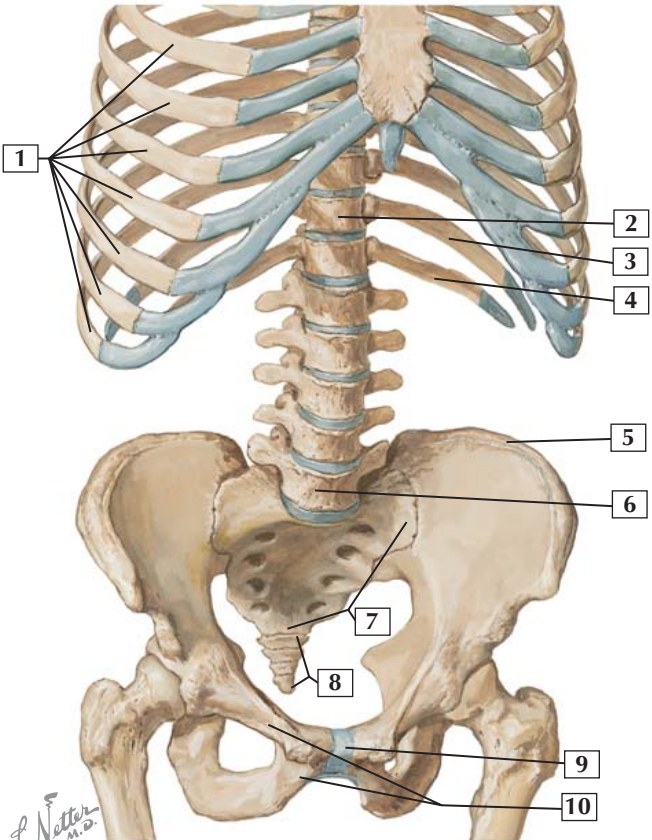
Anterior view

Posterior view

F. Netter M.D.

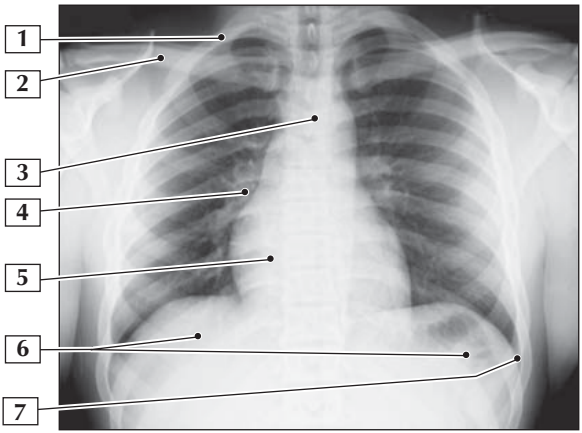
1. Jugular notch of sternum
2. Manubrium
3. Sternal angle
4. Body of sternum
5. Xiphoid process
6. Sternum
7. Costal cartilages
8. Head of the rib
9. Neck of the rib
10. Angle of the rib
11. Body of the rib
12. Ribs

Comment: The thorax comprises 12 pairs of ribs. Each articulates with the corresponding vertebra posteriorly; ribs 1-7 articulate with the sternum anteriorly (true ribs). Other articulations of the thorax include the sternoclavicular joints and the costochondral joints.

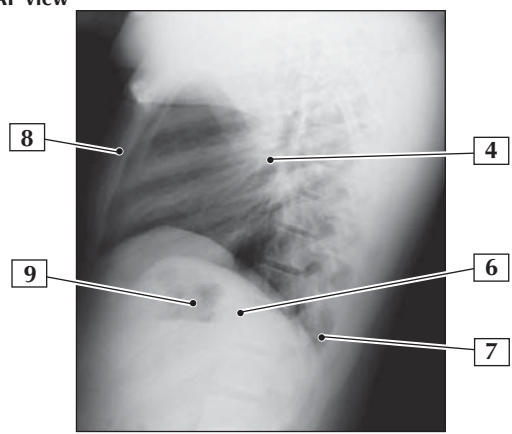

1
2
3
4
5
6
7
8
9
10
F. Netter M.D.

1. Ribs 4-10
2. T11
3. Rib 11
4. Rib 12
5. Iliac crest
6. L5
7. Sacrum
8. Coccyx
9. Pubic symphysis
10. Pubic ramus

Comment: The bony framework of the abdomen includes the ribs, the lower thoracic vertebrae, the lumbar vertebrae, the sacrum, and the pelvis. These structures provide important stability and sites of attachment for the muscles that make up the anterior and posterior abdominal wall.



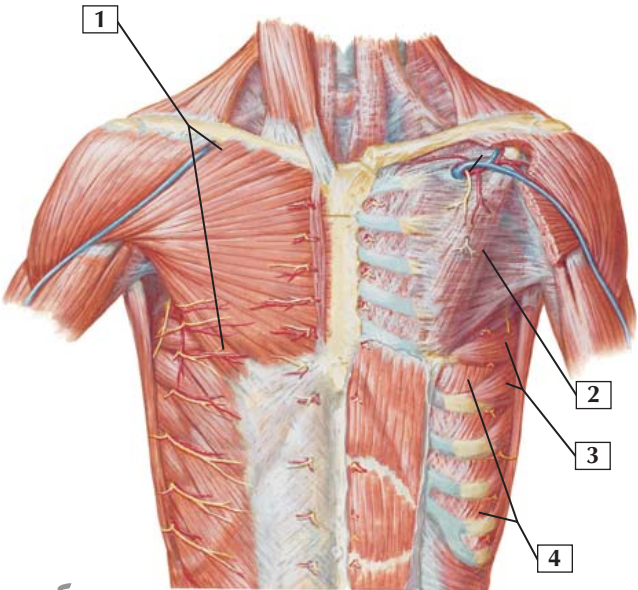
AP view



Lateral

1. 1st Rib
2. Clavicle
3. Aortic knob
4. Hilar nodes
5. Cardiac shadow
6. Diaphragm
7. Costophrenic angle
8. Sternum
9. Gastric bubble

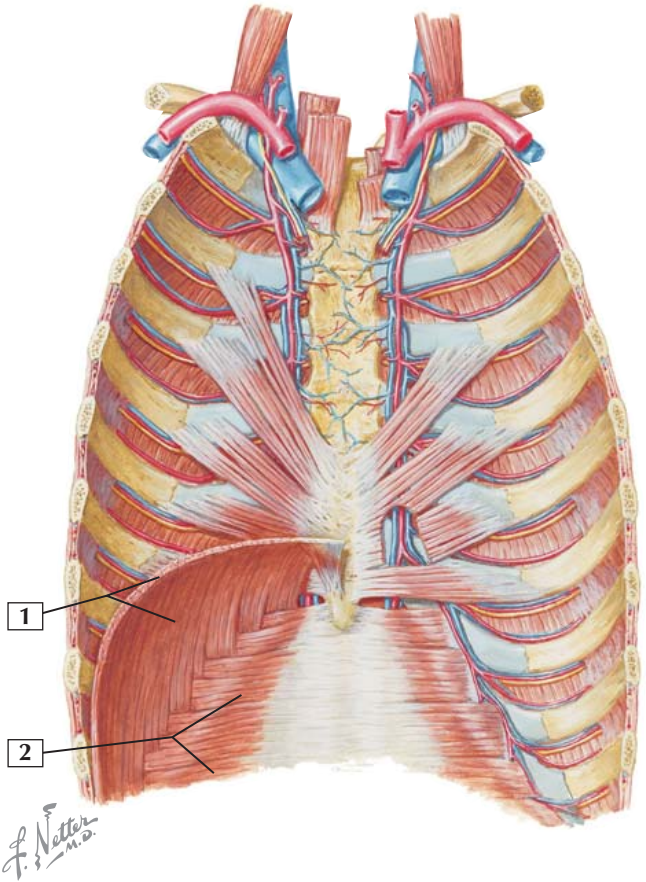
Comment: Anteroposterior (AP) and lateral views of the chest are helpful in evaluating a variety of conditions ranging from disorders of the lungs (pneumothorax, pneumonia), the heart (cardiomegaly, aortic dissection), and the musculoskeletal system (sternal fractures, rib fractures).



F. H. Netter M.D.

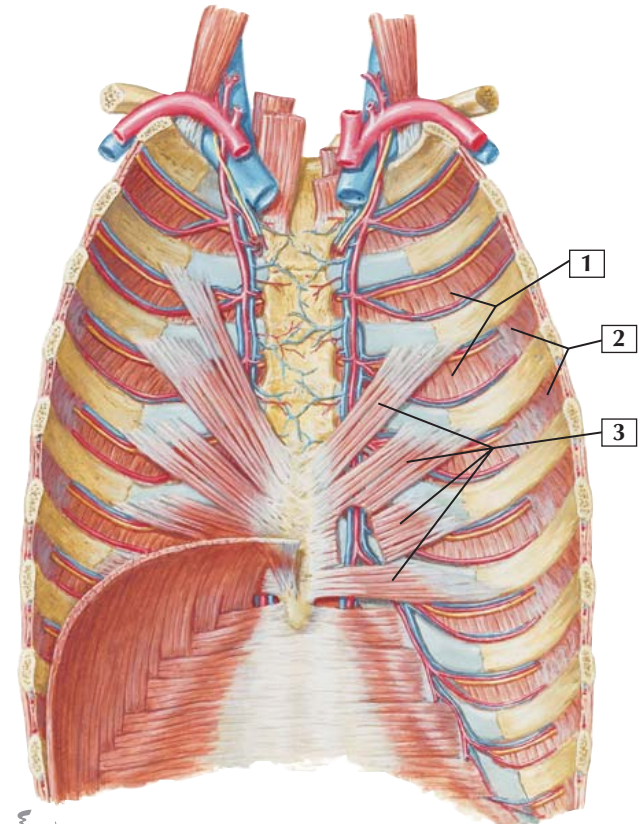
1. Pectoralis major muscle
2. Pectoralis minor muscle
3. Serratus anterior muscle
4. External intercostal muscles

	Pectoralis Major Muscle	Pectoralis Minor Muscle	Serratus Anterior Muscle	External Intercostal Muscles
Origin	Sternum (sternal head) and medial clavicle (clavicular head)	Ribs 3-5	Outer superior aspect of ribs 1-8	Inferior border of the first 11 ribs
Insertion	Intertubercular groove of the humerus	Coracoid process of the scapula	Vertebral border of the scapula	Superior border of the rib below
Actions	Adduction and internal rotation of the humerus	Holds scapula to chest wall	Holds scapula to thoracic wall and laterally rotates the scapula to assist in shoulder abduction	Elevation of the ribs
Innervation	Medial and lateral pectoral nerves (C5-6)	Medial pectoral nerve (C8-T1)	Long thoracic nerve (C5-7)	Intercostal nerves at each level


1
2
F. Netter M.D.

1. Diaphragm
2. Transversus abdominis

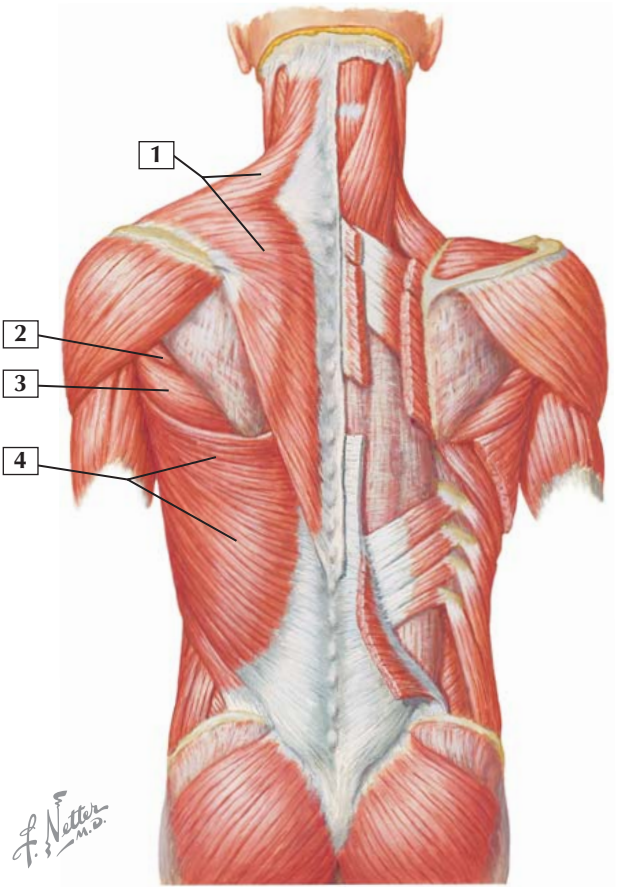
	Diaphragm	Transversus Abdominis
Origin	Xiphoid process (sternal portion), costal cartilages of lower 6 ribs (costal portion), and L1-3 vertebrae (lumbar portion)	Internal surface of ribs 7-12, thoracolumbar fascia, and iliac crest
Insertion	Central tendon	Linea alba and pubic crest
Actions	Assists in respiration by pulling the central tendon down and forward	Compression of abdomen
Innervation	Phrenic nerve (C3-5)	Ventral rami of T7-L1



F. H. Netter M.D.

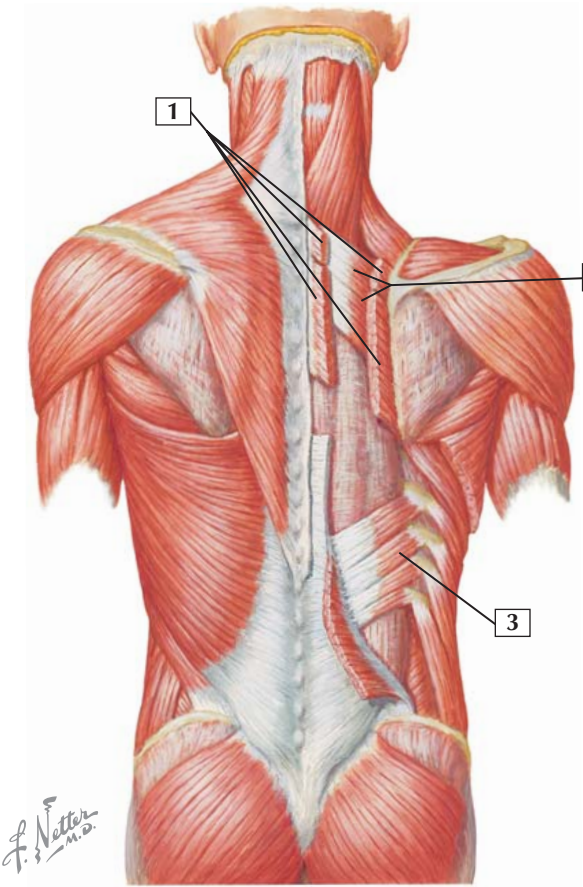
1. Internal intercostal muscles
2. Innermost intercostal muscles
3. Transversus thoracis muscle

	Internal Intercostal Muscle	Innermost Intercostal Muscle	Transversus Thoracis Muscle
Origin	Inferior border of each rib	Inferior border of each rib	Xiphoid process, inferior body of sternum, and adjacent costal cartilage
Insertion	Superior border of rib below	Superior border of rib below	Costal cartilages 2-6
Actions	Elevation of the ribs	Elevation of the ribs	Elevation of the ribs
Innervation	Intercostal nerves at each level	Intercostal nerves at each level	Intercostal nerves


1
2
3
4
F. Netter M.D.

1. Trapezius muscle
2. Teres minor muscle
3. Teres major muscle
4. Latissimus dorsi

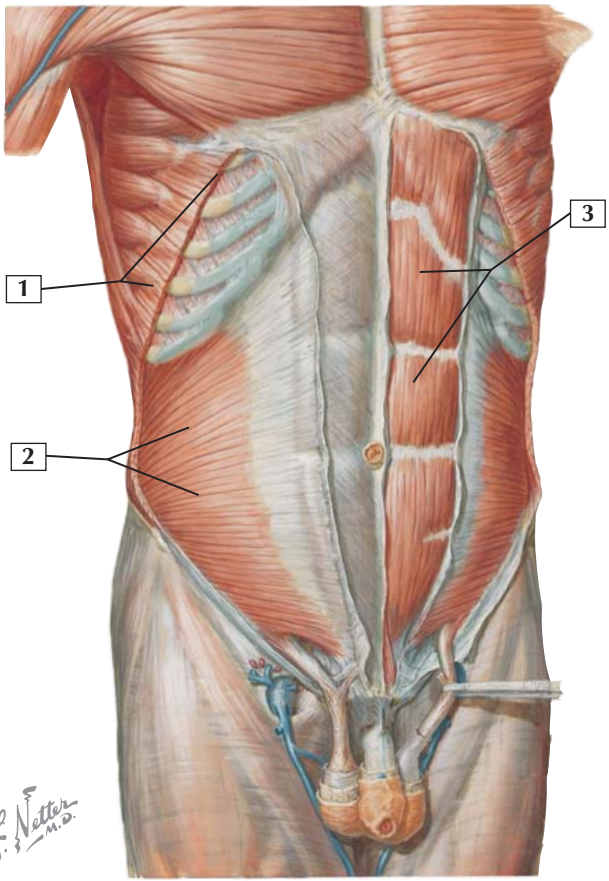
	Trapezius Muscle	Teres Minor Muscle	Teres Major Muscle	Latissimus Dorsi
Origin	Spinous processes of C7-T12	Lateral border of the scapula	Inferior angle of the scapula	Spinous processes of T6-S5
Insertion	Clavicle, scapula (spine and acromion)	Greater tuberosity of humerus	Medial intertubercular groove of humerus	Humerus
Actions	Elevation and rotation of the scapula	Shoulder external rotation and assists with adduction	Helps to extend, adduct, and internally rotate the arm	Shoulder extension, adduction, and internal rotation
Innervation	Cranial nerve XI	Axillary nerve (C5-6)	Lower subscapular nerve (C7-7)	Thoracodorsal nerve


1
2
3
F. Netter M.D.

Muscles: Intermediate Layer of Posterior Thorax

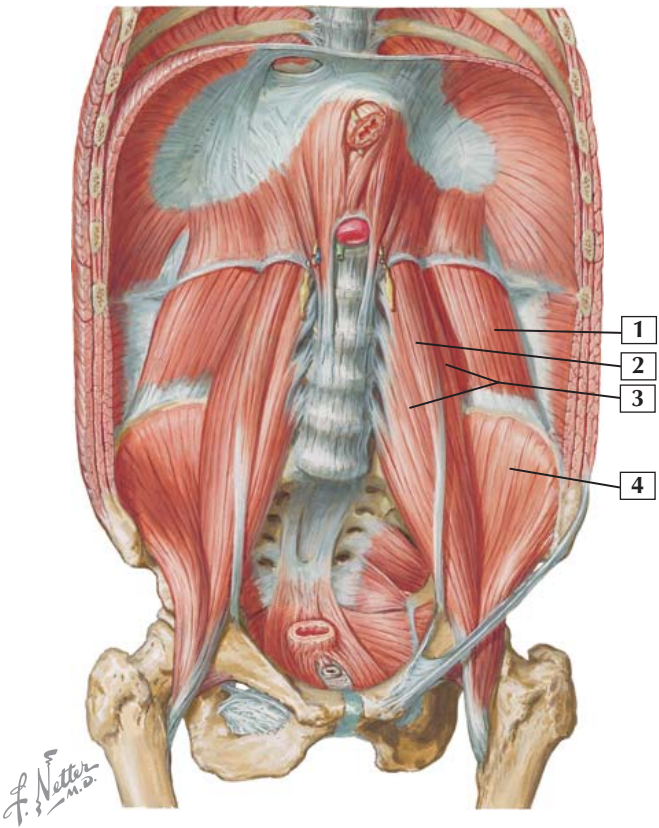
1. Rhomboid major and minor muscles
2. Serratus posterior superior muscle
3. Serratus posterior inferior muscle

	Rhomboid Major and Minor Muscles	Serratus Posterior Superior Muscle	Serratus Posterior Inferior Muscle
Origin	Major: spinous processes T2-5 Minor: ligamentum nuchae and C7-T1 spinous processes	Ligamentum nuchae and C7-T3 spinous processes	Ligamentum nuchae and T11-L2 spinous processes
Insertion	Medial border of the scapula	Ribs 2-5	Ribs 9-12
Actions	Scapular retraction and rotation (adduction)	Rib elevation	Rib depression
Innervation	Dorsal scapular nerve (C4-5)	Intercostal nerve (ventral rami of T1-4)	Intercostal nerve (ventral rami T9-12)


1
2
3
F. Netter M.D.

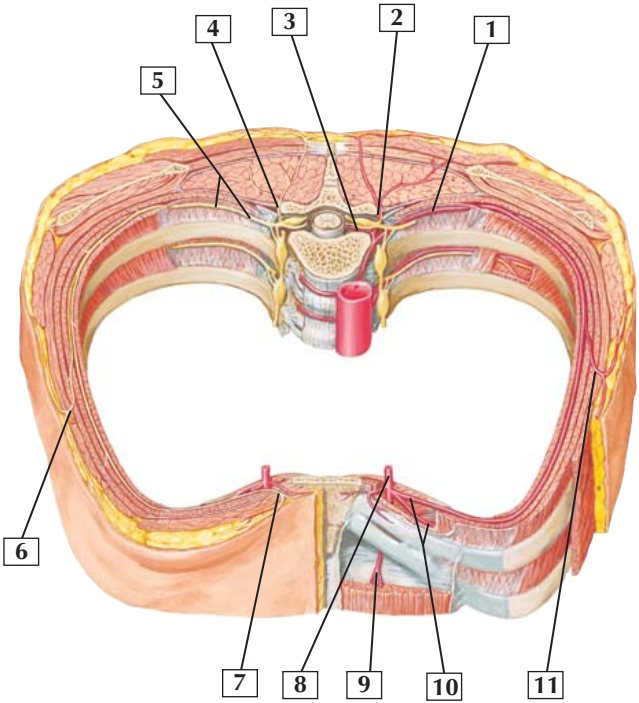
1. External oblique muscle
2. Internal oblique muscle
3. Rectus abdominis muscle

	External Oblique Muscle	Internal Oblique Muscle	Rectus Abdominis Muscle
Origin	Inferior border of ribs 5-12	Lateral part of the inguinal ligament, iliac crest, and thoracolumbar fascia	Pubic crest (lateral tendon), public symphysis (medial tendon)
Insertion	Anterior iliac crest inferiorly and via its broad aponeurosis to the linea alba medially	Inferior aspect of last 4 ribs, linea alba, public crest, and pectineal line	Costal cartilage of ribs 5-7 and xiphoid process
Actions	Compression of the abdomen, forward flexion of the spine, and lateral flexion and rotation of the spine	Compression of the abdomen, forward flexion of the spine, and lateral flexion and rotation of the spine	Compression of abdomen, depression of ribs, flexion of spine
Innervation	Intercostal nerves (T7-11) and subcostal nerve (T12)	Intercostal nerves (T7-11), subcostal nerve (T12), and iliohypogastric and ilioinguinal nerves (L1)	Intercostal nerves (T7-11) and subcostal nerve (T12)


1
2
3
4
F. Netter M.D.

1. Quadratus lumborum muscle
2. Psoas minor muscle
3. Psoas major muscle
4. Iliacus muscle

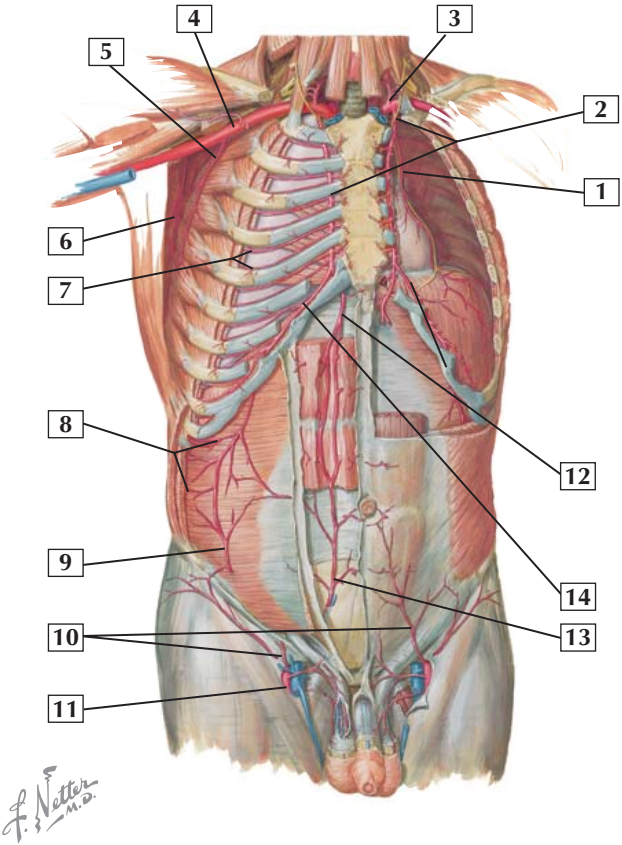
	Quadratus Lumborum Muscle	Psoas Minor Muscle	Psoas Major Muscle	Iliacus Muscle
Origin	Inferomedial aspect of rib 12 and lumbar transverse processes	Vertebral bodies T12-L1	Lumbar transverse processes, bodies of T12-L5	Superior iliac fossa, ala of sacrum, anterior sacroiliac ligaments
Insertion	Iliolumbar ligament and internal lip of the iliac crest	Iliopubic eminence	Lesser trochanter of the femur	Lesser trochanter of the femur
Actions	Extension and lateral flexion of the spine	Weakly assists lumbar flexion (not always present)	Hip flexion, flexion and lateral flexion of the spine	Hip flexion
Innervation	Ventral branches of T12-L4	Ventral ramus of L1	Ventral branches of L2-4	Femoral nerve (L2-4)



F. Netter M.D.

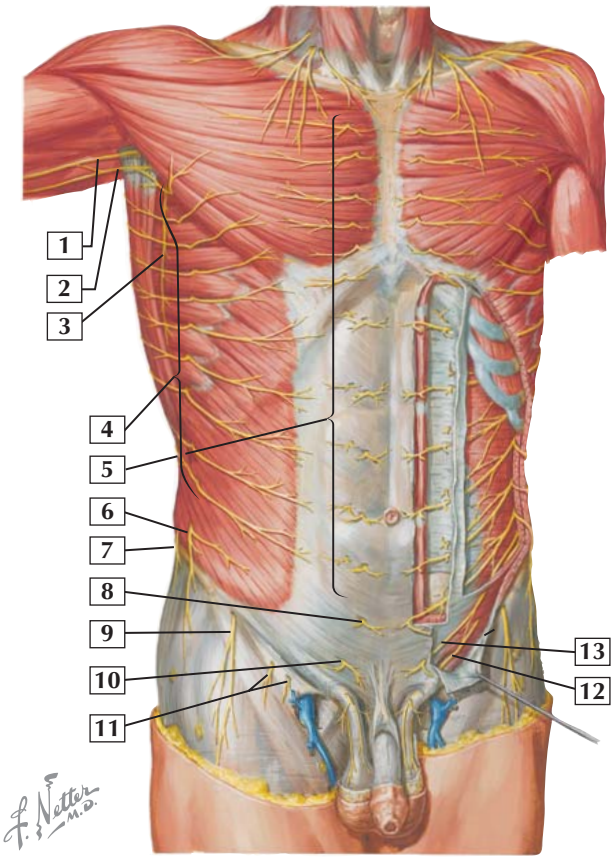
1. Posterior intercostal artery
2. Dorsal branch of the posterior intercostal artery
3. Spinal branch of the posterior intercostal artery
4. Dorsal ramus of thoracic nerve
5. Intercostal nerve (ventral ramus of thoracic nerve)
6. Lateral cutaneous branch of the intercostal nerve
7. Anterior cutaneous branch of the intercostal nerve
8. Internal thoracic artery
9. Superior epigastric artery
10. Anterior intercostal arteries
11. Lateral cutaneous branch of the posterior intercostal artery

Comment: Each intercostal space contains a large posterior intercostal artery and two smaller anterior intercostal arteries. The intercostal nerves are found in the same intercostal space and are also known as the ventral rami of T1-11. The intercostal arteries and nerves serve the intercostal muscles, which power respiration.


4
3
5
2
1
6
7
8
12
9
14
13
10
11
F. Netter M.D.

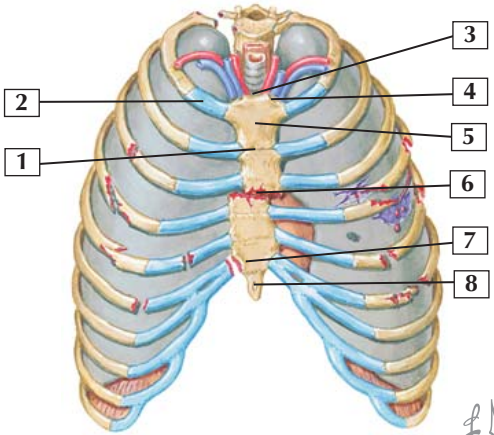
1. Pericardiacophrenic artery
2. Internal thoracic arteries
3. Subclavian artery
4. Axillary artery
5. Lateral thoracic artery
6. Thoracodorsal artery
7. Anterior intercostal arteries
8. Anastomoses with lower intercostal, subcostal, and lumbar arteries
9. Ascending branch of the deep circumflex iliac artery
10. Superficial epigastric artery
11. Femoral artery
12. Superior epigastric artery
13. Inferior epigastric artery
14. Musculophrenic arteries

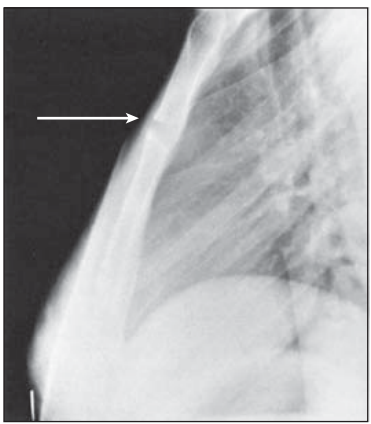
Comment: The main blood supply to the anterior abdominal wall is provided by the superior and inferior epigastric and deep circumflex iliac arteries. The superior epigastric artery is a branch of the internal thoracic artery, whereas the inferior epigastric and deep circumflex iliac arteries are branches of the external iliac artery.


1
2
3
4
5
6
7
8
9
10
11
13
12
F. Netter M.D.

1. Medial brachial cutaneous nerve
2. Intercostobrachial nerve (T1-2)
3. Long thoracic nerve
4. Lateral cutaneous branches of the intercostal nerve (T2-11)
5. Anterior cutaneous branches of the intercostal nerve (T1-11)
6. Lateral cutaneous branch of the subcostal nerve (T12)
7. Lateral cutaneous branch of the iliohypogastric nerve (L1)
8. Anterior cutaneous branch of the subcostal nerve (T12)
9. Lateral femoral cutaneous nerve (L2-3)
10. Anterior cutaneous branch of the iliohypogastric nerve (L1-2)
11. Femoral branches of the genitofemoral nerve (L1-2)
12. Ilioinguinal nerve (L1)
13. Anterior branch of the iliohypogastric nerve (L1)

Comment: The nerve supply to the anterior abdominal wall is provided mainly by the ventral rami of the thoracic and lumbar nerves. In the upper abdomen, this supply is essentially an extension of the lower thoracic-derived intercostal and subcostal nerves. In the lower abdomen, this supply is derived mainly from the ilioinguinal and iliohypogastric nerves.



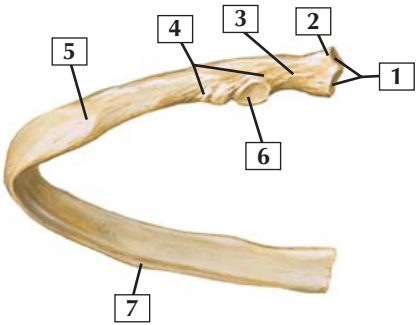


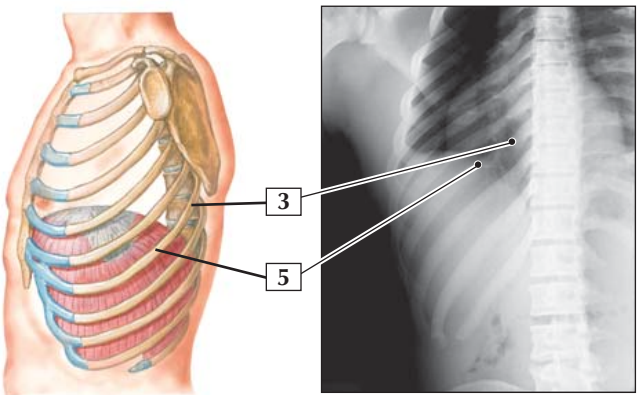
9

1. Sternal angle
2. First costal cartilage
3. Jugular notch
4. Clavicular notch
5. Manubrium
6. Body of sternum (with fracture)
7. Xiphisternal junction
8. Xiphoid process
9. Radiographic appearance of sternal fracture

	Sternal Fracture
Mechanism	Usually direct trauma (motor vehicle accident)
Signs and Symptoms	Pain, tenderness, and crepitus over the sternum
Imaging	Lateral view of sternum; computed tomography (CT)
Treatment	Usually symptomatic pain control but reduction if displaced

Radiograph from DeLee J, Drez D, Miller M: DeLee & Drez's Orthopaedic Sports Medicine. Philadelphia: WB Saunders, 2002.

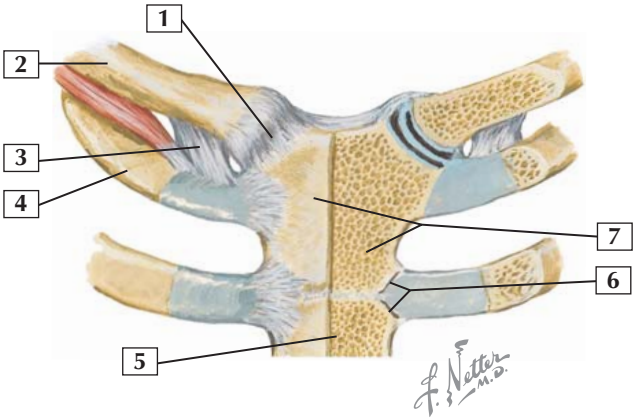


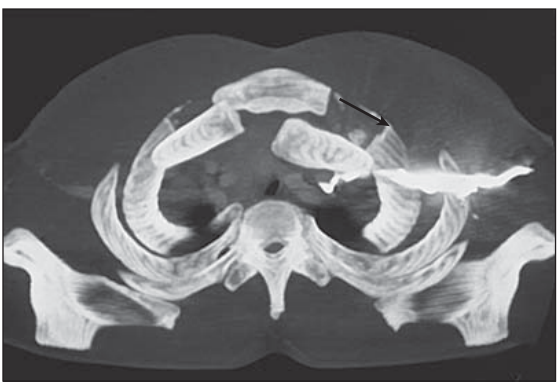


F. Netter M.D.

1. Articular facets (vertebral body)
2. Head
3. Neck
4. Tubercle
5. Angle
6. Articular facet (vertebral transverse process)
7. Costal groove

	Rib Fractures
Mechanism	Direct trauma or crushing injury; also stress reaction in rowers
Signs and Symptoms	Pain worsened by deep inspiration; focal tenderness and crepitus
Imaging	Anteroposterior (AP) and lateral chest radiograph (pneumothorax); rib series; bone scan (stress fracture)
Treatment	Generally symptomatic with pain medication and activity modification; intervention required only in cases of unstable segment from multiple fractures (flail chest) that impedes breathing



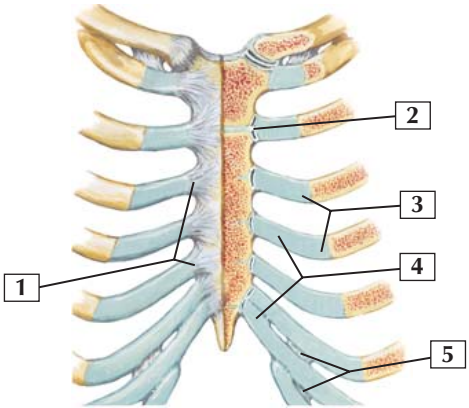


8

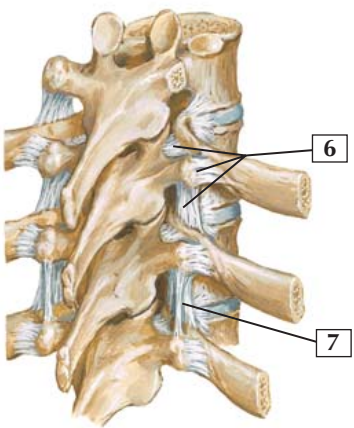
1. Sternoclavicular ligament
2. Clavicle
3. Costoclavicular ligament
4. 1st Rib
5. Body of the sternum
6. Sternocostal joint
7. Manubrium of sternum
8. Computed tomography (CT) of sternoclavicular joint dislocation

	Sternoclavicular Joint Injuries	Sternocostal Joint Injuries (Rib Dislocation)
Mechanism	Traumatic dislocation, spontaneous atraumatic subluxation	Direct trauma, crush injury
Signs and Symptoms	Acute focal pain; palpable step-off	Focal pain and deformity, pain with inspiration; neurovascular integrity should be evaluated
Imaging	Plain radiograph (serendipity view) and/or CT	Anteroposterior (AP) and lateral chest radiographs (usually involves joints 2-10)
Treatment	Subluxations are treated conservatively Dislocations necessitate closed reduction Posterior dislocations may necessitate open reduction and ligament reconstruction	Generally conservative

Computed tomogram from Miller M, Sekiya JK: Core Knowledge in Orthopaedics: Sports Medicine. Philadelphia: Elsevier, 2006.



Sternocostal articulations: anterior view



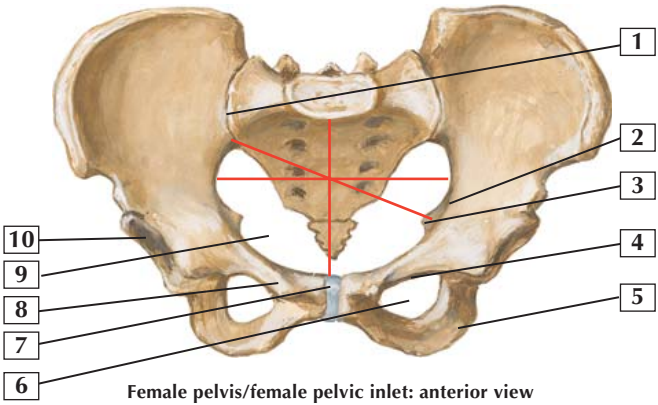
Right posterior

1. Radiate sternocostal ligaments
2. Sternocostal ligament
3. Costochondral joint
4. Costal cartilage
5. Interchondral joint
6. Costotransverse ligament
7. Intertransverse ligament

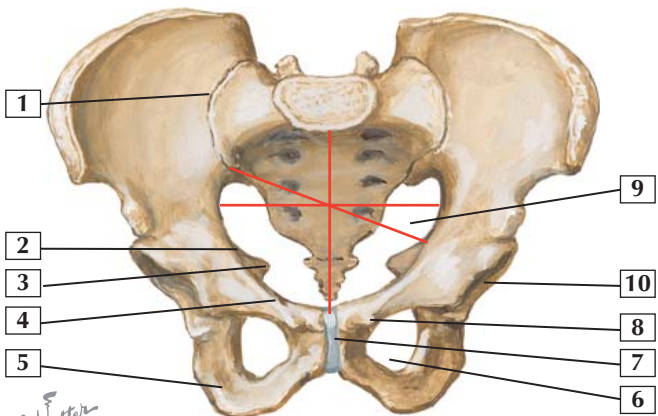
	Costochondral Injury (Rib Separation)	Costochondritis (Tietze Syndrome)	Costovertebral Joint Dislocation
Mechanism	Direct trauma, crush injury	Inflammatory process of the costochondral joint	Rare but from high-velocity trauma
Signs and Symptoms	Focal pain and deformity, pain with inspiration; neurovascular integrity should be evaluated	Focal pain and tenderness that is not exertional	Focal tenderness; other trauma extremely common
Imaging	Anteroposterior (AP) and lateral chest radiographs	Usually none, but bone scan may help pinpoint injury	AP lateral radiograph, computed tomography (CT)
Treatment	Generally conservative	Nonsteroidal antiinflammatory drugs (NSAIDs); corticosteroid injections in refractory cases	Usually conservative with focus on other injuries

5 The Pelvis, Hip, and Thigh
Plates 5-1 to 5-31

The Pelvis, Hip, and Thigh
Plates 5-1 to 5-31



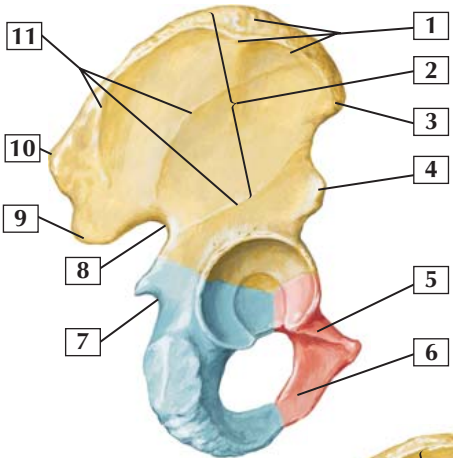
Female pelvis/female pelvic inlet: anterior view



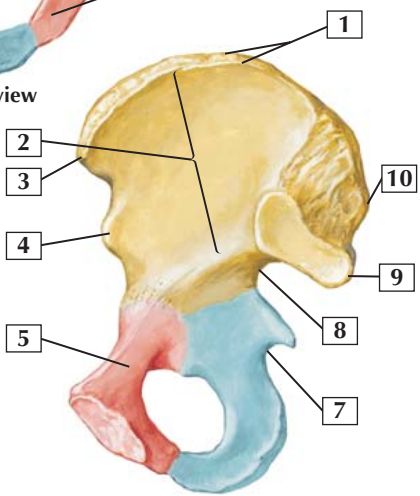
Male pelvis/male pelvic inlet: anterior view

1. Sacroiliac joint
2. Arcuate line
3. Ischial spine
4. Pectineal line
5. Ischial tuberosity
6. Obturator foramen
7. Pubic symphysis
8. Pubic tubercle
9. Pelvic inlet
10. Acetabulum

Comment: The pelvis is made up of two large "wings" that join with the sacrum (sacroiliac joints) proximally and each other (pubic symphysis) inferiorly. There are distinct structural differences between the male pelvis and the female pelvis: The female pelvis has more flared wings with a transversely oval pelvic inlet and a smaller pubic symphysis.



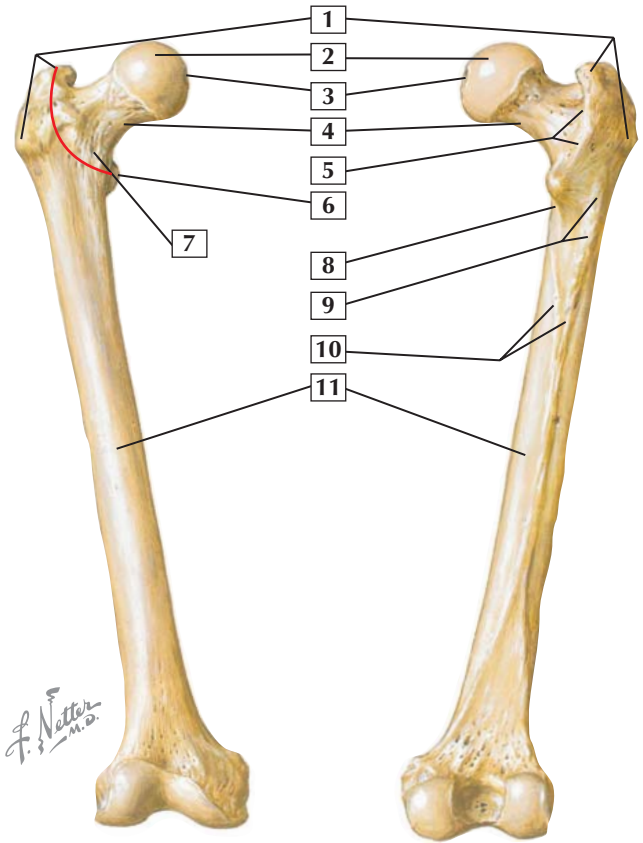
Lateral view



Medial view

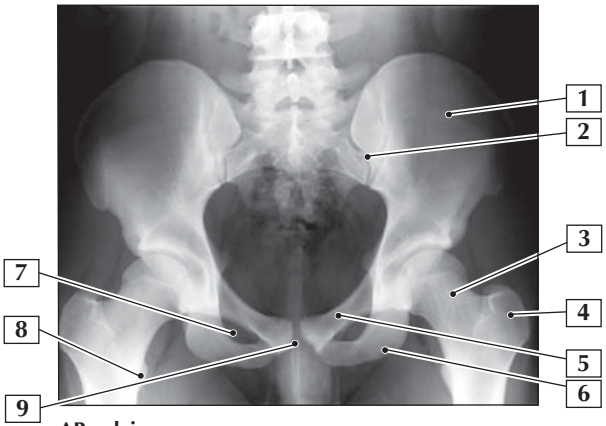
1. Iliac crest
2. Ala (wing) of ilium
3. Anterior superior iliac spine
4. Anterior inferior iliac spine
5. Superior pubic ramus
6. Inferior pubic ramus
7. Lesser sciatic notch
8. Greater sciatic notch
9. Posterior inferior iliac spine
10. Posterior superior iliac spine
11. Gluteal lines

Comment: The coxal (hip) bones are two winglike bones that articulate medially with the sacrum to form the pelvis. The large flat surfaces of these bones provide a site for the attachment of the powerful muscles of the hip. The coxal bones are really made up of three parts: the ilium (shown in yellow), the ischium (shown in blue), and the pubis (shown in red).

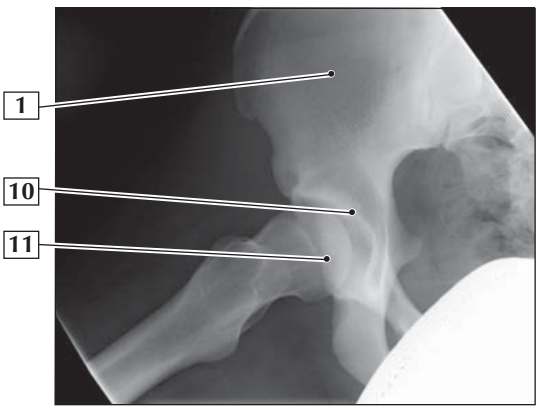

1
2
3
4
5
6
7
8
9
10
11
F. Netter M.D.
Anterior view
Posterior view

1. Greater trochanter
2. Femoral head
3. Fovea
4. Femoral neck
5. Intertrochanteric crest
6. Lesser trochanter
7. Intertrochanteric line
8. Pectineal line
9. Gluteal tuberosity
10. Linea aspera
11. Femoral shaft

Comment: The femur is the largest, strongest bone in the body. Injury is typically associated with high-energy trauma in young patients. However, the femoral neck becomes a weak point in osteoporotic bone, which leads to the high incidence of hip fractures in elderly persons.



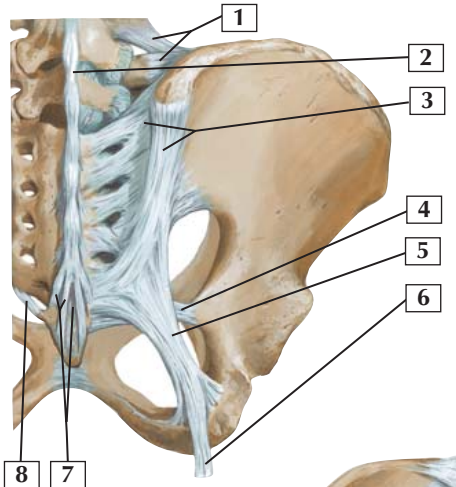
AP pelvis



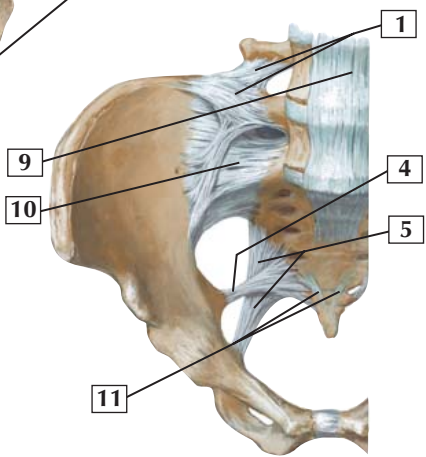
Lateral hip

1. Ilium
2. Sacroiliac joint
3. Femoral neck
4. Greater trochanter
5. Pubis
6. Ischium
7. Obturator foramen
8. Lesser trochanter
9. Pubic symphysis
10. Acetabulum
11. Femoral head

Comment: Anteroposterior (AP) and lateral radiographs of the pelvis and hip are the views most commonly used. The traditional lateral view of the hip is taken in the "frog leg" position. An alternative lateral radiograph should be specified in postoperative cases when extreme hip rotation is not appropriate. Other helpful views include the obturator oblique view (anterior column or posterior wall) and the iliac oblique view (posterior column or anterior wall), which are collectively called *Judet views*.



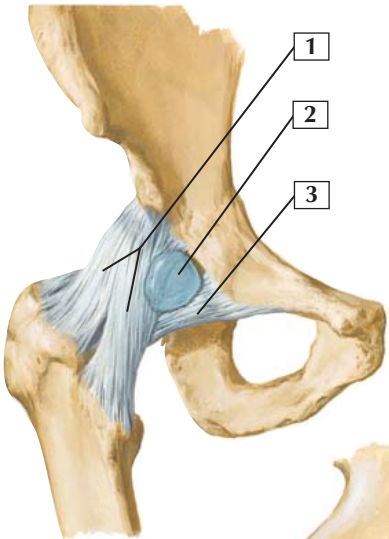
Posterior view



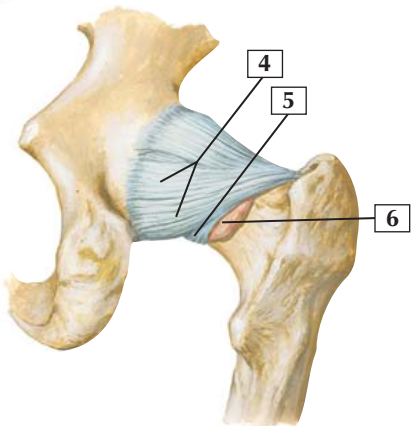
Anterior view

1. Iliolumbar ligament
2. Supraspinous ligament
3. Posterior sacroiliac ligaments
4. Sacrospinous ligament
5. Sacrotuberous ligament
6. Tendon of the long head of the biceps femoris muscle
7. Posterior sacrococcygeal ligaments
8. Lateral sacrococcygeal ligament
9. Anterior longitudinal ligament
10. Anterior sacroiliac ligament
11. Anterior sacrococcygeal ligaments

Comment: The sacroiliac joint is stabilized by anterior and posterior sacroiliac ligaments that prevent rotation and vertical shear. Of these, the posterior ligaments are the strongest and therefore the most important in determining stability of pelvic fractures. The two pubic bones join at the pubic symphysis, which is connected by stabilizing ligaments and a fibrocartilage disc.



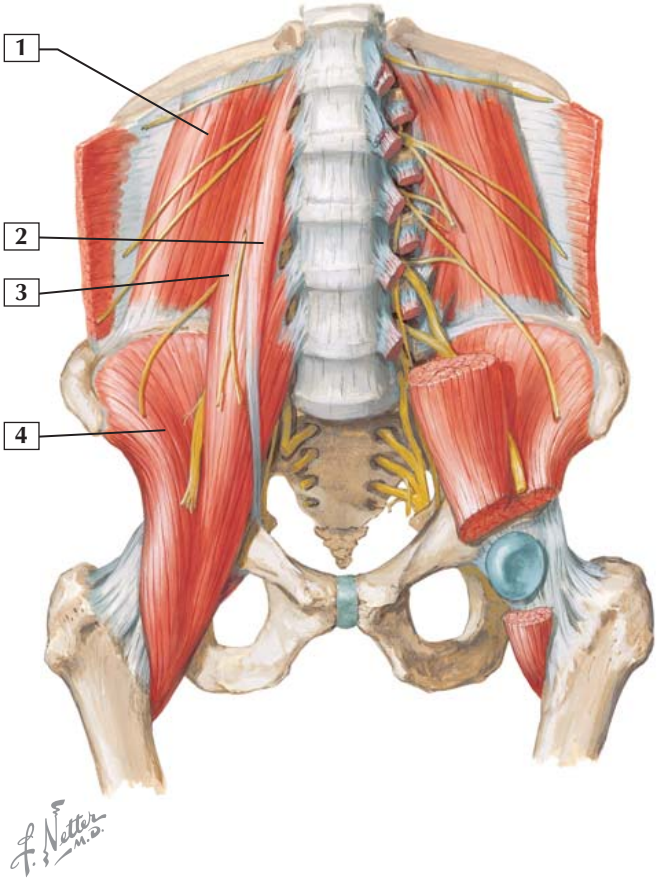
Anterior view



Posterior view

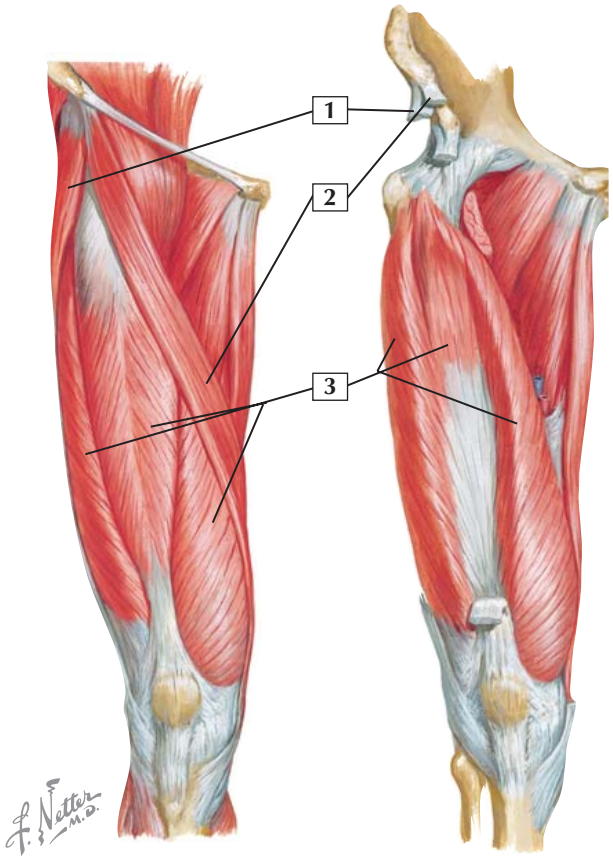
1. Iliofemoral ligament
2. Iliopectineal bursa
3. Pubofemoral ligament
4. Ischiofemoral ligament
5. Zona orbicularis
6. Synovial membrane

Comment: The hip joint is a ball-and-socket joint that is surrounded by a strong joint capsule. The ligaments here are really thickenings of the capsule, as are the ligaments in the shoulder. The pubofemoral and iliofemoral ligaments constitute the anterior and inferior parts of this capsule, whereas the ischiofemoral and zona orbicularis make up the posterior part. Of these, the iliofemoral (also known as the *Y ligament of Bigelow*) is the strongest. The ligamentum teres is a deep ligament that runs from the fovea of the head of the femur, and the artery is contained within this ligament.


1
2
3
4
F. H. Netter M.D.

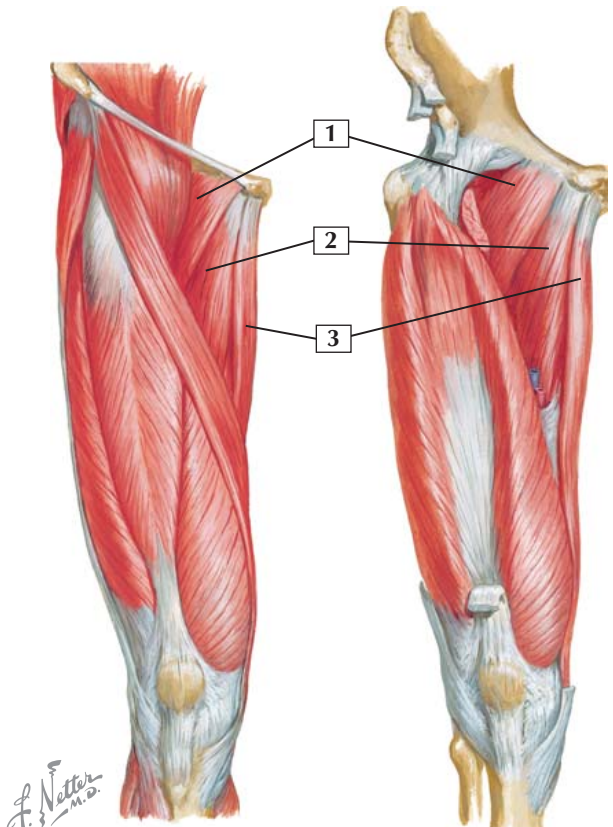
1. Quadratus lumborum muscle
2. Psoas minor muscle
3. Psoas major muscle
4. Iliacus muscle

	Quadratus Lumborum Muscle	Psoas Minor Muscle	Psoas Major Muscle	Iliacus Muscle
Origin	Inferomedial aspect of rib 12 and lumbar transverse processes	Vertebral bodies T12-L1	Lumbar transverse processes, bodies of T12-L5	Superior iliac fossa, ala of sacrum, anterior sacroiliac ligaments
Insertion	Iliolumbar ligament and internal lip of the iliac crest	Iliopubic eminence	Lesser trochanter of the femur	Lesser trochanter of the femur
Actions	Extension and lateral flexion of the spine	Weakly assists lumbar flexion (not always present)	Hip flexion, flexion and lateral flexion of the spine	Hip flexion
Innervation	Ventral branches of T12-L4	Ventral ramus of L1	Ventral branches of L2-L4	Femoral nerve (L2-L4)


1
2
3
F. H. Netter M.D.

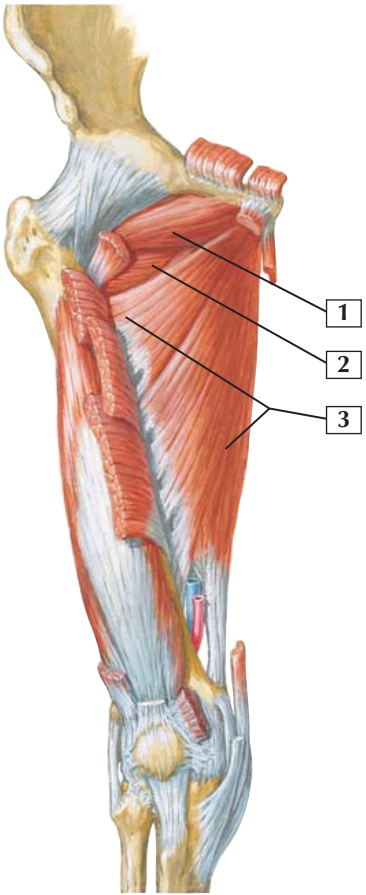
1. Tensor fascia latae muscle
2. Sartorius muscle
3. Quadriceps femoris muscles

	Tensor Fascia Latae Muscle	Sartorius Muscle
Origin	Anterior superior iliac spine	Anterior superior iliac spine
Insertion	Iliotibial band	Proximal medial tibia
Actions	Flexion, abduction, internal rotation of the hip	Flexion and external rotation of the hip
Innervation	Superior gluteal nerve	Femoral nerve


1
2
3
F. H. Netter M.D.

1. Pectineus muscle
2. Adductor longus muscle
3. Gracilis muscle

	Pectineus Muscle	Adductor Longus and Brevis Muscles	Gracilis Muscle
Origin	Pubis (pectineal line)	Inferior pubis	Pubic ramus
Insertion	Femur (pectineal line)	Linea aspera (longus) Pectineal line (brevis)	Proximal medial tibia
Actions	Flexion and adduction of the hip	Adduction of the hip	Flexion and adduction of the hip
Innervation	Femoral nerve	Obturator nerve	Obturator nerve



F. Netter M.D.

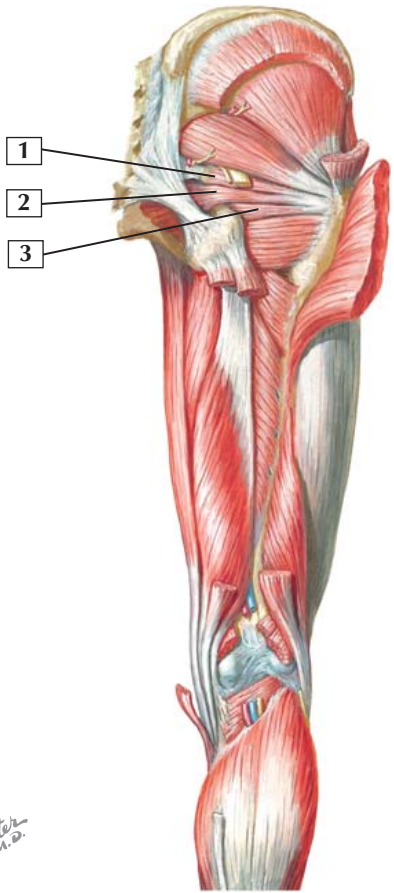
1. Obturator externus muscle
2. Quadratus femoris muscle
3. Adductor magnus muscle

	Obturator Externus Muscle	Quadratus Femoris Muscle	Adductor Magnus Muscle
Origin	Ischiopubic rami	Ischial tuberosity	Ischiopubic ramus and ischial tuberosity
Insertion	Trochanteric fossa	Intertrochanteric crest	Linea aspera and adductor tubercle
Actions	External rotation of the hip	External rotation of the hip	Adduction and flexion of the hip
Innervation	Obturator nerve	Nerve to quadratus femoris muscle	Obturator and sciatic nerves


1
2
3
F. Netter M.D.

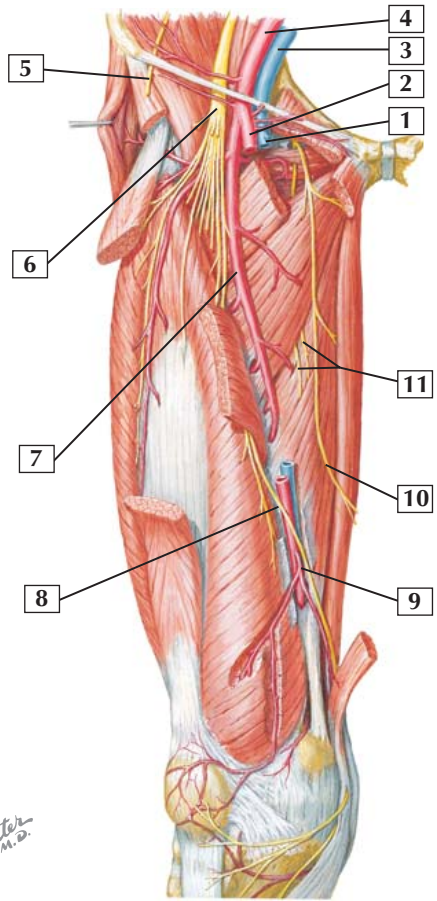
1. Gluteus medius and minimus muscles
2. Gluteus maximus muscles
3. Piriformis muscle

	Gluteus Medius and Minimus Muscles	Gluteus Maximus Muscles	Piriformis Muscle
Origin	Ilium (between gluteal lines)	Ilium and dorsal sacrum	Anterior aspect of the sacrum
Insertion	Greater trochanter	Gluteal tuberosity of femur and iliotibial band	Greater trochanter
Actions	Abduction and internal rotation of the hip	Extension and external rotation of the hip	External rotation of the hip
Innervation	Superior gluteal nerve	Inferior gluteal nerve	Piriformis nerve


1
2
3

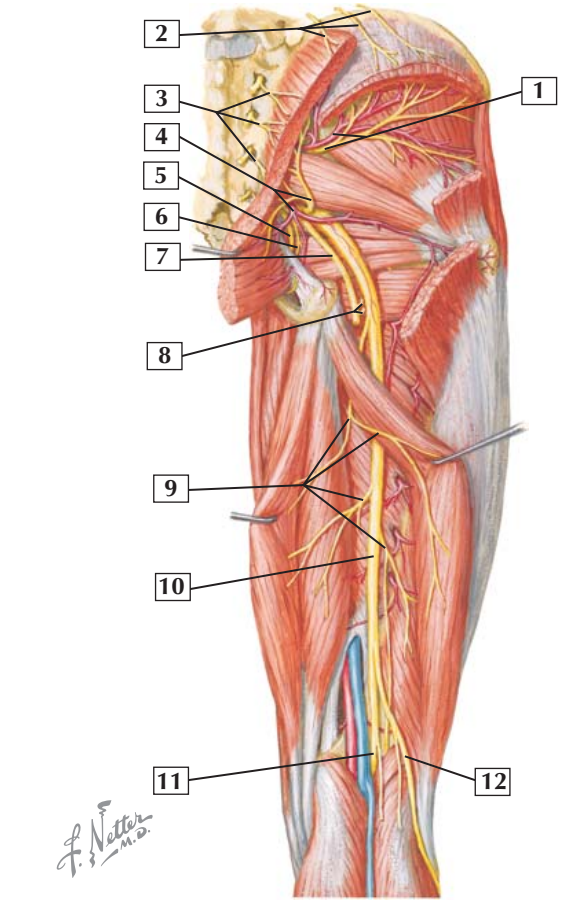
1. Superior gemellus muscle
2. Obturator internus muscle
3. Inferior gemellus muscle

	Superior and Inferior Gemellus Muscles	Obturator Internus Muscle
Origin	Ischial spine (superior) Ischial tuberosity (inferior)	Ischiopubic rami and obturator membrane
Insertion	Greater trochanter	Greater trochanter
Actions	External rotation of the hip	External rotation of the hip
Innervation	Nerve to obturator internus (superior) Nerve to quadratus femoris (inferior)	Nerve to obturator internus


4
3
5
2
1
6
11
7
10
8
9

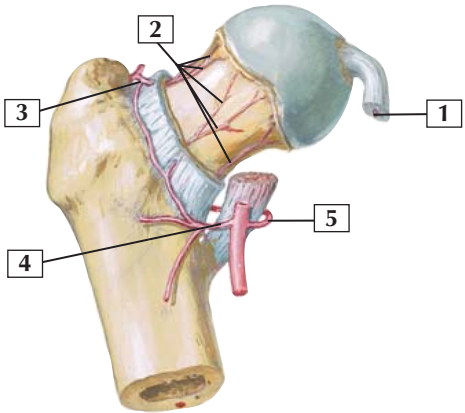
1. Femoral vein
2. Femoral artery
3. External iliac vein
4. External iliac artery
5. Lateral femoral cutaneous nerve
6. Femoral nerve
7. Profunda femoris artery
8. Saphenous nerve
9. Descending genicular artery
10. Cutaneous branch of the obturator nerve
11. Obturator nerve (anterior and posterior branches)

Comment: The femoral triangle contains the femoral vein (most medial), artery, and nerve (most lateral). A useful mnemonic for this relation is "Lateral → Medial = NAVEL," where "NAVEL" is *n*erve, *a*rtery, *v*ein, *e*mpty space, *l*ymphatics. The femoral artery passes between the adductor longus and the vastus medialis muscles before traveling to the knee, where it becomes the popliteal artery. The femoral nerve supplies innervation to the majority of the muscles of the anterior thigh, including the quadriceps, as it passes through the thigh.

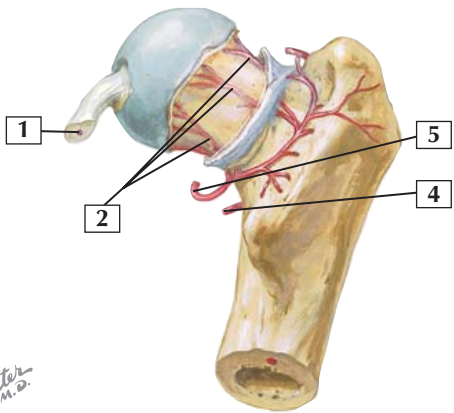

2
1
3
4
5
6
7
8
9
10
11
12
F. Netter M.D.

1. Superior gluteal nerve and artery
2. Superior clunial nerves
3. Medial clunial nerves
4. Inferior gluteal artery and nerve
5. Pudendal nerve
6. Nerve to obturator internus
7. Posterior femoral cutaneous nerve
8. Inferior clunial nerves
9. Muscular branches of the sciatic nerve
10. Sciatic nerve
11. Tibial nerve
12. Common peroneal nerve

Comment: The sciatic nerve (L4-S3) exits the greater sciatic foramen and travels distally, dividing into the common peroneal and tibial nerves. It supplies innervation to the hamstring muscles and part of the adductor magnus.



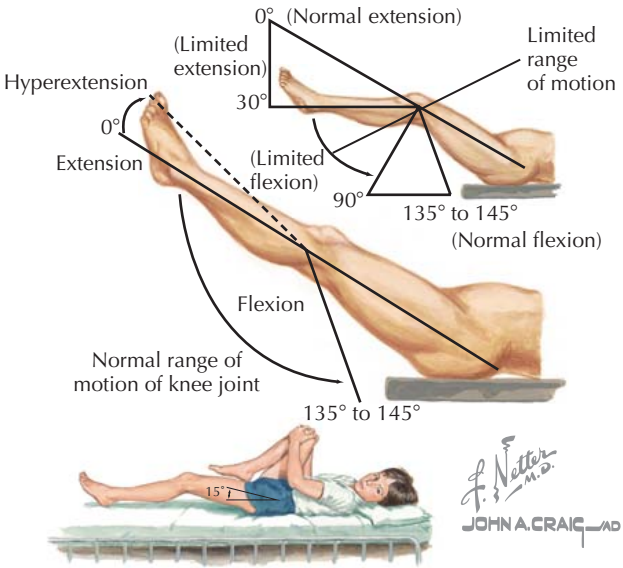
Anterior view



Posterior view

1. Acetabular branch of the obturator artery
2. Retinacular arteries (superior, anterior, and inferior)
3. Anastomosis
4. Lateral circumflex femoral artery
5. Medial femoral circumflex artery

Comment: The foveal artery runs inside the ligamentum teres but is only minimally involved in the vascular supply of the femoral head. The primary source of vascularity here is from the terminal branch of the medial femoral circumflex artery. The location of this main artery puts it at risk with femoral neck fractures.



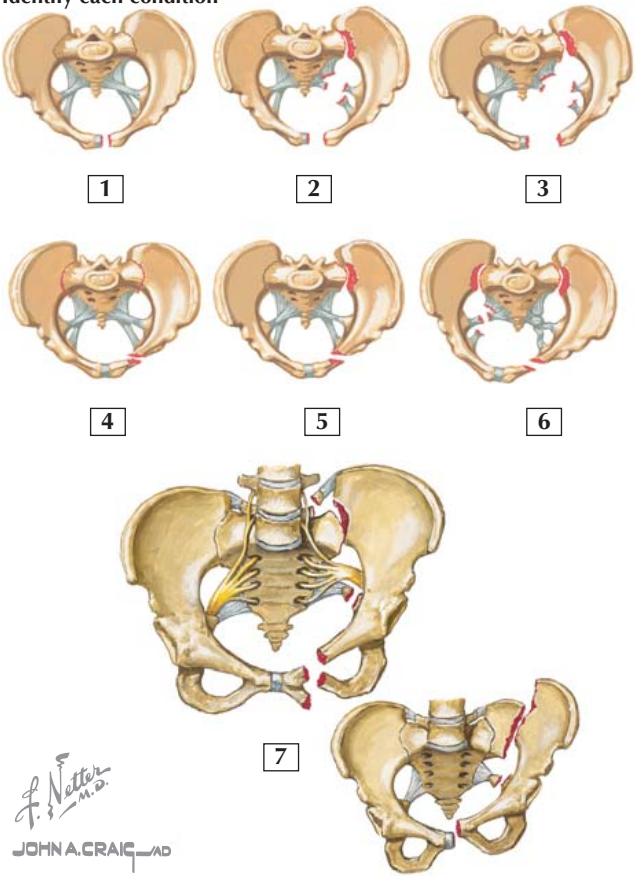
Thomas sign. Hip flexion contracture determined with patient supine. Unaffected hip flexed only until lumbar spine is flat against examining table. Affected hip cannot be fully extended, and angle of flexion is recorded. 15° flexion contracture of hip is typical of Legg-Calvé-Perthes disease

Roll test for muscle spasm. Patient relaxed and supine on table. Examiner places hands on limb, gently rolls hip into internal and external rotation, noting resistance

Movement	Normal Range of Motion
Flexion	120-125 Degrees
Extension	30 Degrees
Abduction	45 Degrees
Adduction	25 Degrees
External rotation	45-60 Degrees
Internal rotation	35-45 Degrees

Test/Sign	Reason for Examination
Flexion, abduction, and external rotation (FABER) test	Intra-articular lesion (labral tear, loose body, degenerative joint disease)
Thomas sign	Flexion contracture of the hip
Trendelenburg test	Gluteus medius weakness
Ober test	Iliotibial band tightness
Ortolani sign Barlow test Galeazzi sign	Congenital dislocation of the hip (pediatrics)

Identify each condition

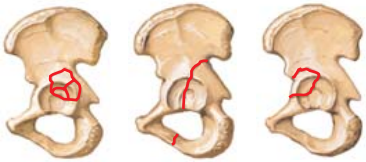


1. Anteroposterior compression type I (APC-I)
2. Anteroposterior compression type II (APC-II)
3. Anteroposterior compression type III (APC-III)
4. Lateral compression type I (LC-I)
5. Lateral compression type II (LC-II)
6. Lateral compression type III (LC-III)
7. Vertical shear (Malgaigne fracture)

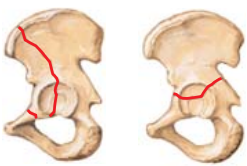
Young and Burgess Classification

Fracture Type	Fracture Pattern	Stability	Treatment
APC-I	Symphysis diastasis <2 cm	Stable	Conservative
APC-II	Symphysis and anterior sacroiliac joint disruption	Stable	Conservative
APC-III	Symphysis and complete sacroiliac joint disruption	Unstable	External fixation Open reduction, internal fixation (ORIF)
LC-I	Rami + ipsilateral sacral compression	Stable	Conservative
LC-II	Rami + ipsilateral posterior ilium	Stable	Conservative
LC-III	Ipsilateral lateral compression + contralateral anteroposterior compression	Unstable	External fixation ORIF
Vertical Shear	Anterior and posterior involvement	Vertically unstable	External fixation ORIF

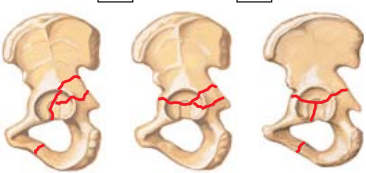
Identify each condition



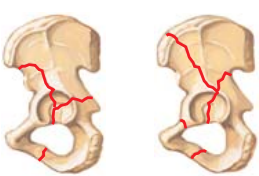
1 2 3



4 5



6 7 8



9 10

F. Netter M.D.

JOHN A. CRAIG, MD

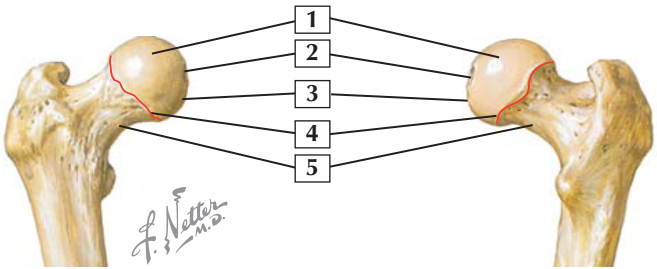
Letournel Classification of Simple Acetabular Fractures

1. Posterior wall
2. Posterior column
3. Anterior wall
4. Anterior column
5. Transverse

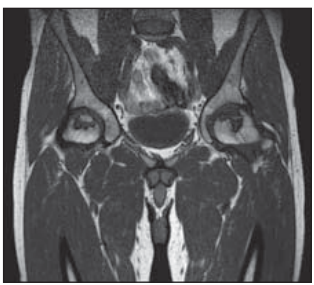
Letournel Classification of Combined Acetabular Fractures

6. Posterior column/posterior wall
7. Transverse/posterior wall
8. T-fracture
9. Anterior column/posterior hemi-transverse
10. Both columns

	Acetabular Fractures
Mechanism	High-energy trauma forcing femoral head into acetabulum
Signs and Symptoms	Pain, often with hip dislocation and/or gastrointestinal/genitourinary symptoms
Imaging	Anteroposterior (AP)/lateral pelvis radiographs; computed tomography (CT)
Treatment	Traction on ipsilateral side; open reduction, internal fixation (ORIF) for unstable or displaced fractures



6



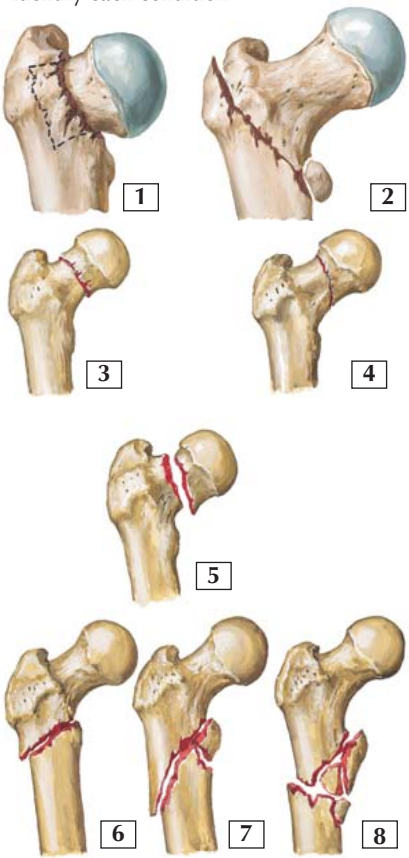
7

1. Femoral head
2. Fovea
3. Articular cartilage
4. Line of synovial membrane attachment
5. Femoral neck
6. Subcapital femoral head fracture
7. Magnetic resonance imaging (MRI) appearance of bilateral hip avascular necrosis

	Femoral Head Fractures	Avascular Necrosis
Mechanism	Flexion, abduction/adduction, internal/external rotation (with hip dislocation)	Microvascular injury often a result of trauma, chronic steroid use, or alcohol use.
Classification	Pipkin type I: below the fovea Pipkin type II: above the fovea Pipkin type III: type I or II plus femoral neck Pipkin type IV: type I or II plus acetabulum	Based on the degree of bony involvement and severity of the patient's symptoms
Signs and Symptoms	Pain, often external rotation of the foot	Groin pain, positive result of flexion, abduction, and external rotation (FABER) test
Imaging	Anteroposterior (AP) and lateral radiographs, postreduction computed tomography (CT)	AP and lateral radiographs of the hip often show joint destruction; MRI can confirm the diagnosis
Treatment	Pipkin types I and II fractures: conservative, protect weight-bearing Pipkin types III and IV fractures: open reduction, internal fixation (ORIF) or arthroplasty (older patients)	Core drilling of avascularized area, hip replacement

Image from Eustace S, Johnston C, O'Byrne J, et al: Sports Injuries. Philadelphia: Elsevier, 2007.

Identify each condition

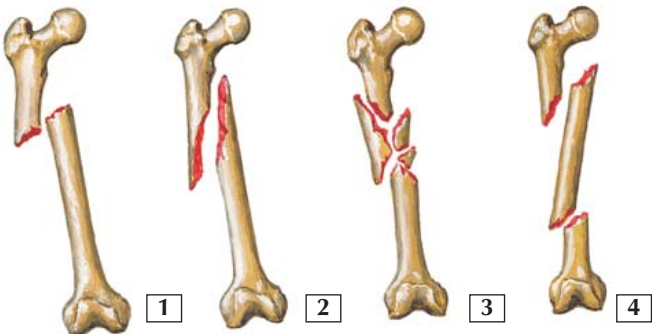


F. Netter M.D.

1. Intertrochanteric fracture: stable
2. Intertrochanteric fracture: unstable
3. Femoral neck fracture: type I
4. Femoral neck fracture: type II
5. Femoral neck fracture: type III
6. Subtrochanteric fractures: type I
7. Subtrochanteric fractures: type II
8. Subtrochanteric fractures: type III

Fracture Type	Classification	Treatment
Intertrochanteric	Stable (2-part) Unstable (3- or 4-part)	Fixation with sliding hip screw Hemiarthroplasty or total arthroplasty for primary failures
Femoral Neck (Garden Classification)	Type I: impacted Type II: nondisplaced Type III: displaced <50% Type IV: significantly displaced	Fixation with hip screws Hemiarthroplasty (older patients, weak bone)
Subtrochanteric (Russell-Taylor Classification)	Type I: nondisplaced Type II: displaced, 2 parts Type III: displaced, 3 parts Type IV: comminuted, 4 parts Type V: subtrochanteric and intertrochanteric fracture	Intramedullary (IM) nail *or* Fixed-angle device with long sideplate

Identify each condition



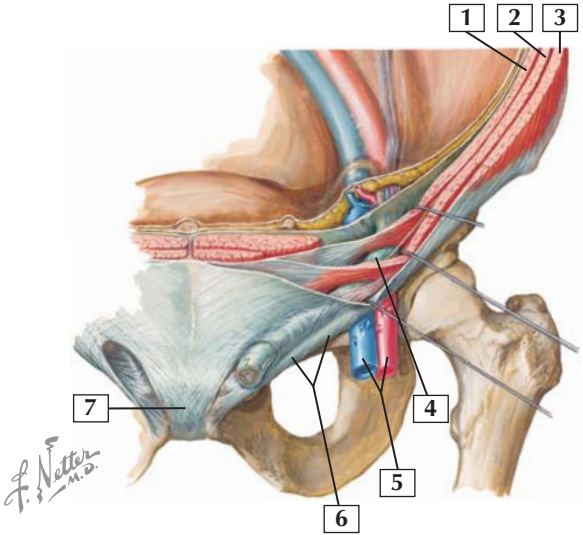
1 2 3 4

F. Netter M.D.

5

1. Transverse femoral shaft fracture
2. Spiral fracture
3. Comminuted fracture
4. Segmental fracture
5. Radiographic appearance of comminuted femur fracture

	Femoral Shaft Fractures	Femoral Shaft Stress Fractures
Mechanism	High-energy trauma	Overuse; most common in runners
Signs and Symptoms	Pain, deformity, shock	Pain with activity that improves with rest; positive fulcrum test result
Imaging	Anteroposterior (AP) and lateral radiographs of the femur, include hip and knee	AP and lateral radiographs (often negative), magnetic resonance imaging (MRI), bone scan
Treatment	Surgical treatment with intramedullary (IM) nail	Rest until symptoms resolve; fixation with femoral nail if injury progresses to pending or complete fracture



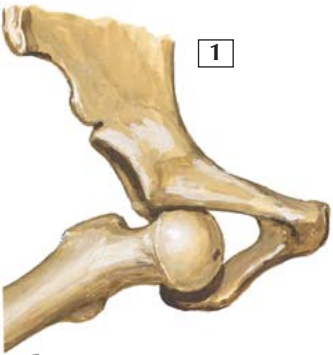
8

1. Transversus abdominis muscle
2. Internal oblique muscle
3. External oblique muscle
4. Spermatic cord
5. Femoral artery and vein
6. Inguinal ligament
7. Pubic symphysis
8. Irregularity of pubic symphysis consistent with osteitis pubis

	Osteitis Pubis	Sports Hernia
Mechanism	Inflammation of the pubic symphysis from repetitive motion such as with kicking sports	Weakness of abdominal wall and/or the posterior inguinal wall
Signs and Symptoms	Gradual onset of pain that is worse with activity and relieved by rest; +/– click	Groin pain with activity; no palpable mass/bulge on examination
Imaging	Anteroposterior (AP) radiographs of the pelvis, bone scan, magnetic resonance imaging (MRI) to rule out other disorders	Not usually indicated
Treatment	Rest, activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), local steroid injections Surgical resection/stabilization procedures (rare)	Activity modification, surgical repair

Imaging from Eustace S, Johnston C, O'Byrne J, et al. (2007). Sports Injuries. Philadelphia: Saunders.

Identify each condition



1

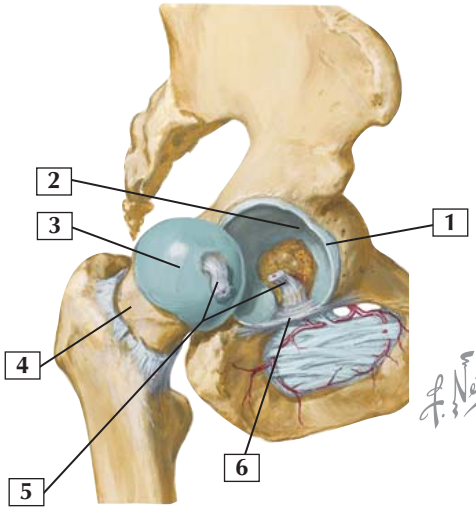
2

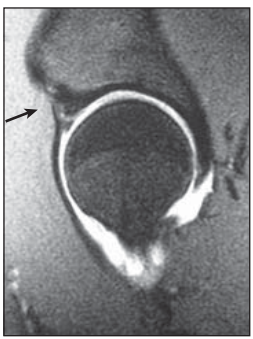
F. Netter M.D.

3

1. Anterior hip dislocation
2. Posterior hip dislocation
3. Radiographic appearance of posterior hip dislocation

	Hip Dislocations
Mechanism	Flexion, adduction, internal rotation (posterior, most common) Flexion, abduction, external rotation (anterior)
Signs and Symptoms	Pain, deformity, internally rotated foot
Imaging	Anteroposterior (AP) and lateral radiographs, postreduction computed tomography (CT) to evaluate for occult fractures
Treatment	Immediate reduction, protect weight-bearing for 4-6 weeks; recurrence rare





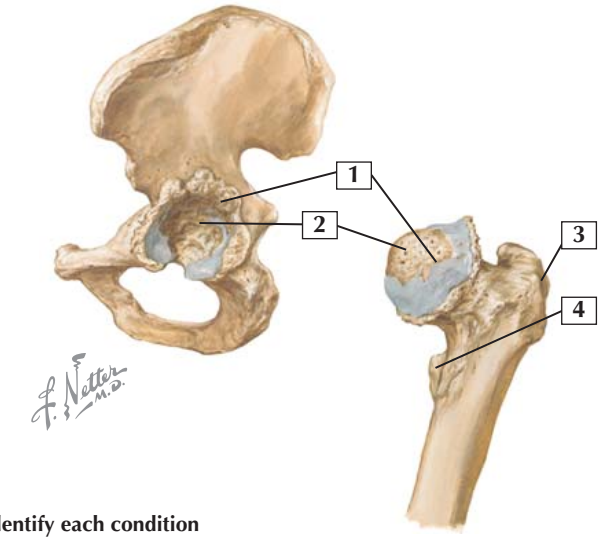
7

8

1. Acetabular labrum
2. Articular surface of acetabulum
3. Articular cartilage of femoral head
4. Neck of femur
5. Ligament of head of femur
6. Transverse acetabular ligament
7. MRI appearance of anterior labral tear of the hip
8. Arthroscopic image of labral tear of the hip

	Labral Tears and Chondral Injuries of the Hip
Mechanism	Traumatic or degenerative
Signs and Symptoms	Groin pain, catching and locking, positive result of flexion, abduction, and external rotation (FABER) test
Imaging	Arthrographic magnetic resonance imaging (MRI)
Treatment	Nonsteroidal antiinflammatory drugs (NSAIDs), injections, hip arthroscopy with débridement, repair, or microfracture as indicated

Image from Miller M, Cole B: Textbook of Arthroscopy. Philadelphia: Elsevier, 2004.



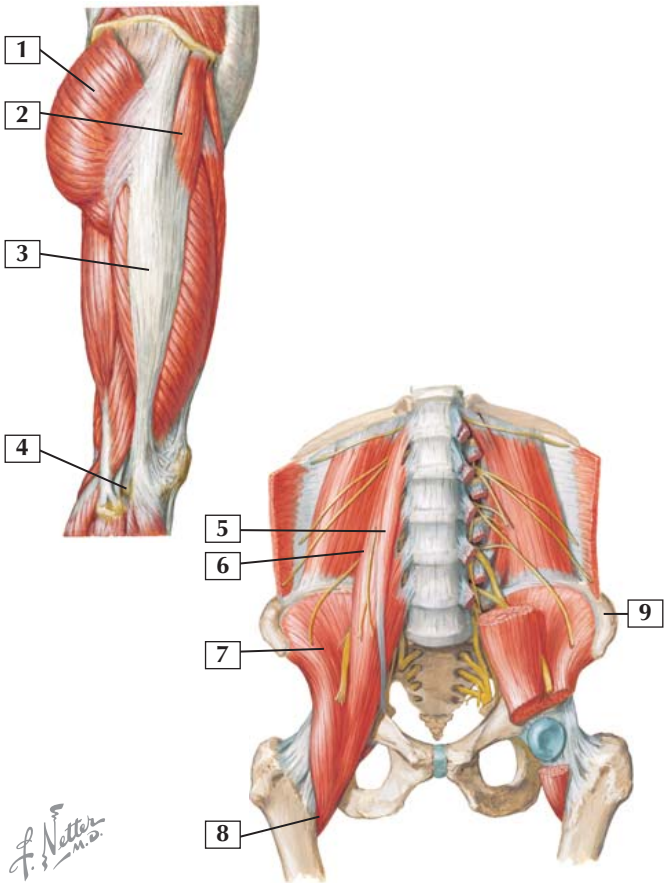
Identify each condition

5

6

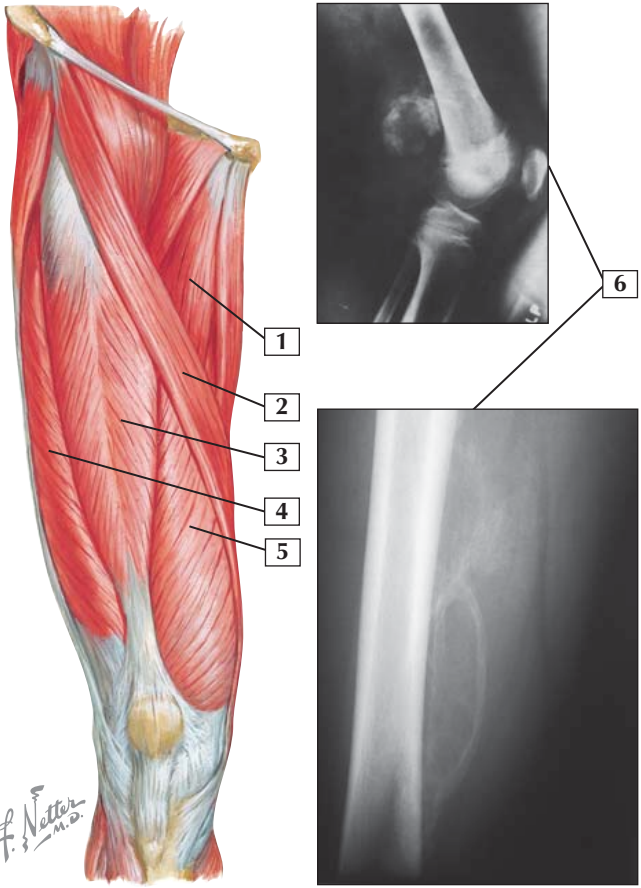
1. Osteophytes
2. Articular cartilage wear
3. Greater trochanter
4. Lesser trochanter
5. Hip arthritis appearance on anteroposterior (AP) pelvis radiograph
6. Hip arthritis appearance on lateral radiograph

	Hip Arthritis	Trochanteric Bursitis
Mechanism	Degenerative, posttraumatic	Local trauma or repetitive friction
Signs and Symptoms	Groin pain, hip stiffness, positive result of flexion, abduction, and external rotation (FABER) test	Local pain and tenderness over the greater trochanter
Imaging	AP and lateral radiographs of the hip	Not usually necessary
Treatment	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), steroid injections, hip arthroplasty	NSAIDs, steroid injections, surgical bursectomy rare


1
2
3
4
5
6
7
8
9
F. Netter M.D.

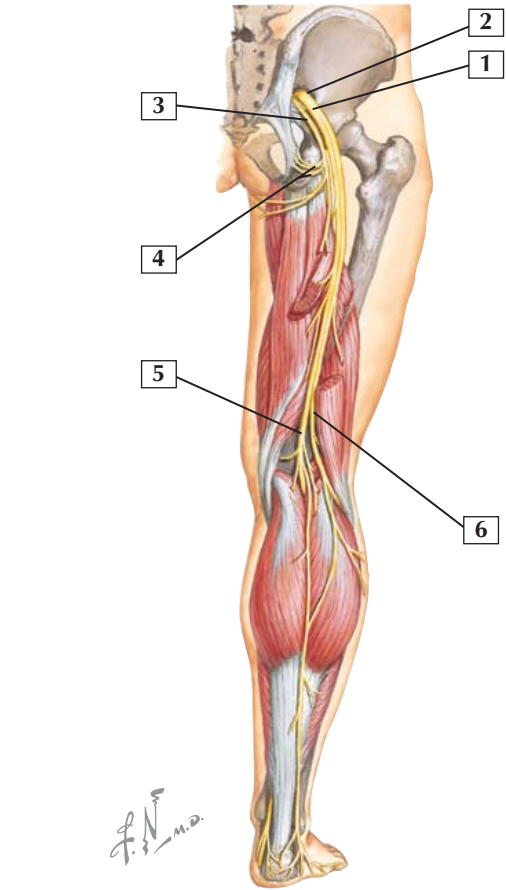
1. Gluteus maximus muscle
2. Tensor fascia latae muscle
3. Iliotibial band
4. Gerdy tubercle
5. Psoas minor muscle
6. Psoas major muscle
7. Iliacus muscle
8. Iliopsoas muscle insertion on lesser trochanter
9. Iliac crest

	Pathology	Signs/Symptoms	Imaging	Treatment
External Snapping Hip	Iliotibial band or gluteal tendon snaps over greater trochanter	Lateral pain/snapping	Not needed	Physical therapy, release or Z-plasty of iliotibial band
Internal Snapping Hip	Iliopsoas tendon over iliopectineal eminence	Groin pain	Iliopsoas bursography or ultrasound	Physical therapy Iliopsoas bursa injection or iliopsoas release
Intra-Articular Snapping Hip	May be any intraarticular lesion such as labral tear or loose body	Mechanical catching in groin/joint	Arthrographic magnetic resonance imaging (MRI)	Hip arthroscopy


1
2
3
4
5
6
F. Netter M.D.

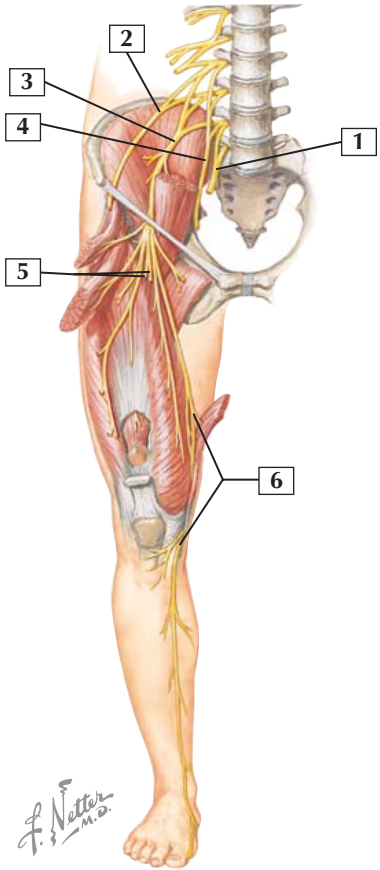
1. Adductor longus muscle
2. Sartorius muscle
3. Rectus femoris muscle
4. Vastus lateralis muscle
5. Vastus medialis muscle
6. Radiographic appearance of myositis ossificans

	Quadriceps Contusion and Myositis Ossificans	Muscle Strains
Mechanism	Direct blow to the thigh	Sudden stretch of the muscle (most common in hamstring and adductors)
Signs and Symptoms	Pain with knee extension, local tenderness, and fluctuant mass that may become firm later (myositis ossificans) as the hematoma calcifies	Posterior thigh pain and tenderness that worsen with active muscle contraction or passive stretch
Imaging	Anteroposterior (AP) and lateral radiographs only for late cases of suspected myositis ossificans	Not necessary
Treatment	Ice and compression sleeve for acute injury, immobilization in flexion; matured myositis ossificans may necessitate surgical excision and/or radiation	Rest, ice, nonsteroidal antiinflammatory drugs (NSAIDs), activity modification


2
1
3
4
5
6

1. Sciatic nerve (L4-S3)
2. Greater sciatic foramen
3. Posterior cutaneous nerve of thigh
4. Inferior cluneal nerves
5. Tibial nerve
6. Common peroneal nerve

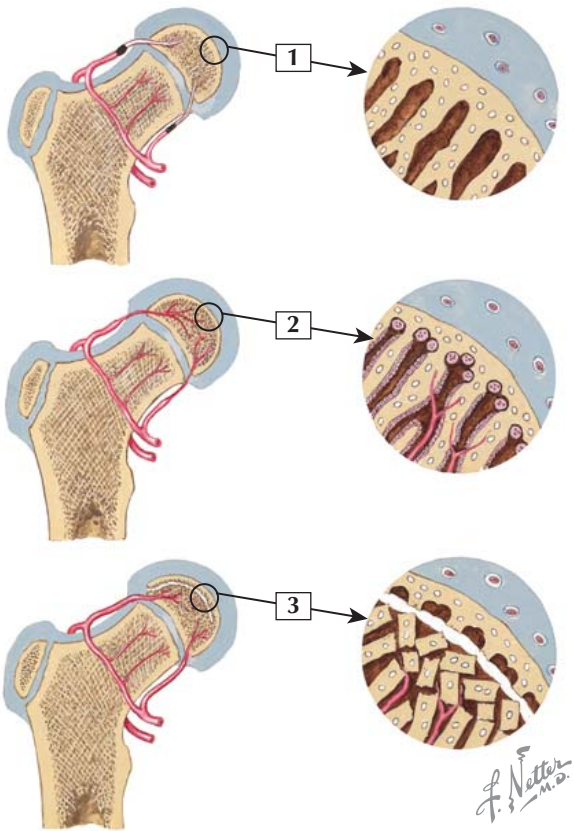
	Sciatica
Mechanism	Irritation of sciatic nerve from compression as it passes through the greater sciatic foramen or underneath the piriformis muscle (piriformis syndrome)
Signs and Symptoms	Posterior radiating leg pain, numbness, paresthesias; positive result of straight leg raise test
Imaging	Usually not necessary but may include magnetic resonance imaging (MRI) to rule out stenosis at the spinal level and/or electromyography
Treatment	Nonsteroidal antiinflammatory drugs (NSAIDs), stretching program for piriformis muscle, activity modification


2
3
4
1
5
6
F. Netter M.D.

1. Lumbosacral trunk
2. Lateral femoral cutaneous nerve (L2-3)
3. Femoral nerve (L2-4)
4. Obturator nerve
5. Anterior cutaneous branches of femoral nerve
6. Saphenous nerve

	Meralgia Paresthetica
Pathology	Compression of the lateral femoral cutaneous nerve as it passes by the anterior superior iliac spine
Signs and Symptoms	Burning pain or numbness in lateral thigh, history of wearing compressive clothing or belt
Imaging	Not necessary, but electromyography may be helpful.
Treatment	Removal of constricting clothing, device, other material; surgical release for refractory cases

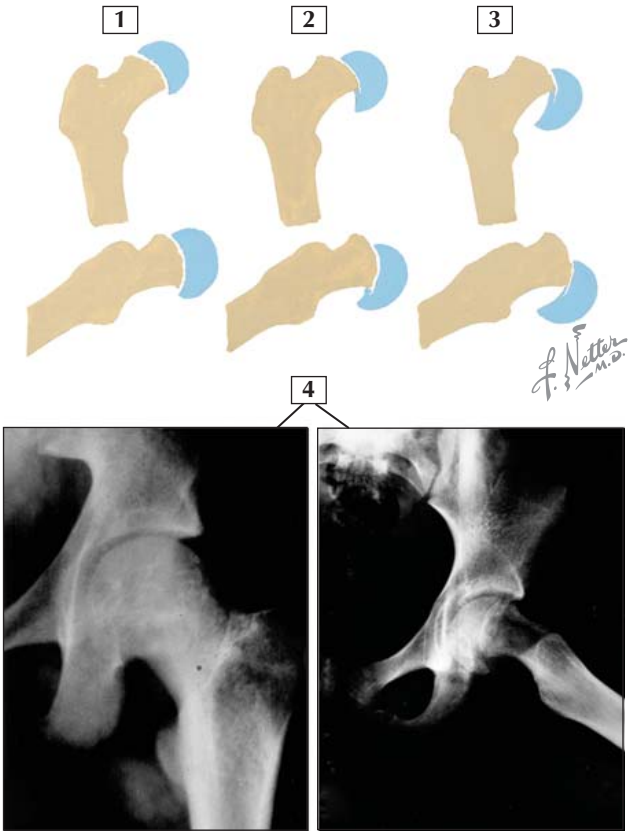
Identify the stages shown of this condition



1. Decreased vascularity of the femoral head (osteonecrosis)
2. Revascularization of femoral head
3. Remodeling of femoral head

	Legg-Calvé-Perthes Disease
Pathology	Idiopathic osteonecrosis of the femoral head in pediatric population
Signs and Symptoms	Usually in boys aged 4-8 years, hip or knee pain, limited hip abduction
Imaging	Anteroposterior (AP) and lateral radiographs of hip show femoral head density with crescent sign
Treatment	Traction, muscle releases, range-of-motion exercises, Petrie casting, femoral or pelvic osteotomies

Identify each condition

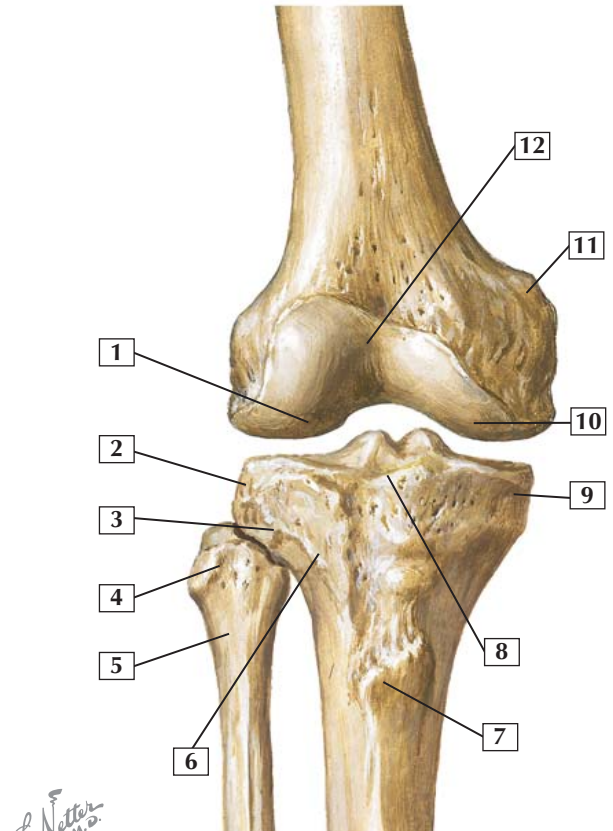


1. Slipped capital femoral epiphysis (SCFE) with mild displacement (<30 degrees)
2. SCFE with moderate displacement (30-50 degrees)
3. SCFE with severe displacement (>50 degrees)
4. Radiographic appearance of SCFE

	SCFE
Pathology	Slippage of proximal femoral epiphysis
Signs and Symptoms	Patients aged 11-14; obese patients; hip or knee pain; limited abduction and internal rotation
Imaging	Anteroposterior (AP) and lateral radiographs of hip
Treatment	Make hip non–weight-bearing; percutaneous pinning for unstable lesions

The Knee and Lower Leg
Plates 6-1 to 6-27

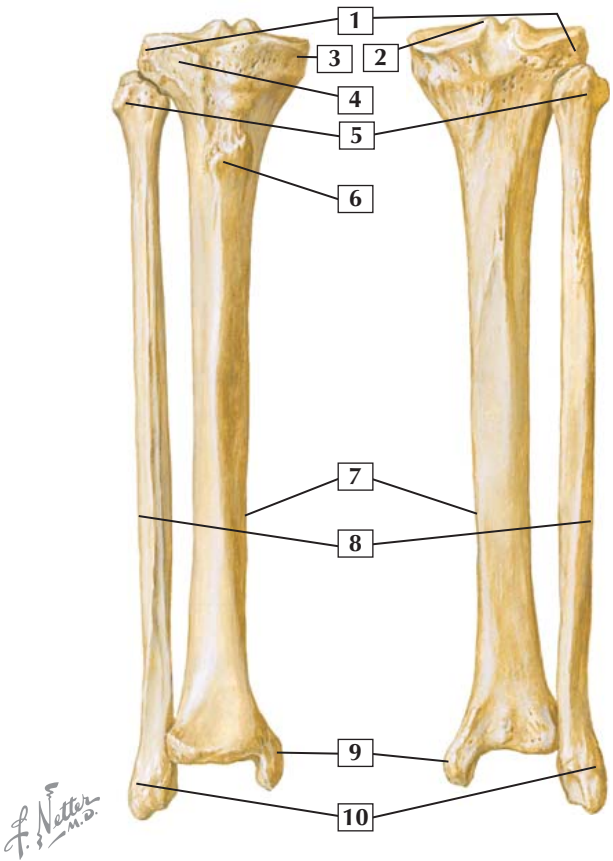
The Knee and Lower Leg
Plates 6-1 to 6-27



Anterior view

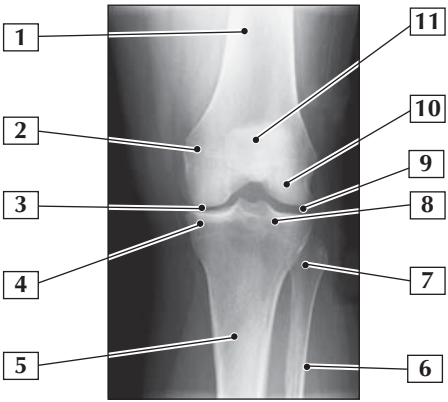
1. Lateral femoral condyle
2. Lateral tibial condyle
3. Gerdy tubercle (insertion of iliotibial tract)
4. Head of fibula
5. Neck of fibula
6. Oblique line
7. Tibial tuberosity
8. Intercondylar eminence
9. Medial tibial condyle
10. Medial femoral condyle
11. Adductor tubercle
12. Trochlear notch

Comment: The knee joint comprises three articulations: the femur and tibia, the femur and patella, and the tibia and fibula. Stability of the joint is primarily through the ligaments, menisci, and joint capsule.

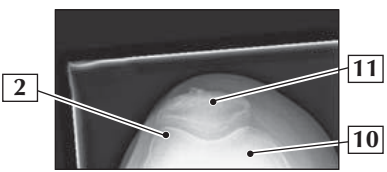

1
2
3
4
5
6
7
8
9
10
F. Netter M.D.

1. Lateral tibial condyle
2. Intercondylar eminence
3. Medial tibial condyle
4. Gerdy's tubercle
5. Head of fibula
6. Tibial tuberosity
7. Tibia
8. Fibula
9. Medial malleolus
10. Lateral malleolus

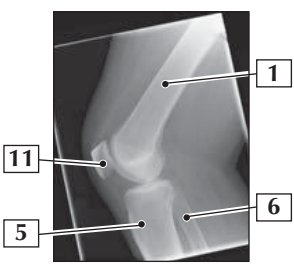
Comment: The 2 bones of the lower leg are connected by a fibrous syndesmosis. They articulate both proximally at the knee and distally at the ankle. The tibia is the primary load-bearing bone of the lower leg. The fibula is most important at the ankle, where its distal malleolus forms the lateral side of the ankle mortise. Proximally, it articulates with the tibia below the level of the knee.



Standing flexion PA



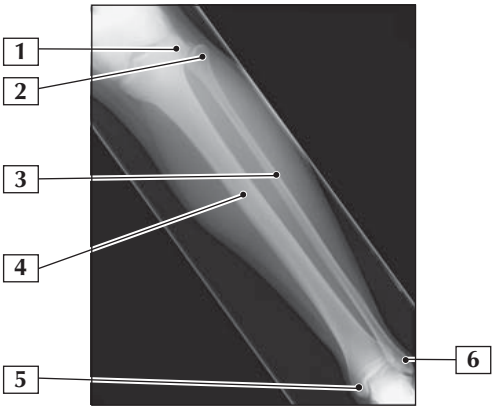
Sunrise



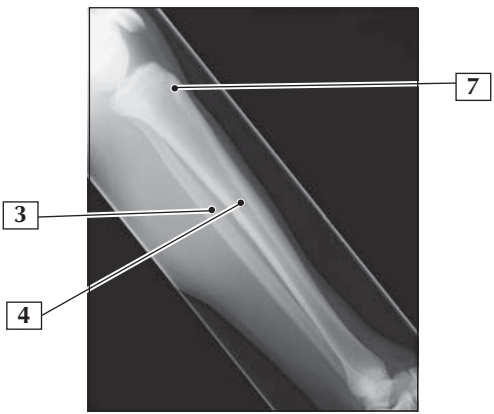
Lateral

1. Femur
2. Medial femoral condyle
3. Medial joint space
4. Medial tibial plateau
5. Tibia
6. Fibula
7. Head of fibula
8. Lateral tibial plateau
9. Lateral joint space
10. Lateral femoral condyle
11. Patella

Comment: Flexion weight-bearing radiographs are the most sensitive for knee arthritis. Sunrise views (with the knee in 30-45 degrees of flexion) are useful for evaluating the patellofemoral joint. Other useful knee radiographs include the tunnel view (for osteochondritis dissecans [OCD], loose bodies), oblique views (for tibial plateau fractures), and stress views (for ligamentous or physeal injuries).



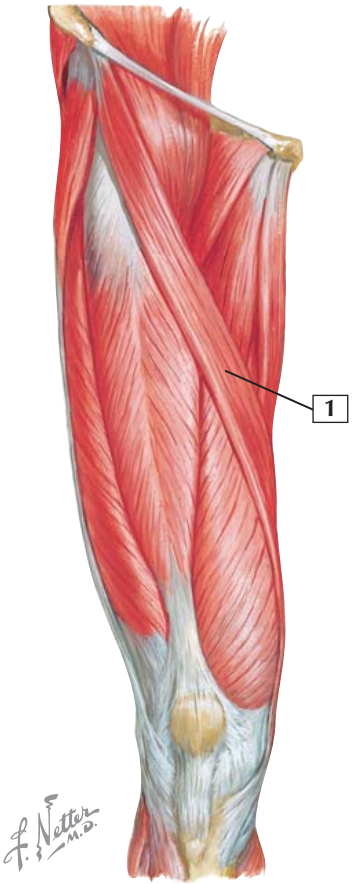
AP view



Lateral view

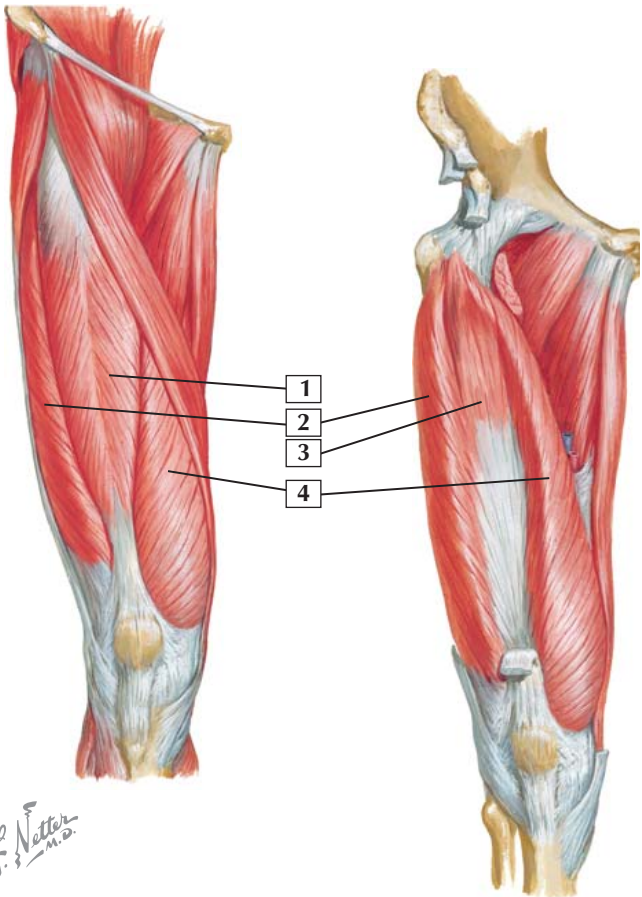
1. Lateral tibial condyle
2. Head of fibula
3. Fibula
4. Tibia
5. Medial malleolus
6. Lateral malleolus
7. Tibial tuberosity

Comment: Anteroposterior (AP) and lateral views of the lower leg can be useful to evaluate for fractures in trauma patients. They are also commonly used, although not very sensitive, in evaluating for the presence of stress fractures. Additional helpful imaging studies include bone scan and magnetic resonance imaging (MRI).


1
F. Netter M.D.

1. Sartorius muscle

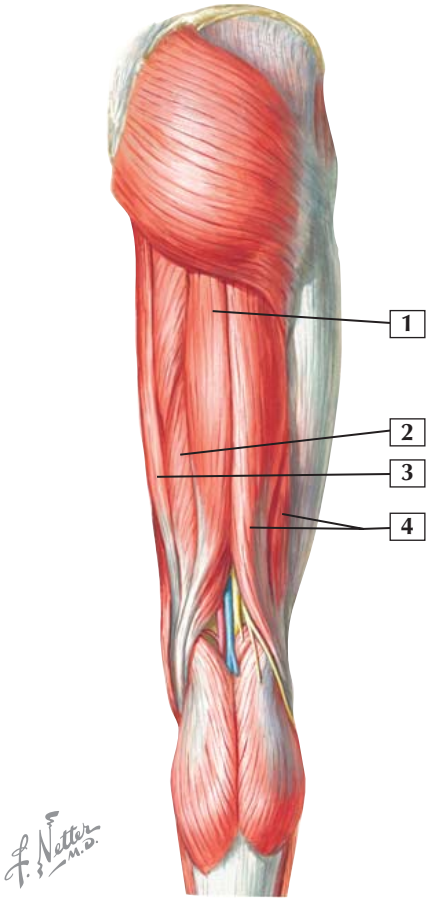
	Sartorius Muscle
Origin	Anterior superior iliac spine
Insertion	Superomedial tibia, near insertion of gracilis and semitendinosus muscles
Actions	Hip: flexion, abduction, external rotation Knee: flexion
Innervation	Femoral nerve (L2, L3)


1
2
3
4
F. Netter M.D.

1. Rectus femoris muscle
2. Vastus lateralis muscle
3. Vastus intermedius muscle
4. Vastus medialis muscle

Quadriceps Group

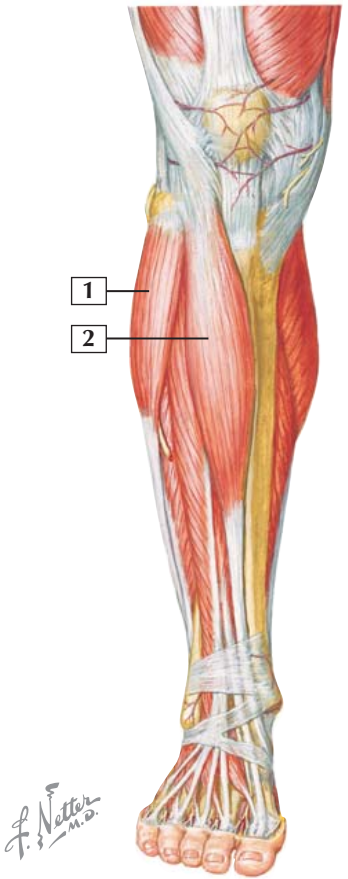
	Rectus Femoris Muscle	Vastus Lateralis Muscle	Vastus Intermedius Muscle	Vastus Medialis Muscle
Origin	One head from anterior superior iliac spine, second from ilium superior to acetabulum	Posterior femur (greater trochanter, inferior to lateral linea aspera)	Anterolateral femoral shaft	Intertrochanteric line and medial linea aspera
Insertion	By way of quadriceps tendon onto tibial tuberosity	By way of quadriceps tendon onto tibial tuberosity	By way of quadriceps tendon onto tibial tuberosity	By way of quadriceps tendon onto tibial tuberosity
Actions	Knee extension Also assistance iliopsoas with hip flexion	Knee extension	Knee extension	Knee extension
Innervation	Femoral nerve (L2, L3, L4)	Femoral (L2, L3, L4)	Femoral (L2, L3, L4)	Femoral (L2, L3, L4)


1
2
3
4
F. Netter M.D.

1. Semitendinosus muscle
2. Semimembranosus muscle
3. Gracilis muscle
4. Biceps femoris muscle (short and long head)

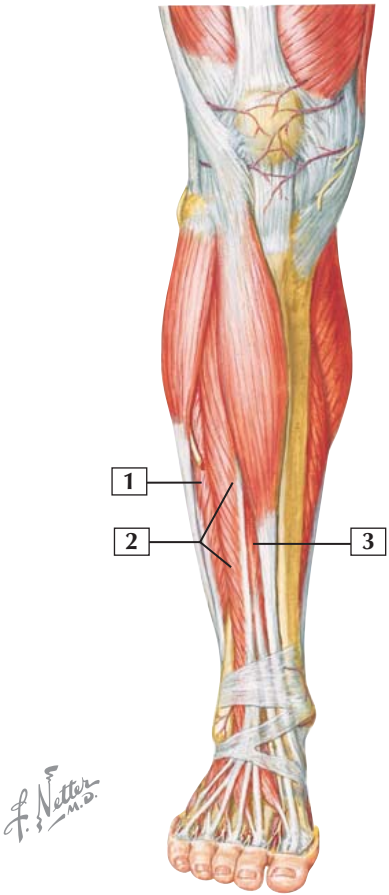
	Semitendinosus Muscle	Semimembranosus Muscle	Gracilis Muscle*	Biceps Femoris Muscle (Short and Long Head)
Origin	Ischial tuberosity	Ischial tuberosity	Body and inferior ramus of pubis	Long head: ischial tuberosity Short head: linea aspera and supracondylar line of femur
Insertion	Superomedial tibia	Posteromedial aspect of the medial tibial condyle	Superior medial tibia	Lateral head of the fibula
Actions	Knee flexion and internal rotation, hip extension	Knee flexion and internal rotation, hip extension	Hip adduction, knee flexion	Knee flexion and external rotation; long head also acts as a hip extensor
Innervation	Sciatic nerve, tibial division (L5, S1, and S2)	Sciatic nerve, tibial division (L5, S1, and S2)	Obturator nerve (L2, L3)	Long head: sciatic nerve, tibial division (L5, S1, and S2) Short head: sciatic nerve, common peroneal division (L5, S1, and S2)

*Weak hip adductor; crosses the knee joint


1
2
F. Netter M.D.

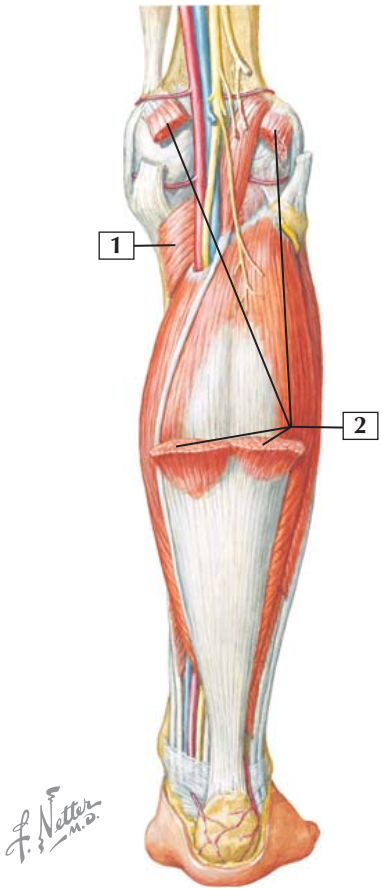
1. Peroneus longus muscle
2. Tibialis anterior muscle

	Peroneus Longus Muscle	Tibialis Anterior Muscle
Origin	Head and neck of fibula	Lateral side of proximal tibia
Insertion	Base of 1st metatarsal	Medial cuneiform and base of 1st metatarsal
Actions	Foot eversion and assistance with plantar flexion	Foot dorsiflexion and assistance with inversion
Innervation	Superficial peroneal nerve (L5, S1, S2)	Deep peroneal nerve (L4, L5)


1
2
3
F. Netter M.D.

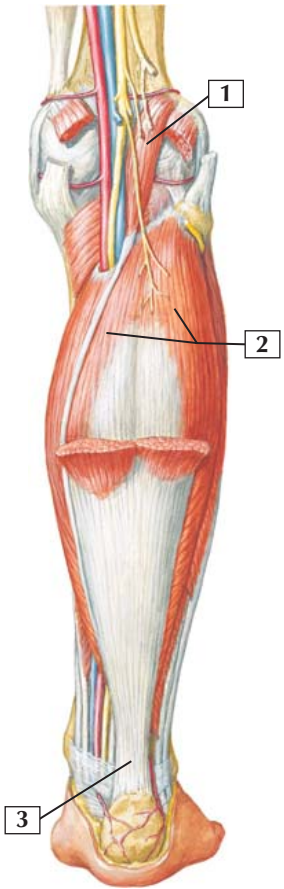
1. Peroneus brevis muscle
2. Extensor digitorum longus muscle
3. Extensor hallucis longus muscle

	Peroneus Brevis Muscle	Extensor Digitorum Longus Muscle	Extensor Hallucis Longus Muscle
Origin	Distal 2/3 of fibula	Lateral tibial condyle and proximal fibula	Middle anterior fibula
Insertion	Lateral aspect of the base of the 5th metatarsal	Middle and distal phalanges of the 2nd, 3rd, 4th, and 5th toes	Dorsal base of the distal phalanx of great toe
Actions	Foot eversion	Extension of the phalanges, ankle dorsiflexion	Great toe extension, ankle dorsiflexion
Innervation	Superficial peroneal nerve (L5, S1, S2)	Deep peroneal nerve (L5, S1)	Deep peroneal nerve (L5, S1)


1
2
F. Netter M.D.

1. Popliteus muscle
2. Gastrocnemius muscle

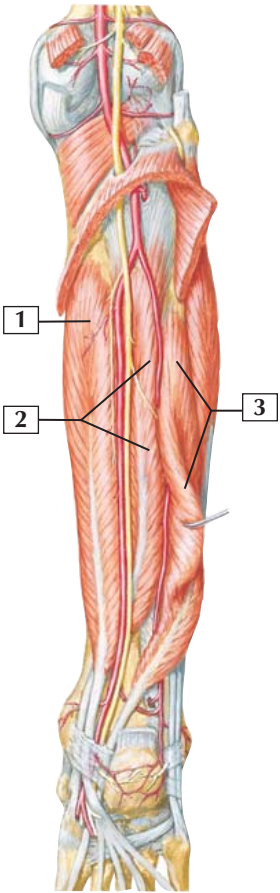
	Popliteus Muscle	Gastrocnemius Muscle
Origin	Lateral aspect of lateral femoral condyle and lateral knee joint capsule	Lateral head from lateral aspect of lateral femoral condyle; medial head from posterior aspect of medial femoral condyle
Insertion	Posterior tibia, just proximal to the soleal line	Via the Achilles tendon on the posterior calcaneus
Actions	Leg flexion and internal rotation at the knee, "unlocks" knee when standing	Ankle plantar flexion, assistance with knee flexion
Innervation	Tibial nerve (L4, L5, S1)	Tibial nerve (S1, S2)


1
2
3

1. Plantaris muscle
2. Soleus muscle

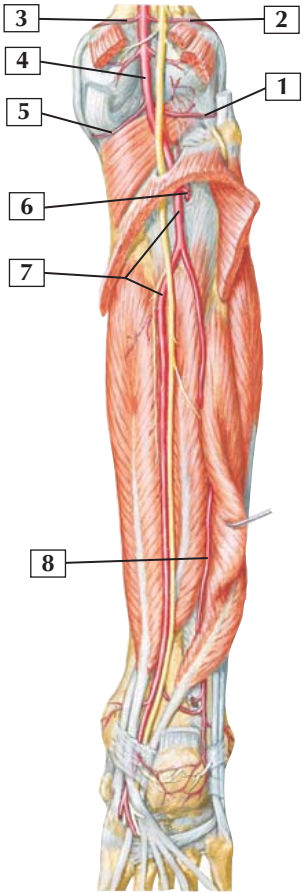
	Plantaris Muscle	Soleus Muscle
Origin	Lateral supracondylar line of femur and oblique popliteal ligament	Posterior aspect of proximal fibula and medial tibia
Insertion	Posterior calcaneus	By way of Achilles tendon* onto the posterior calcaneus
Actions	Assistance with ankle plantar flexion and knee flexion	Ankle plantar flexion
Innervation	Tibial nerve (S1-S2)	Tibial nerve (S1, S2)

*The medial and lateral head of the gastrocnemius join with the soleus muscle to form the Achilles tendon, which then inserts on the posterior calcaneus.


1
2
3

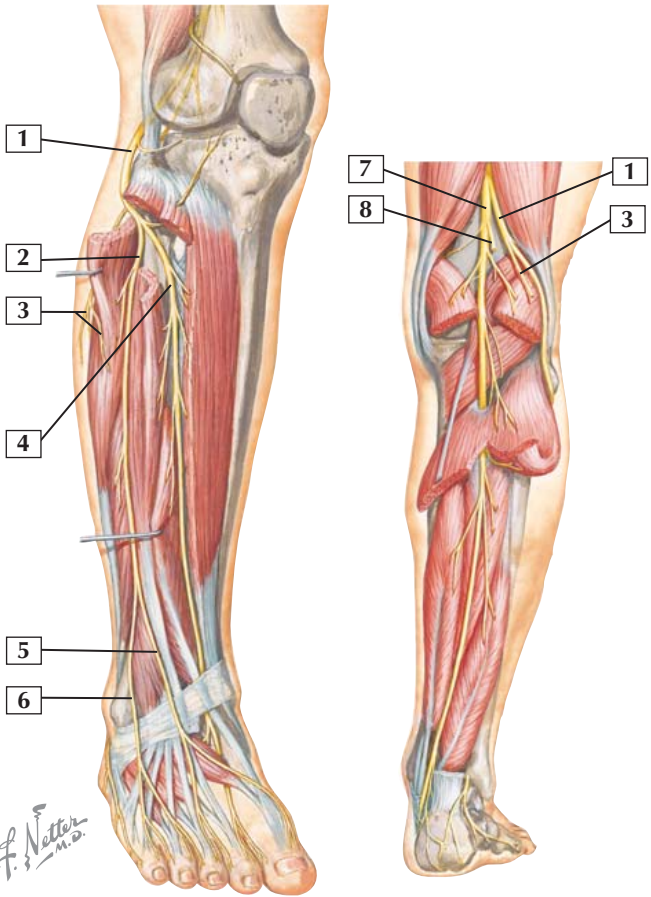
1. Flexor digitorum longus muscle
2. Tibialis posterior muscle
3. Flexor hallucis longus muscle

	Flexor Digitorum Longus Muscle	**Tibialis Posterior Muscle**	**Flexor Hallucis Longus Muscle**
Origin	Posterior middle tibia	Posterior tibia and fibula	Posterior aspect of fibula
Insertion	Bases of the distal phalanges of toes 2, 3, 4, and 5	Navicular tuberosity; plantar aspects of cuneiform and cuboid bones; and the bases of the 2nd, 3rd, and 4th metatarsals	Base of distal phalanx of great toe
Actions	Toe flexion; assistance with ankle plantar flexion and inversion	Ankle plantar flexion and inversion	Great toe flexion; assistance with ankle plantar flexion
Innervation	Tibial nerve (S2, S3)	Tibial nerve (L4, L5)	Tibial nerve (S2, S3)


3
2
4
1
5
6
7
8

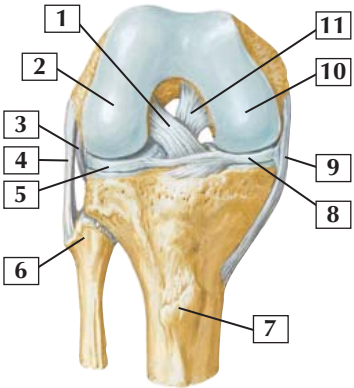
1. Inferior lateral genicular artery
2. Superior lateral genicular artery
3. Superior medial genicular artery
4. Popliteal artery
5. Inferior medial genicular artery
6. Anterior tibial artery
7. Posterior tibial artery
8. Peroneal artery

Comment: The knee and lower leg are supplied by branches of the femoral artery. The popliteal artery passes through the popliteal fossa posteriorly and forms the geniculate arteries, which supply the knee. The anterior and posterior tibial arteries supply the muscles of the anterior and posterior compartments, respectively. The peroneal artery wraps around the head of the fibula before passing distally to supply the peroneal muscles and the lateral compartment.

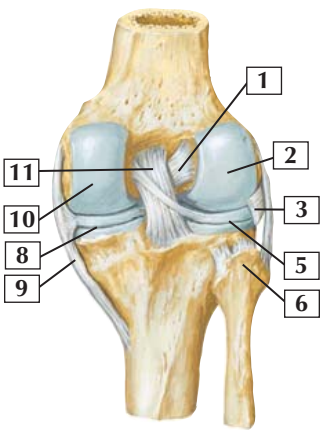

1
2
3
4
5
6
7
8
1
3
F. Netter M.D.

1. Common peroneal nerve
2. Superficial peroneal nerve
3. Lateral sural cutaneous nerve
4. Deep peroneal nerve
5. Medial dorsal cutaneous nerve
6. Intermediate dorsal cutaneous nerve
7. Tibial nerve
8. Medial sural cutaneous nerve

Comment: The tibial nerve (L4-S3) passes through the midline of the popliteal space and runs between the heads of the gastrocnemius muscle as it travels to the foot. It provides sensation to the posterolateral calf and innervation to the posterior muscles of the lower leg. The common peroneal nerve crosses the knee joint passing between the biceps and the lateral head of the gastrocnemius muscle. It wraps around the fibular head (where it is prone to injury with fractures) and then moves distally to supply the anterior and lateral compartments of the lower leg.



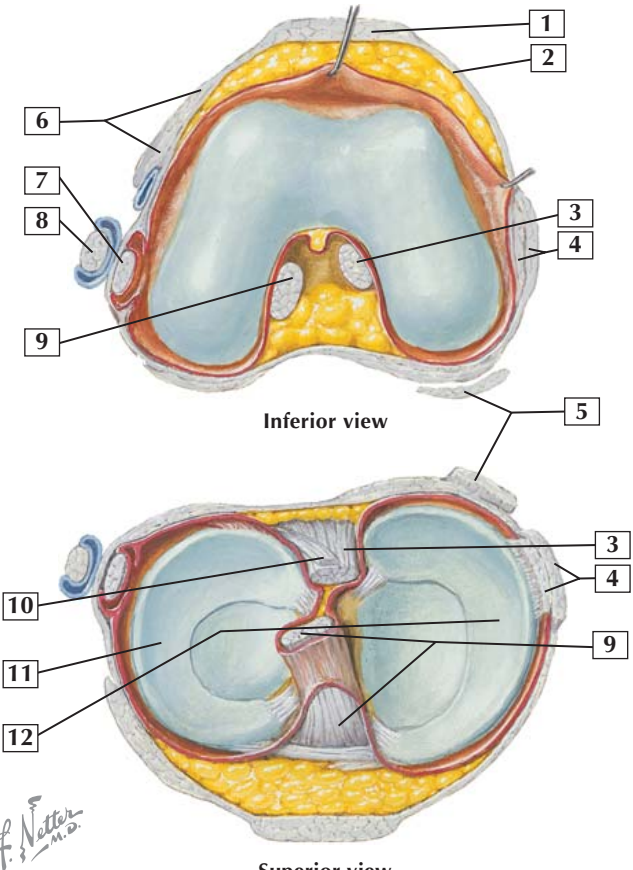
Right knee in flexion: anterior view



Right knee in extension: posterior view

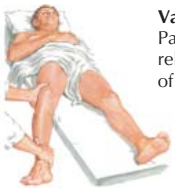
1. Anterior cruciate ligament (ACL)
2. Lateral femoral condyle
3. Popliteus tendon
4. Lateral collateral ligament
5. Lateral meniscus
6. Head of the fibula
7. Tibial tuberosity
8. Medial meniscus
9. Medial collateral ligament
10. Medial femoral condyle
11. Posterior cruciate ligament (PCL)

Comment: The anterior and posterior cruciate ligaments control anterior and posterior stability of the knee joint. Similarly, the medial and lateral collateral ligaments provide stability in those directions. The meniscus and capsule are important secondary stabilizers of this joint.


1
2
6
7
8
3
4
9
Inferior view
5
3
4
10
9
11
12
F. Netter M.D.
Superior view

1. Patella tendon
2. Medial patellofemoral ligament (MPFL)
3. Posterior cruciate ligament (PCL)
4. Medial collateral ligament
5. Semimembranosus tendon
6. Lateral patellar retinaculum and iliotibial band
7. Popliteus tendon
8. Lateral collateral ligament
9. Anterior cruciate ligament (ACL)
10. Posterior meniscofemoral ligament
11. Lateral meniscus
12. Medial meniscus

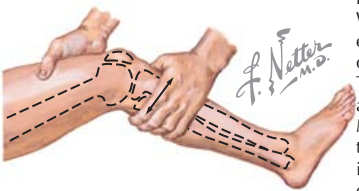
Comment: The menisci are important secondary stabilizers of the knee joint. The medial meniscus is C-shaped, whereas the lateral meniscus is O-shaped.



Varus and valgus tests
Patient supine on table, relaxed, leg over edge of table, flexed about 30°

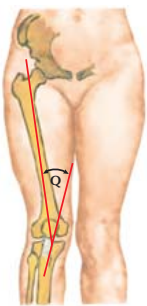
With one hand fixing thigh, examiner places other hand just above ankle and applies valgus stress. Degree of mobility compared with that of uninjured side, which is tested first. For varus stress test, direction of pressure reversed

Posterior drawer test
Procedure same as for anterior drawer test, except that pressure on tibia is backward instead of forward



Lachman test
With patient's knee bent 20°–30°, examiner's hands grasp limb over distal femur and proximal tibia. Tibia alternately pulled forward and pushed backward. Movement of 5 mm or more than that in normal limb indicates rupture of anterior cruciate ligament

Q angle formed by intersection of lines from anterior superior iliac spine and from tibial tuberosity through midpoint of patella. Large Q angle predisposes to patellar subluxation



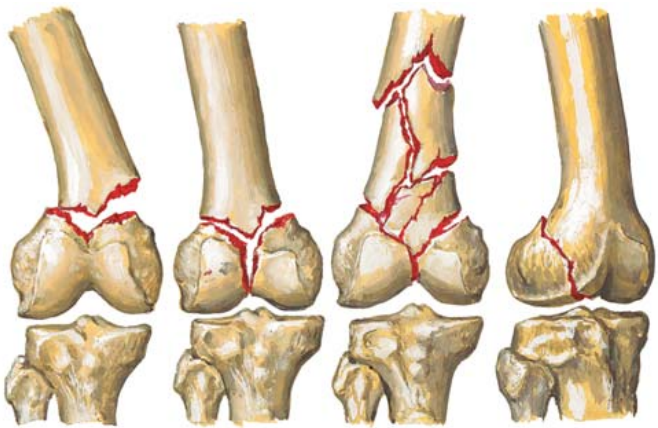
Apprehension (Fairbank) test As examiner displaces patella laterally, patient feels pain and forcefully contracts quadriceps femoris muscle

Posterior sag sign.
Leg drops backward

Movement	Normal Range of Motion
Flexion	135-140 Degrees
Extension	0 Degrees

Test/Sign	Reason for Evaluation
Anterior drawer test Lachman test Pivot shift test	Anterior cruciate ligament (ACL) tear
Posterior drawer test Sag sign Reverse pivot shift	Posterior cruciate ligament (PCL) tear
Dial test (rotary stability)	Posterolateral corner injury
Valgus stress test	Medial collateral ligament (MCL) tear
Varus stress test	Lateral collateral ligament (LCL) tear
McMurray test	Meniscal tear
Quadriceps (Q) angle measurement	Patella tracking
Apprehension	Patella instability
Patella grind	Patellofemoral pain/arthritis
Homan sign	Deep vein thrombosis

Identify each condition



1 2 3 4

F. Netter M.D.

1. Extraarticular fracture
2. Bicondylar fracture
3. Comminuted bicondylar fracture
4. Unicondylar fracture

	Supracondylar Femur Fractures
Mechanism	High-energy trauma
Imaging	Anteroposterior (AP) and lateral radiographs, computed tomography (CT) for operative planning
Treatment	Typically open reduction, internal fixation (ORIF)

Identify each condition

1

2

3

4

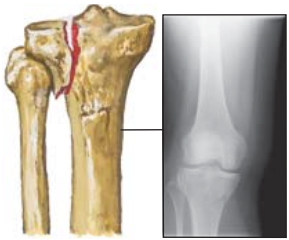
F. Netter M.D.

5

1. Transverse fracture, nondisplaced
2. Transverse fracture, displaced
3. Transverse, comminuted fracture
4. Stellate fracture
5. Radiograph of transverse patella fracture

	Patella Fractures
Mechanism	Fall on front of knee, direct trauma
Imaging	Anteroposterior (AP), lateral, and sunrise radiographs
Treatment	Conservative in hinged brace if fracture is nondisplaced and extensor mechanism is intact Open reduction, internal fixation (ORIF) with tension band construct or partial patellectomy

Identify each condition



1

2

3

4

5

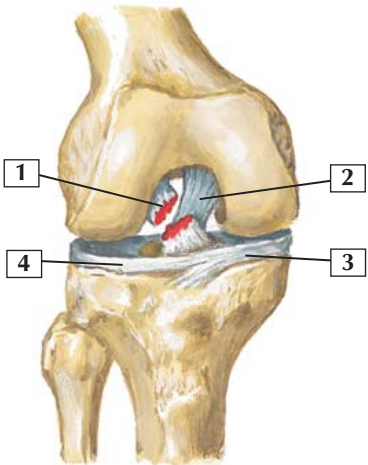
6

7

1. Type I tibial plateau fracture
2. Type II tibial plateau fracture
3. Type IV tibial plateau fracture
4. Type V tibial plateau fracture
5. Type VI tibial plateau fracture
6. Open reduction, internal fixation (ORIF) with medial buttress plate
7. Transverse fracture of tibia and fibula

Schatzker Fracture (Tibial Plateau)	Description
Type I	Lateral split
Type II	Lateral split with depression
Type III	Lateral depression without split
Type IV	Medial depression
Type V	Bicondylar
Type VI	Split with extension into metadiaphysis

Comment: Tibial shaft fractures are described by type of fracture (transverse, displaced, open, closed) and are typically treated surgically with an intermedullary nail.



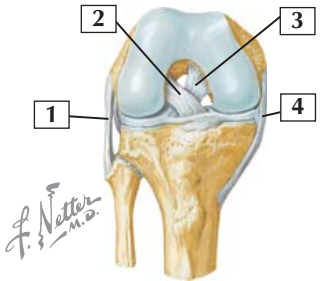
5

6

1. Anterior cruciate ligament (ACL) (ruptured)
2. Posterior cruciate ligament (PCL)
3. Medial meniscus
4. Lateral meniscus
5. Magnetic resonance imaging (MRI) appearance of normal ACL and PCL
6. Arthroscopic image of normal ACL

	ACL Tear	PCL Tear
Mechanism	Noncontact pivot	Hyperextension; direct blow to tibia of flexed knee
Signs and Symptoms	Immediate swelling; "pop"; inability to continue playing; positive Lachman ("gold standard"), anterior drawer, and pivot shift test	Pain; swelling; positive posterior drawer test, sag sign, and quadriceps active test
Imaging	Segond fracture on plain radiograph is pathognomonic, MRI confirms	Stress radiographs; MRI confirms
Treatment	Reconstruction of ligament with tendon (autograft or allograft)	Usually conservative (grades I and II) unless combined ligamentous injury or grade III with persistent symptoms

Grade	Posterior Drawer Test Result	Treatment
I	Anterior tibia anterior to femoral condyles	Conservative
II	Anterior tibia flush with femoral condyles	Conservative
III	Anterior tibia posterior to femoral condyles	Often surgical reconstruction



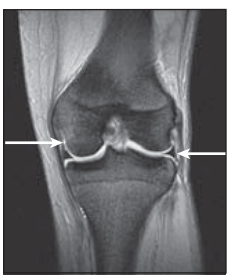
Identify each condition

5

6

7

8

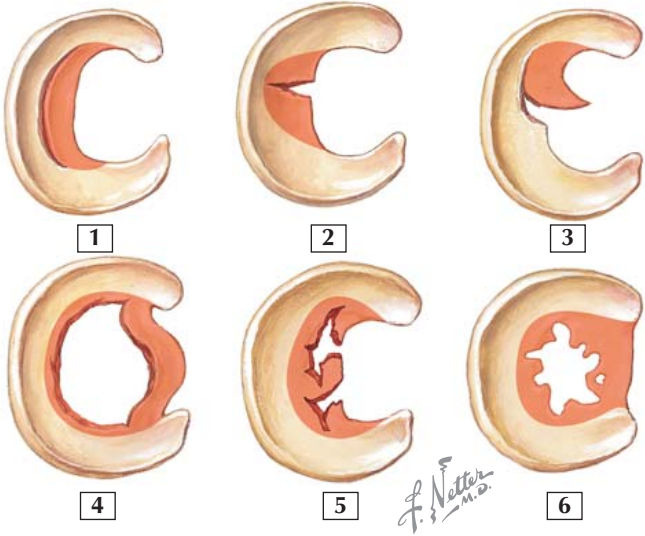


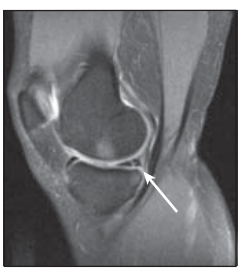
9

1. Lateral collateral ligament (LCL)
2. Anterior cruciate ligament (ACL)
3. Posterior cruciate ligament (PCL)
4. Medial collateral ligament (MCL)
5. Grade I MCL injury
6. Grade II MCL injury
7. Grade III MCL injury
8. Combined ACL/MCL injury
9. Magnetic resonance imaging (MRI) appearance of normal collateral ligaments

	MCL Tear	LCL Tear
Mechanism	Blow to lateral leg (forced valgus)	High-energy trauma, rarely isolated
Signs and Symptoms	Medial pain and tenderness over MCL origin/insertion, positive valgus stress test at 30 degrees (at 0 degrees, indicates combined injury)	Lateral pain, positive varus stress test result; evaluate for posterolateral corner injury (rotary instability)
Imaging	Pellegrini-Stieda lesion (chronic MCL injury only); MRI confirms	Anteroposterior (AP) and lateral radiographs; MRI confirms
Treatment	Hinged brace for 6 weeks; for chronic instability or combined injury: surgical reconstruction	If isolated, hinged brace For combined injury: surgical reconstruction

Identify each condition





7

8

1. Vertical tear
2. Radial tear
3. Oblique ("parrot-beak") tear
4. Bucket-handle tear
5. Complex tear
6. Discoid meniscus with tear
7. Tear of posterior horn of the medial meniscus as seen on magnetic resonance imaging (MRI)
8. Arthroscopic appearance of meniscal tear

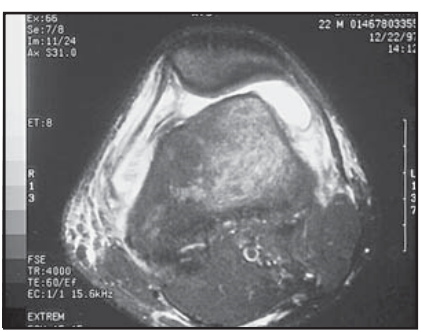
	Meniscal Tears	Discoid Meniscus*
Mechanism	Twisting injury most common	Normal variant but can tear owing to twisting injury
Signs and Symptoms	Pain, swelling, giving way, catching/locking, joint line tenderness, positive McMurray test (pain and click)	Same as normal meniscal tear, often presenting in adolescents
Imaging	MRI confirms diagnosis	Anteroposterior (AP) and lateral radiographs may show joint space widening and cupping; MRI confirms diagnosis
Treatment	Arthroscopic partial meniscectomy most common; meniscal repair reserved for small, vertical, peripheral (red zone) tears where the blood supply can support healing	Saucerization/partial meniscectomy for torn meniscus; simple observation for incidentally noted discoid meniscus without tear

*Usually of the lateral meniscus, this involves a shape that is more rounded ("filled in") than the usual C-shape of the meniscus, predisposing it to tears.

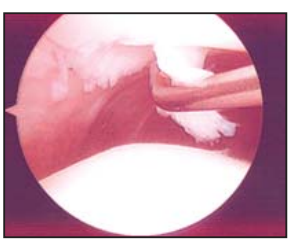
Identify each condition

1 2 3

4



5



6

1. Normal patellofemoral alignment
2. Lateral subluxation of the patella
3. Medial patellofemoral ligament (MPFL) tear from patella dislocation
4. Sunrise view, demonstrating chronic patella subluxation (bilateral)
5. Magnetic resonance imaging (MRI) of MPFL injury
6. Arthroscopic image of patella chondral flap

	Patellar Dislocation	Patella Chondromalacia
Mechanism	Direct blow resulting in lateral displacement	Almost always caused by quadriceps imbalance
Signs and Symptoms	Deformity, patellofemoral tenderness and laxity, medial pain over MPFL origin	Anterior knee pain that worsens with prolonged sitting or stair climbing, pseudolocking, patellofemoral tenderness, positive patella grind
Imaging	Anteroposterior (AP), lateral, and sunrise views; MRI to evaluate MPFL tear and loose body	AP, lateral, and sunrise views; in rare cases, MRI to evaluate for chondral flap in the presence of mechanical symptoms
Treatment	Conservative with emphasis on quadriceps muscle strengthening Surgical reconstructive procedures and MPFL reconstruction are later options	Quadriceps strengthening (emphasize vastus medialis oblique muscle), braces, nonsteroidal antiinflammatory drugs (NSAIDs), steroid injections

Sunrise view from Miller M, Cole B: Textbook of Arthroscopy. Philadelphia: Elsevier, 2004.
MRI from Miller M, Howard R, Plancher K: Surgical Atlas of Sports Medicine. Philadelphia: Elsevier, 2003.

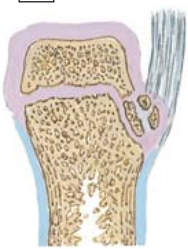
Identify each condition

1

2

3

4



5

F. Netter M.D.

6

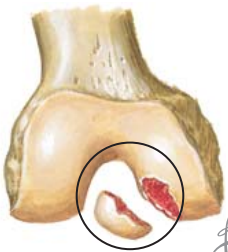
7

1. Patella tendon rupture
2. Quadriceps tendon rupture
3. External appearance of Osgood-Schlatter disease
4. Normal appearance of ossifying tibial tuberosity
5. Osgood-Schlatter disease with additional ossification at tuberosity
6. Mild separation of the apophysis at the tendon insertion
7. Fragmentation of the tibial tuberosity

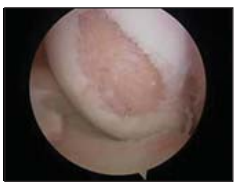
	Quadriceps/Patella Tendon Ruptures	Osgood-Schlatter Disease
Mechanism	Fall on flexed knee Patella injury more common before age 40; quadriceps injury more common after age 40	Traction apophysitis secondary to rapid bone growth, in comparison to soft tissue growth
Diagnosis	Failed extensor mechanism (inability to hold extended knee against resistance)	Tenderness over tibial tuberosity; radiographs may reveal enlarged bony apophysis
Imaging	Lateral radiographs may reveal patella alta (patella tendon rupture); magnetic resonance imaging (MRI) confirms	AP and lateral radiographs may show separation or fragmentation of the apophysis
Treatment	Surgical repair	Condition is self-limited; therefore, treatment is conservative with Cho-Pat strap, rest, and activity modification

Identify each condition

1



2



3

4

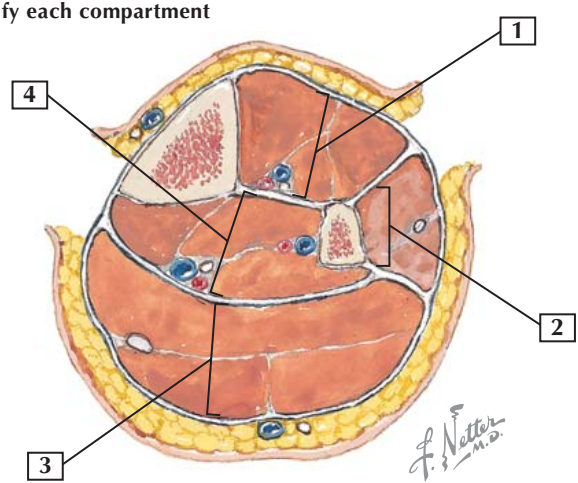
5

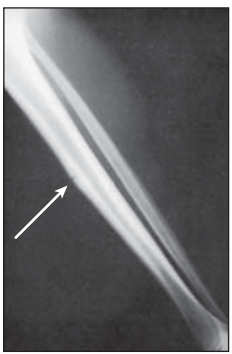
1. Osteochondritis dissecans (OCD), nondisplaced
2. OCD with displaced fragment
3. Traumatic chondral lesion, arthroscopic view
4. Osteoarthritis
5. Total joint replacement

	OCD and Traumatic Chondral Injury	Degenerative Joint Disease (DJD) of the Knee
Mechanism	Chondral injury can be traumatic, but OCD is usually idiopathic and occurs in adolescents	Degenerative (wear and tear), or posttraumatic process
Signs and Symptoms	Pain, effusions, mechanical catching	Pain, walking intolerance, effusion, decreased range of motion
Imaging	Anteroposterior (AP), lateral, and tunnel radiographs; magnetic resonance imaging (MRI) confirms and helps with surgical planning	Standing flexion PA, lateral, and sunrise radiographs show osteophytes and narrowed joint space
Treatment	OCD: conservative while physes are still open, but surgical débridement with or without bone grafting and fixation of lesion may be required later Traumatic lesions usually necessitate débridement, microfractures, or chondral plug transfer	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), steroid or hyaluronic acid injections; unicompartmental or total knee replacement if conservative treatment fails

Radiograph from Miller M, Sekiya J: Core Knowledge in Orthopaedics: Sports Medicine. Philadelphia: Elsevier, 2006.

Identify each compartment



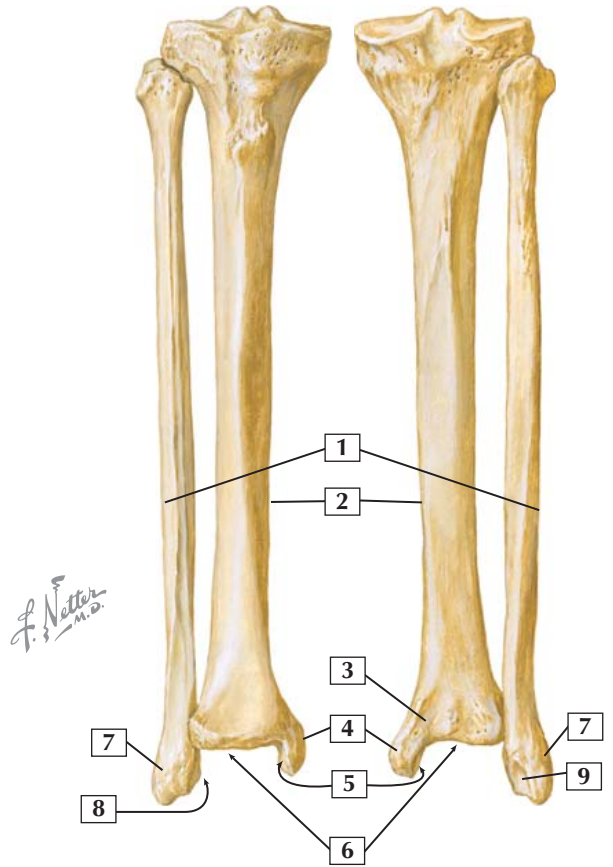


5

1. Anterior compartment
   - Tibialis anterior muscle
   - Extensor digitorum longus muscle
   - Extensor hallucis longus muscle
   - Anterior tibial artery and vein
   - Deep peroneal nerve
2. Lateral compartment
   - Peroneus longus muscle
   - Peroneus brevis muscle
   - Superficial peroneal nerve
3. Superficial posterior compartment
   - Soleus muscle
   - Gastrocnemius muscle
   - Plantaris muscle
4. Deep posterior compartment
   - Flexor digitorum longus muscle
   - Tibialis posterior muscle
   - Flexor hallucis longus muscle
   - Posterior tibial artery and nerve
   - Peroneal artery and nerve
5. Anterior tibial stress fracture

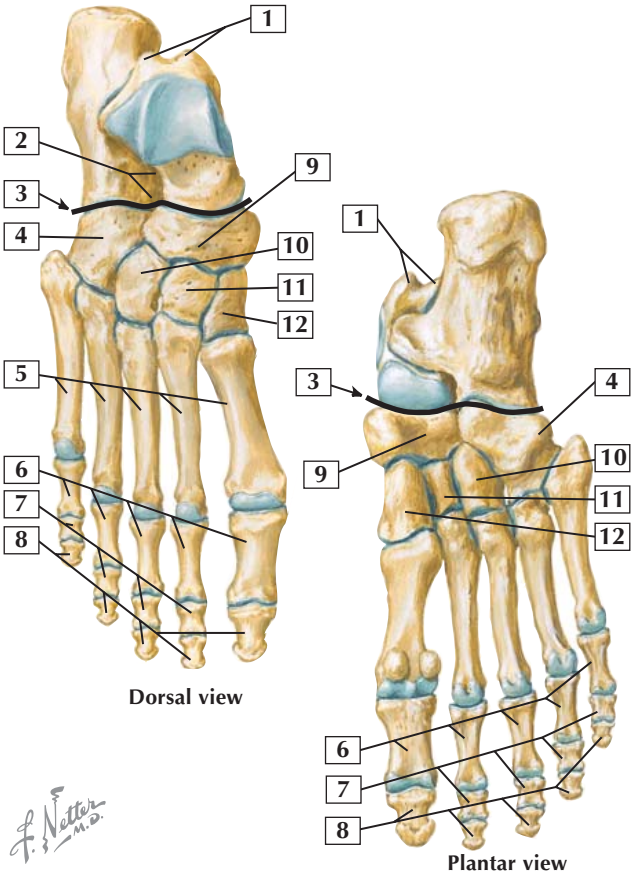
Comment: Both exertional compartment syndrome and tibial stress reactions are common in runners and manifest with exertional lower leg pain. Patients with compartment syndrome often have neurological complaints as well. Radiographs, bone scan, and magnetic resonance imaging (MRI) are all useful for diagnosing stress reactions, which are best treated with rest until symptoms resolve completely. Exertional compartment syndrome is diagnosed with measurement of compartment pressures after exertion (running on a treadmill) and is treated with surgical release of the affected compartments.

The Ankle and Foot
Plates 7-1 to 7-30


1
2
3
4
5
6
7
7
8
9

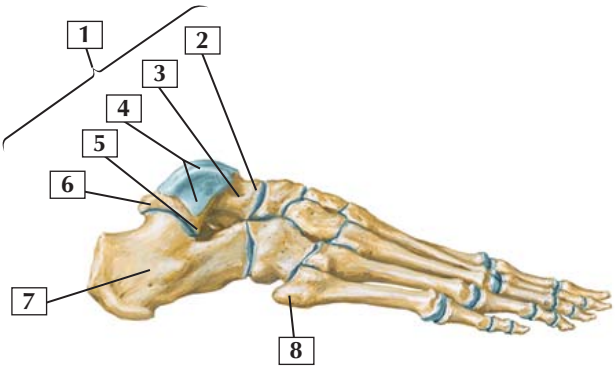
1. Shaft of fibula
2. Shaft of tibia
3. Groove for tibialis posterior and digitorum longus tendons
4. Medial malleolus
5. Articular facet of the medial malleolus
6. Inferior articular surface
7. Lateral malleolus
8. Articular facet of lateral malleolus
9. Malleolar fossa of lateral malleolus

Comment: The tibia and fibula articulate distally to form the superior aspect of the ankle mortise. They are connected by a thick fibrous syndesmotic membrane and the tibiofibular ligament. The talus articulates with both the tibia and fibula and sits between the medial and lateral malleoli.

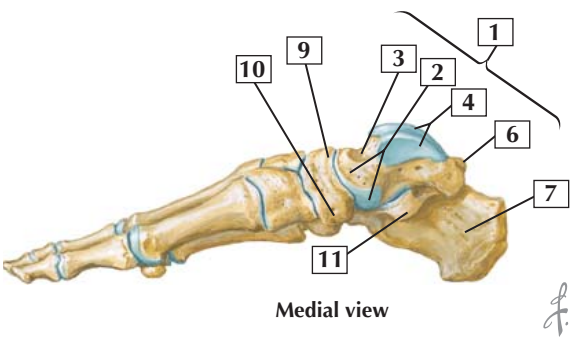

1
2
3
4
9
10
11
12
5
6
7
8
Dorsal view
1
3
4
9
10
11
12
6
7
8
Plantar view
F. Netter M.D.

1. Medial and lateral tubercles of talus
2. Sinus tarsi
3. Transverse tarsal joint
4. Cuboid
5. Metatarsal bones (5)
6. Proximal phalanges (5)
7. Middle phalanges (4)
8. Distal phalanges (5)
9. Navicular
10. Lateral cuneiform
11. Intermediate cuneiform
12. Medial cuneiform

Comment: The foot articulates with the tibia and fibula via the talus, which has no direct muscle attachments but is a site of attachment for several of the strong ligaments of the ankle joint.



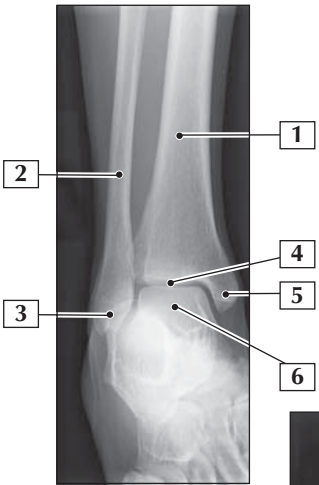
Lateral view

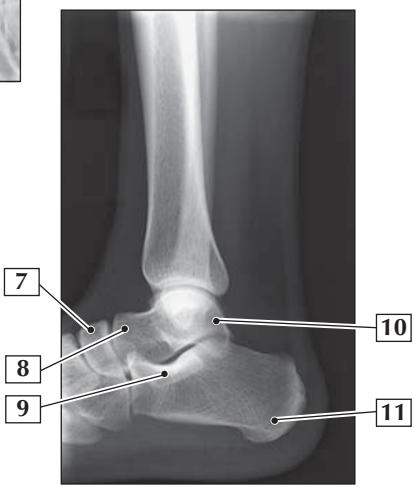


Medial view

1. Talus
2. Talar head
3. Talar neck
4. Trochlea
5. Lateral process of talus
6. Posterior process of talus
7. Calcaneus
8. Base of the 5th metatarsal
9. Navicular bone
10. Navicular tuberosity
11. Sustentaculum tali

Comment: Weight is transmitted through the longitudinal arch of the foot, which is supported posteriorly by the calcaneus.

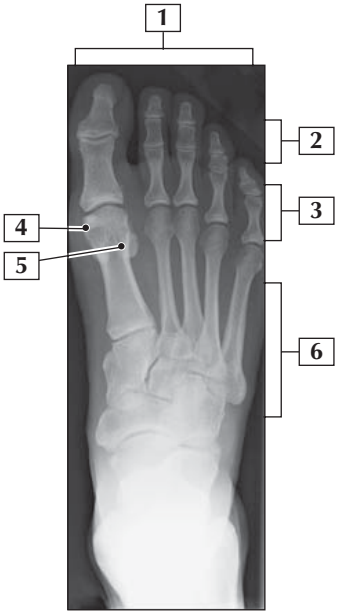

1
2
4
5
3
6

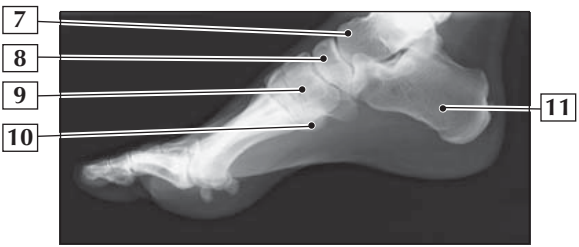

7
10
8
9
11

1. Tibia
2. Fibula
3. Lateral malleolus
4. Ankle mortise
5. Medial malleolus
6. Talus
7. Navicular bone
8. Head of talus
9. Sustentaculum tali
10. Posterior process of talus
11. Calcaneus

Comment: Anteroposterior (AP), lateral, and mortise views are the most commonly used to evaluate ankle injuries. External rotation stress views may be helpful for evaluating occult disruptions of the ankle mortise. The Ottawa ankle rules were designed to help emergency room practitioners decide when ankle radiographs should be ordered.

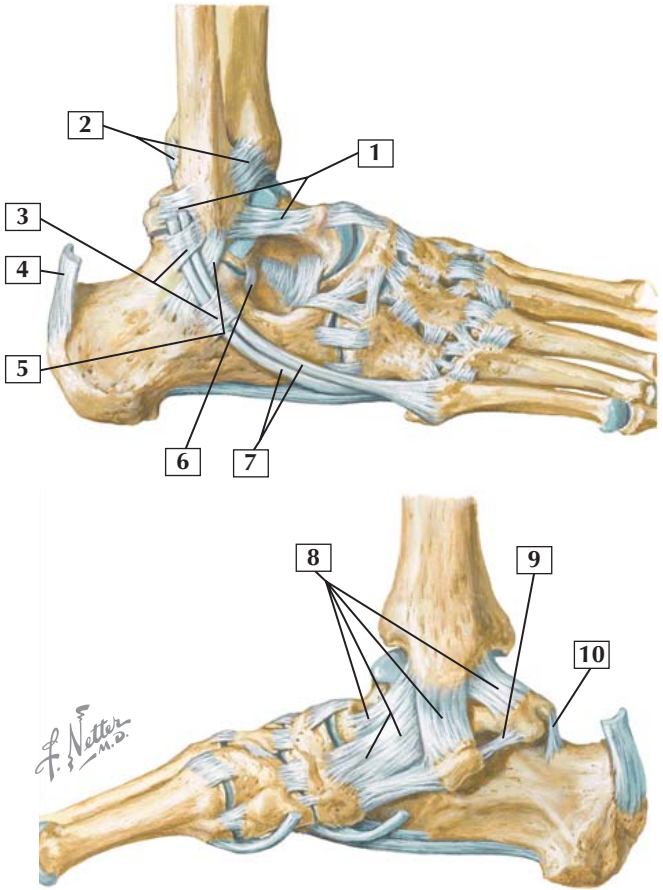
The Ottawa Ankle Rules
Tenderness of the medial malleolus
Tenderness on the lateral malleolus
Tenderness at the base of the 5th metatarsal
Navicular tenderness
Inability to bear weight immediately and in the emergency room


1
2
3
4
5
6


7
8
9
10
11

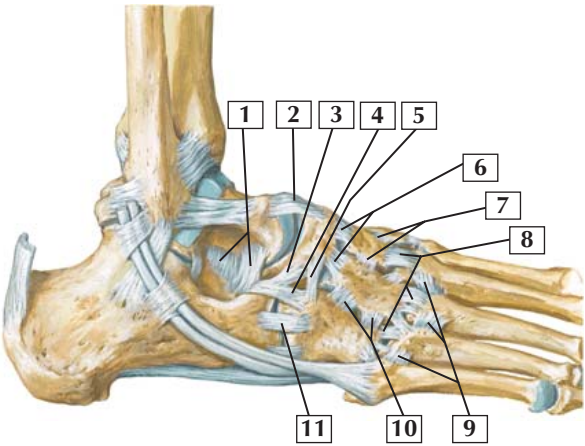
1. Distal phalanges
2. Middle phalanges
3. Proximal phalanges
4. Medial sesamoid
5. Lateral sesamoid
6. Metatarsals
7. Talus
8. Navicular
9. Cuneiforms
10. Base of the 5th metatarsal
11. Calcaneus

Comment: Anteroposterior (AP) and lateral radiographs of the foot are the views most commonly used to evaluate pathology. These should be weight-bearing images in nontraumatic or chronic cases. Special views of the calcaneus can be helpful for diagnosing fracture of this bone.

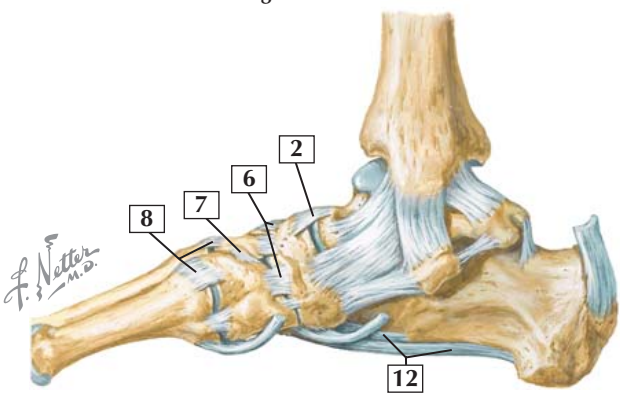

2
1
3
4
5
6
7
8
9
10
F. Netter M.D.

1. Anterior and posterior talofibular ligaments
2. Anterior and posterior tibiofibular ligaments
3. Superior and inferior peroneal retinaculum
4. Achilles tendon (cut)
5. Calcaneofibular ligament
6. Lateral talocalcaneal ligament
7. Peroneus longus and brevis muscles
8. Deltoid ligament
9. Medial talocalcaneal ligament
10. Posterior talocalcaneal ligament

Comment: The lateral ligaments of the ankle (anterior and posterior talofibular ligaments and calcaneofibular ligament) are the ligaments most commonly injured with an inversion ankle sprain. The deltoid ligament on the medial side is much stronger, and the eversion mechanism of injuring it is less common.



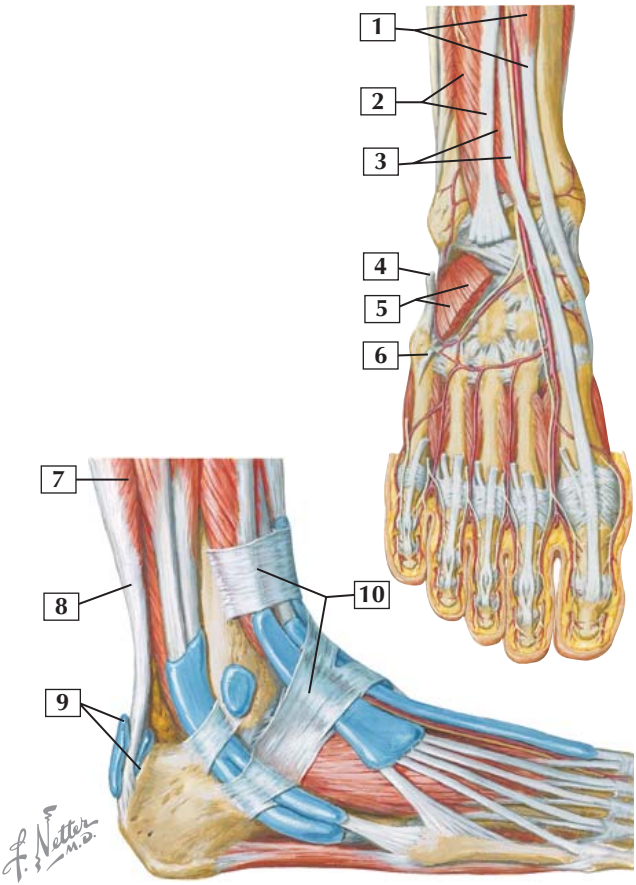
Right foot: lateral view



Right foot: medial view

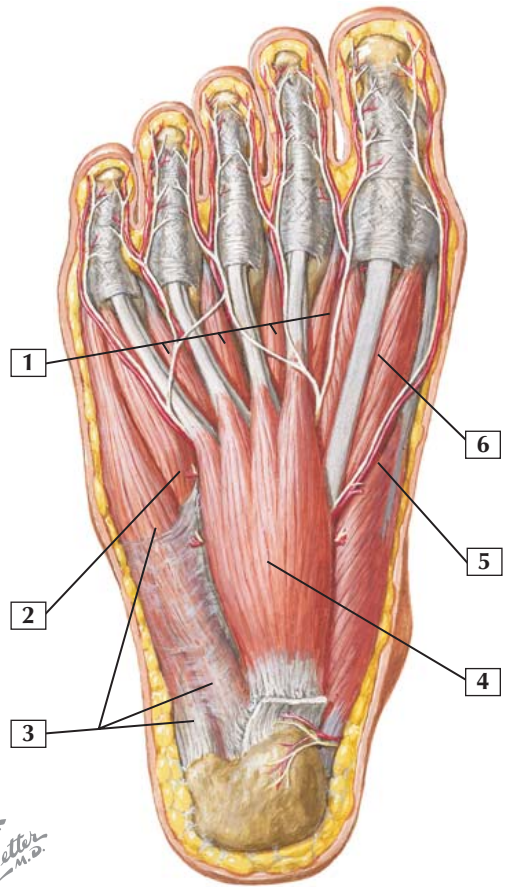
1. Interosseous talocalcaneal ligament
2. Dorsal talonavicular ligament
3. Calcaneonavicular ligament
4. Calcaneocuboid ligament
5. Dorsal cuboideonavicular ligaments
6. Dorsal cuneonavicular ligaments
7. Dorsal intercuneiform ligaments
8. Dorsal tarsometatarsal ligaments
9. Dorsal metatarsal ligaments
10. Dorsal cuneocuboid ligament
11. Dorsal calcaneocuboid ligament
12. Long and short plantar ligaments

Comment: The intertarsal ligaments connect the subtalar and midtarsal joints to provide stability for the midfoot. There are also small dorsal and plantar ligaments of the tarsometatarsal (Lisfranc) joints, as well as the metatarsophalangeal and interphalangeal joints of the forefoot.


1
2
3
4
5
6
7
8
9
10
F. Netter M.D.

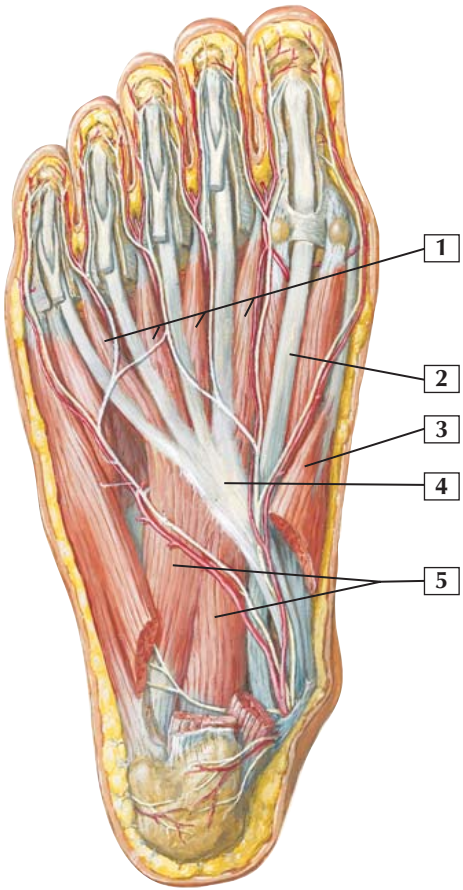
1. Tibialis anterior muscle and tendon
2. Extensor digitorum longus muscle and tendon
3. Extensor hallucis longus muscle and tendon
4. Peroneus longus tendon
5. Extensor digitorum brevis and extensor hallucis brevis muscles (cut)
6. Peroneus tertius tendon
7. Soleus muscle
8. Achilles tendon
9. Calcaneal bursae
10. Superior and inferior extensor retinaculum

Comment: The ankle flexors cross the joint posteriorly; the tendons pass beneath the flexor retinaculum, which prevents them from subluxating over the medial malleolus. Similarly, the ankle extensors cross the joint anteriorly and are supported by the superior and inferior extensor retinaculum.


1
2
3
4
5
6
F. Netter M.D.

1. Lumbricals
2. Flexor digiti minimi brevis muscle
3. Abductor digiti minimi muscle
4. Flexor digitorum brevis muscle
5. Abductor hallucis muscle
6. Flexor hallucis brevis muscle

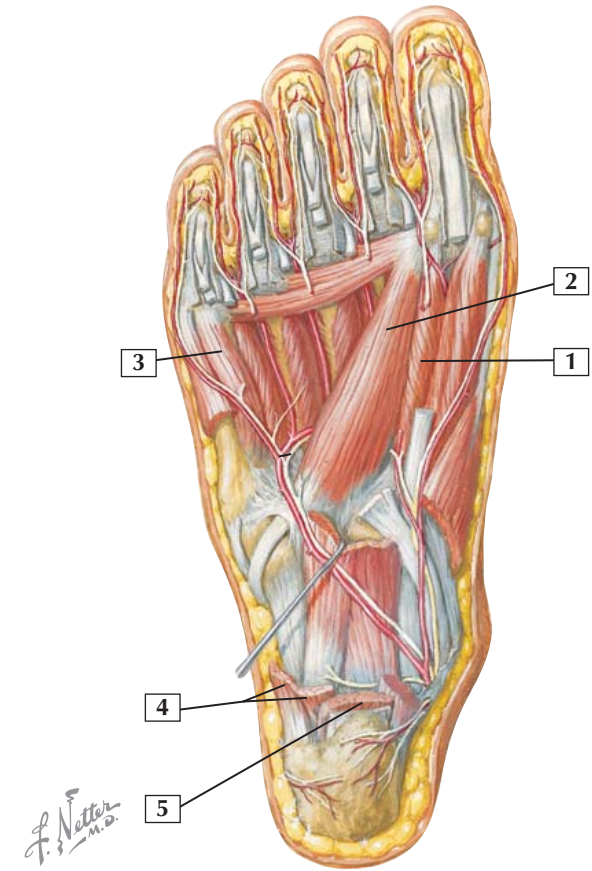
	Abductor Digiti Minimi Muscle	Flexor Digitorum Brevis Muscle	Abductor Hallucis Muscle
Origin	Tuberosity and medial/lateral processes of calcaneus	Tuberosity and medial process of calcaneus	Tuberosity and medial process of the calcaneus
Insertion	Base of 5th proximal phalanx	Middle phalanges of toes 2-5	Proximal phalanx of great toe
Actions	Abduction of toe 5	Flexion of toes 2-5	Abduction of great toe
Innervation	Lateral plantar nerve	Medial plantar nerve	Medial plantar nerve



F. Netter M.D.

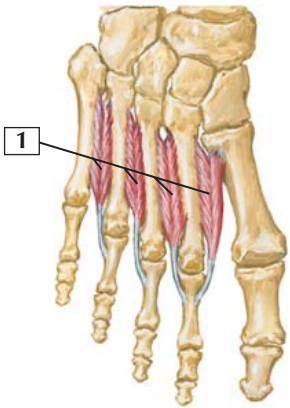
1. Lumbricals
2. Flexor hallucis longus tendon
3. Abductor hallucis muscle (cut)
4. Flexor digitorum longus tendon
5. Quadratus plantae muscle

	Quadratus Plantae Muscle	Lumbricals
Origin	Plantar aspect of the calcaneus	Flexor digitorum longus tendons
Insertion	Lateral aspect of the flexor digitorum longus tendon	Proximal phalanges
Actions	Toe flexion (along with flexor digitorum longus)	Metatarsophalangeal (MTP) joint flexion, interphalangeal joint extension
Innervation	Lateral plantar nerve	1 medial plantar nerve; 2-4 lateral plantar nerves

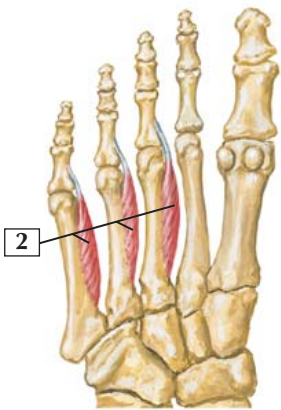

2
3
1
4
5
F. Netter M.D.

1. Flexor hallucis brevis muscle
2. Adductor hallucis muscle
3. Flexor digiti minimi brevis muscle
4. Abductor digiti minimi muscle (cut)
5. Flexor digitorum brevis muscle (cut)

	Flexor Hallucis Brevis Muscle	Adductor Hallucis Muscle	Flexor Digiti Minimi Brevis Muscle
Origin	Cuboid and lateral cuneiform	Oblique: base of metatarsals 2-4 Transverse: lateral 4 metatarsals	Base of 5th metatarsal
Insertion	Proximal phalanx of great toe	Proximal phalanx of great toe	Base of 5th proximal phalanx
Actions	Flexion of great toe	Adduction of great toe	Flexion of toe 5
Innervation	Medial plantar nerve	Lateral plantar nerve	Lateral plantar nerve



Dorsal view

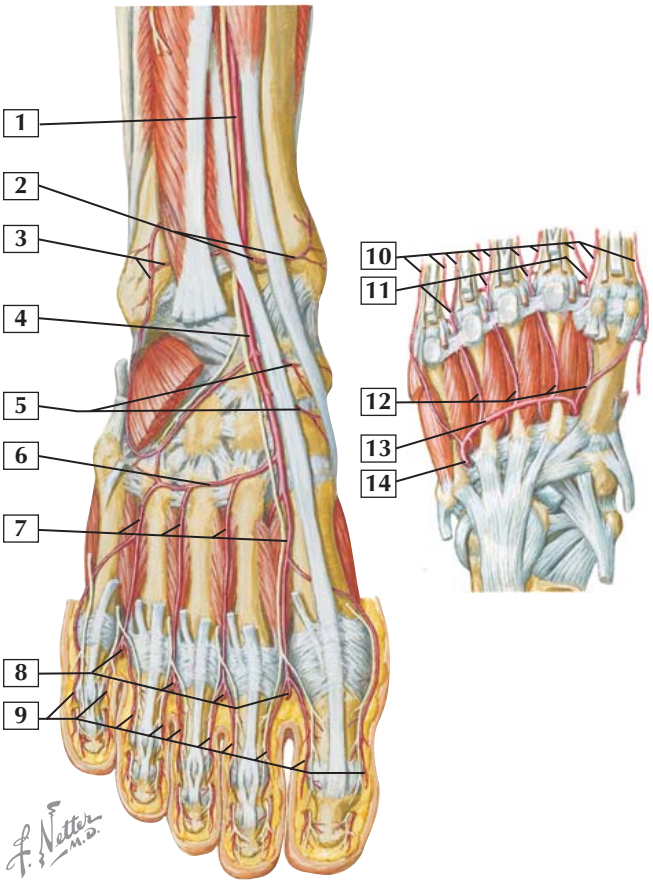


Plantar view

1. Dorsal interosseous muscles (4)
2. Plantar interosseous muscles (3)

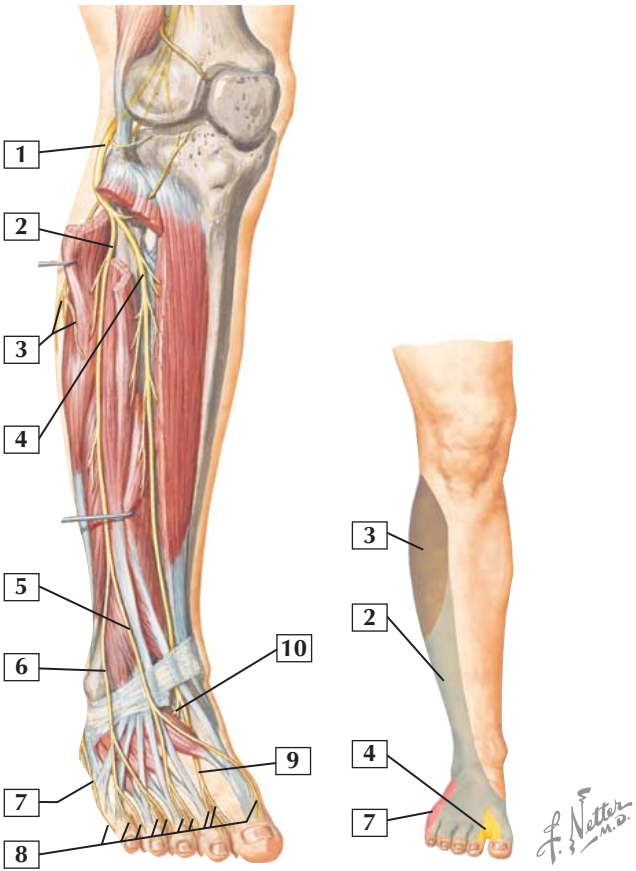
	Dorsal Interosseous Muscles	Plantar Interosseous Muscles
Origin	Shaft of adjacent metatarsal shafts	Medial aspect of metatarsal shafts 3-5
Insertion	Proximal phalanges 2-5	Medial aspect of proximal phalanges 3-5
Actions	Toe abduction	Toe adduction
Innervation	Lateral plantar nerve	Lateral plantar nerve

Comment: Useful mnemonics for remembering these muscles are "PAD = *p*lantar *ad*ducts" and "DAB = *d*orsal *ab*ducts."


1
2
3
4
5
6
7
8
9
10
11
12
13
14
F. Netter M.D.

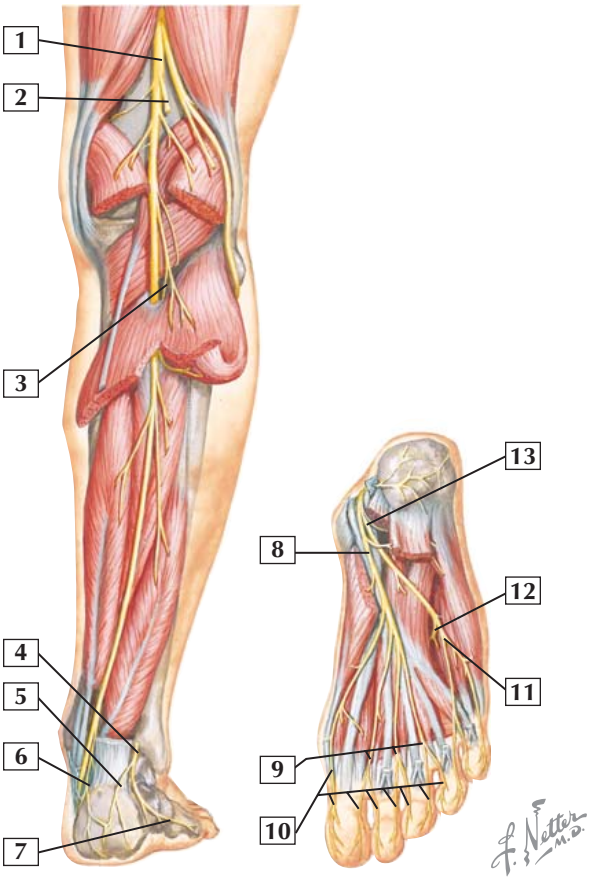
1. Anterior tibial artery
2. Anterior medial malleolar artery
3. Anterior lateral malleolar artery
4. Dorsalis pedis artery
5. Medial tarsal arteries
6. Arcuate artery
7. Dorsal metatarsal arteries
8. Anterior perforating branches from plantar metatarsal arteries
9. Dorsal digital arteries
10. Proper plantar digital arteries
11. Common plantar digital arteries
12. Plantar metatarsal arteries
13. Deep plantar arch
14. Lateral plantar artery

Comment: The anterior tibial, posterior tibial, and peroneal arteries form the branches that supply the foot and ankle. The posterior tibial and dorsalis pedis pulses are the easiest to assess with physical examination.


1
2
3
4
5
6
10
9
7
8
3
2
4
7
F. Netter M.D.

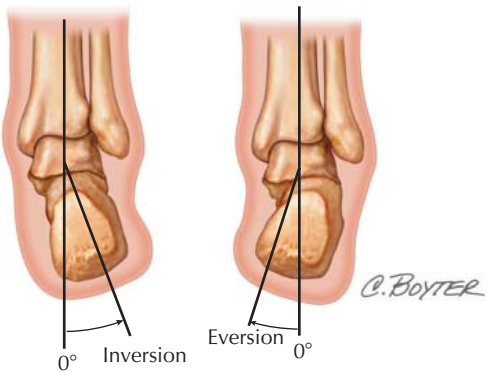
1. Common peroneal nerve (L4-S2)
2. Superficial peroneal nerve
3. Branches of the lateral sural cutaneous nerve
4. Deep peroneal nerve
5. Medial dorsal cutaneous nerve
6. Intermediate dorsal cutaneous nerve
7. Lateral dorsal cutaneous nerve
8. Dorsal digital nerves
9. Medial branch of deep peroneal nerve
10. Lateral branch of deep peroneal nerve

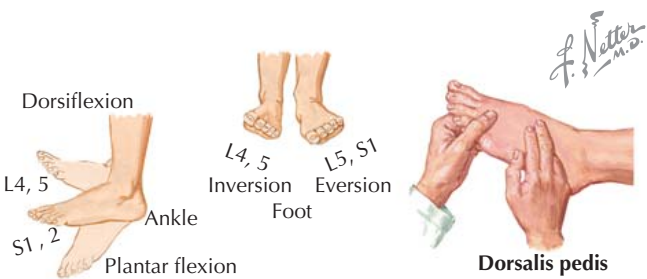
Comment: The common peroneal nerve is derived from the posterior division of the sacral plexus (L4-S2). It divides into the superficial and deep peroneal nerves and supplies the primary innervation to the lateral lower leg and foot. The deep peroneal nerve supplies the tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius muscles. The superficial peroneal nerve supplies the peroneus longus and brevis muscles.


1
2
3
4
5
6
7
8
9
10
11
12
13
F. Netter M.D.

1. Tibial nerve (L4-S3)
2. Medial sural cutaneous nerve
3. Interosseous nerve of the leg
4. Sural nerve (cut)
5. Lateral calcaneal branch
6. Medial calcaneal branch
7. Lateral dorsal cutaneous nerve
8. Medial plantar nerve
9. Common plantar digital nerves
10. Proper plantar digital nerves
11. Superficial branch
12. Deep branch
13. Lateral plantar nerve

Comment: The tibial nerve is derived from the anterior division of the sacral plexus (L4-S3). It crosses the knee in the popliteal fossa and descends between the heads of the gastrocnemius muscle. At the ankle, it crosses medially at the medial malleolus. The tibial nerve provides sensation to the posterolateral leg and innervates the soleus, plantaris, gastrocnemius, popliteus, tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles.


0°
Inversion
Eversion
0°
C. Boyter


Dorsiflexion
L4, 5
Ankle
S1, 2
Plantar flexion
L4, 5
Inversion
L5, S1
Eversion
Foot
F. Netter M.D.
Dorsalis pedis

Movement	Normal Range of Motion
Dorsiflexion	20 Degrees
Plantar flexion	45-50 Degrees
Subtalar eversion	5 Degrees
Subtalar inversion	5-10 Degrees

Test/Sign	Reason for Evaluation
Anterior drawer test Talar tilt test	Ankle instability
Tinel sign	Tarsal tunnel syndrome
Thompson test	Achilles tendon rupture
"Too many toes" sign	Acquired pes planus from posterior tibialis dysfunction
Metatarsal compression test	Morton neuroma

Identify each condition

1

2

3

4

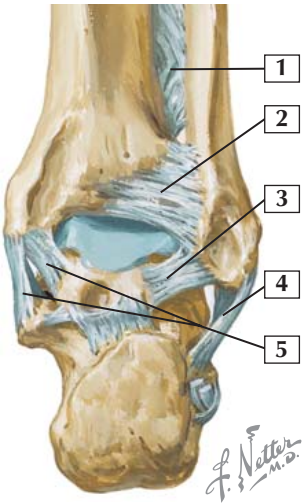
5

6

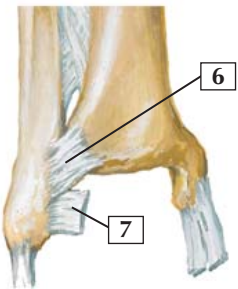
1. Weber A fracture with medial malleolar fracture
2. Weber B fracture with medial malleolar fracture
3. Weber C fracture with medial malleolar fracture
4. Maisonneuve fracture
5. Weber B fracture
6. Weber C fracture

Fractures of the Lateral Malleolus

	Mechanism	Pattern	Treatment
Weber A Fracture	Avulsion	Below level of mortise	Usually nonoperative
Weber B Fracture	Supination External rotation	At the level of mortise, may or may not involve medial malleolus or deltoid ligament	Open reduction, internal fixation (ORIF) if unstable
Weber C Fracture	Pronation External rotation	Above level of the mortise, usually involves medial structures	ORIF if talus displaced in the mortise
Maisonneuve Fracture	External rotation	Proximal fibula fracture Longitudinal tear of interosseous membrane	Syndesmotic screw; proximal fibular treatment unnecessary



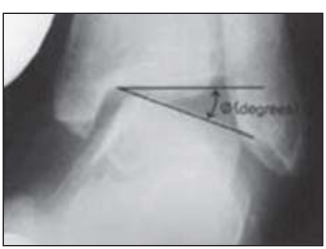
Medial view



Posterior view with ligaments

Identify each condition

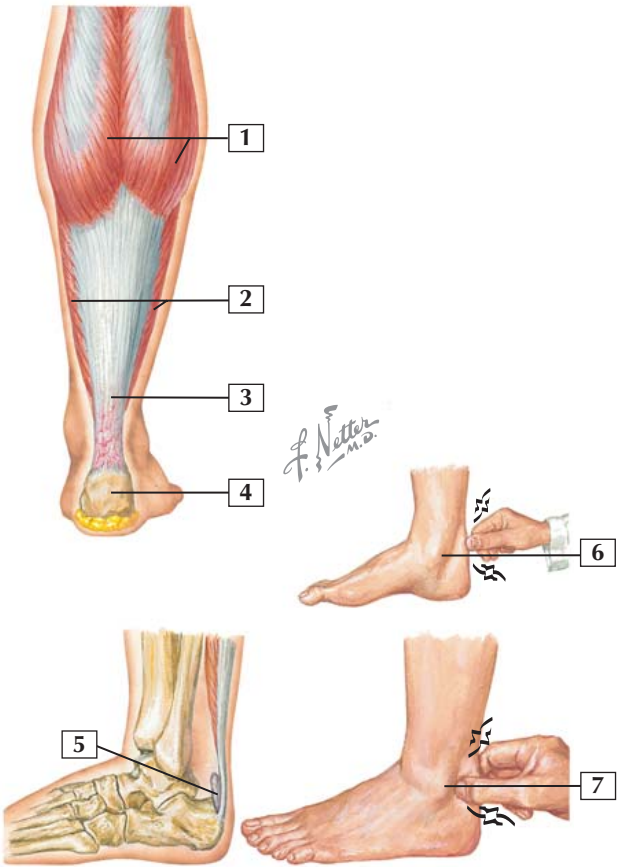
8



9

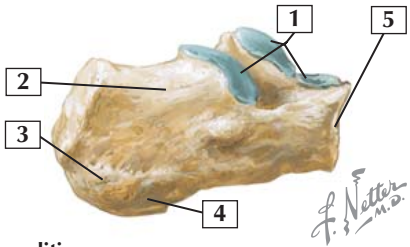
1. Interosseous membrane
2. Posterior tibiofibular ligament
3. Posterior inferior talofibular ligament
4. Calcaneofibular ligament
5. Deltoid ligament
6. Anterior tibiofibular ligament
7. Anterior talofibular ligament
8. Radiographic appearance of Maisonneuve fracture
9. Stress radiograph demonstrating lateral ankle instability

	Acute Ankle Sprain	"High Ankle Sprain"	Chronic Ankle Instability
Mechanism	Eversion/plantar flexion (lateral: most common); inversion (medial)	Dorsiflexion, eversion	Recurrent ankle sprains
Signs and Symptoms	Lateral ankle pain and tenderness, edema, ecchymosis	Lateral and syndesmotic tenderness, positive squeeze test	Subjective instability, positive result of anterior drawer test
Imaging	Anteroposterior (AP), lateral, mortise radiographs to rule out fracture	AP, lateral, and mortise radiographs; may include proximal fibula to rule out Maisonneuve fracture; external rotation stress radiograph	AP, lateral, mortise radiographs; stress radiographs; magnetic resonance imaging (MRI)
Treatment	Conservative with rest, ice, compression, elevation, bracing, proprioception training	Same as for acute ankle sprain plus reassurance that recovery may take longer	Surgical stabilization (Broström procedure)


1
2
3
4
F. Netter M.D.
6
5
7

1. Gastrocnemius muscle
2. Soleus muscle
3. Achilles tendon
4. Calcaneal tuberosity
5. Retrocalcaneal bursa
6. Achilles tendonitis (area of tenderness)
7. Retrocalcaneal bursitis (area of tenderness)

	Achilles Tendinitis and Retrocalcaneal Bursitis (Haglund Disease)	Achilles Tendon Rupture
Mechanism	Overuse, repetitive motion, poorly fitted footwear	"Charge forward" pushing off the foot, jumping
Signs and Symptoms	Focal tenderness just proximal to calcaneal insertion, "pump bump," intact but painful plantar flexion and toe raises	Local pain/tenderness, "pop" or "kicked in calf" sensation, palpable tendon defect, inability to achieve plantar flexion, positive Thompson test result
Imaging	Usually not necessary	Usually not necessary; magnetic resonance imaging (MRI) can confirm tear
Treatment	Conservative with nonsteroidal antiinflammatory drugs (NSAIDs), activity modification, heel lift, or, for refractory cases, casting or fracture boot	Usually surgical repair (high rate of skin healing problems) but can be conservative with 8-12 weeks of casting with foot in plantar flexion (higher rate of recurrence)

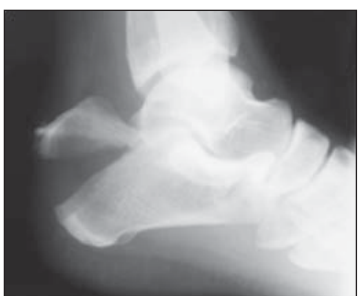


Identify each condition

6

7

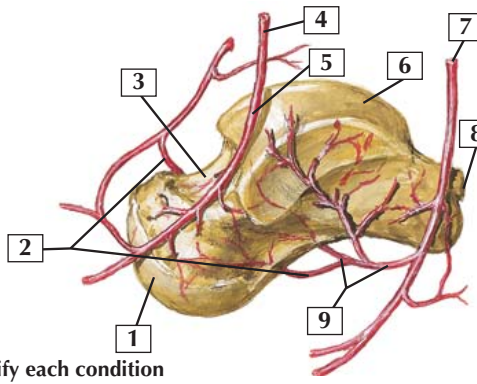
8



9

1. Anterior, middle, and posterior talar articular surface
2. Body of the calcaneus
3. Tuberosity
4. Lateral process of tuberosity
5. Articular surface for the cuboid
6. Fracture of the sustentaculum tali
7. Extraarticular fracture of the body of the calcaneus
8. Intraarticular fracture of the body of the calcaneus
9. Split "tongue" fracture

	Intraarticular Fracture	Extraarticular Fracture
Mechanism	Axial load Fall from height	Axial load Fall from height
Prognosis	Worse	Better
Treatment	Open reduction, internal fixation (ORIF)	Cast (ORIF if unstable)



Identify each condition

10

11

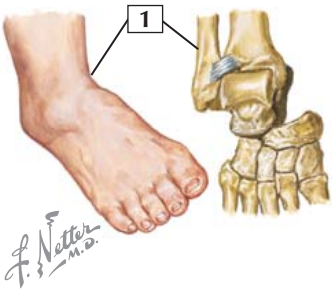
12

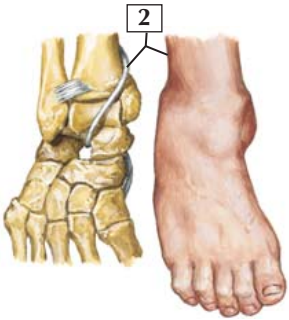
13

1. Head of talus
2. Artery of tarsal sinus
3. Neck of talus
4. Anterior tibial artery
5. Dorsalis pedis artery
6. Trochlea
7. Posterior tibial artery
8. Posterior process
9. Artery of tarsal canal
10. Hawkins type I talar neck fracture
11. Hawkins type II talar neck fracture
12. Hawkins type III talar neck fracture
13. Radiographic appearance of talar neck fracture

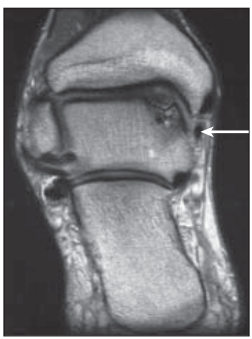
	Talar Neck Fracture	Treatment	Avascular Necrosis Risk
Hawkins Type I	Nondisplaced	Closed reduction Cast	Low
Hawkins Type II	Displaced 20%-50% Subtalar dislocation	Open reduction, internal fixation (ORIF) Early range-of-motion exercises	Intermediate
Hawkins Type III	Displaced 50%-100% Talar body dislocation	ORIF Early range-of-motion exercises	High
Hawkins Type IV	Talar head +/– body dislocation (>100%)	ORIF Early range-of-motion exercises	High

Identify each conditon

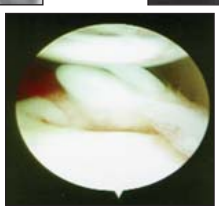




3



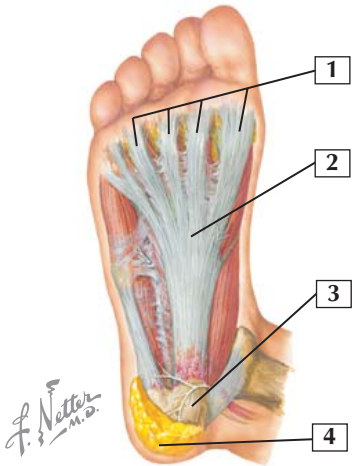
4

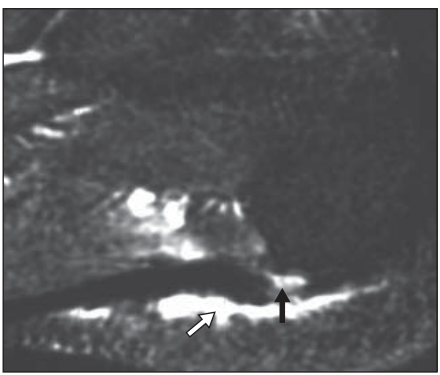


5

1. Medial subtalar dislocation
2. Lateral subtalar dislocation
3. Radiographic appearance of medial subtalar dislocation
4. Magnetic resonance imaging (MRI) appearance of talar chondral defect
5. Arthroscopic appearance of talar chondral defect

	Subtalar Dislocation (Basketball Foot)	Chondral Defects of the Talus/ Osteochondritis Dissecans (OCD)
Mechanism	High-energy trauma	Usually posttraumatic process
Classification	Medial (most common) and lateral	Descriptive: based on size and location of lesion
Signs and Symptoms	Usually obvious deformity, pain, inability to bear weight	Pain and swelling with activity, with or without mechanical catching
Imaging	Plain radiographs and computed tomography (CT) to rule out associated fracture (common)	MRI most sensitive for detecting and defining size and location
Treatment	Immediate reduction; if dislocation is irreducible, suspect interposed tendon; immobilize for 6 weeks	Nonsteroidal antiinflammatory drugs (NSAIDs), steroid injections, arthroscopic débridement with or without microfracture, cartilage plug transfer (osteochondral autograft transfer system [OATS])





5

1. Digital slips of the plantar aponeurosis
2. Plantar aponeurosis
3. Tuberosity of the calcaneus
4. Calcaneal fat pad
5. Plantar fasciitis appearance on magnetic resonance imaging (MRI)

	Plantar Fasciitis	Pes Planus
Mechanism	Overuse, repetitive microtrauma	Congenital, acquired (tibialis posterior tendon dysfunction)
Signs and Symptoms	Focal pain/tenderness over plantar aspect of heel, pain worse in morning with first steps	May be symptomatic with aching pain or asymptomatic
Imaging	Not usually necessary but may show calcaneal bone spur	Not usually necessary
Treatment	Nonsteroidal antiinflammatory drugs (NSAIDs), injections, bracing/night splints, stretching, extracorporeal shock wave therapy, rarely surgical release	Flexible deformities: usually with calf stretches and orthotics; rigid: with failed conservative treatment require arthrodesis

MRI from Osborne J, Warner J, Fu F, et al: MRI-Arthroscopy Correlative Atlas. Philadelphia: WB Saunders, 1997.

Identify each condition

1

2

1. Classic deformity associated with Charcot joint
2. Radiographic appearance of Charcot joint

	Diabetic Ulcers	Neuropathic Arthropathy (Charcot Foot)
Mechanism	Ischemic and/or neurotrophic with underlying infection	Progressive neuropathy from prolonged hyperglycemia
Signs and Symptoms	Often asymptomatic with varying degree of depth of tissue infection and necrosis	Decreased sensation, ulcers, edema, erythema/warmth, deformity
Imaging	Magnetic resonance imaging (MRI) to rule out osteomyelitis; perfusion studies (ankle/brachial index, Doppler imaging)	Standing anteroposterior (AP), lateral, and oblique views (osseous destruction, subluxation)
Treatment	Initially antibiotics and débridement, varying level amputations for advanced disease (based on vascular status)	Skin treatment, immobilization Surgical débridement, arthrodesis

Identify each condition

1

2

3

4

5

1. Radiographic appearance of osteoarthritis of the ankle joint
2. Radiographic appearance of osteoarthritis of the 1st metatarsophalangeal (MTP) joint
3. Characteristic deformities of rheumatoid arthritis
4. Acute appearance of gout of 1st MTP
5. Chronic appearance of gout of 1st MTP

	Osteoarthritis	Rheumatoid Arthritis	Gouty Arthritis
Mechanism	Degenerative or posttraumatic process	Systemic inflammatory arthropathy	Deposition of uric acid crystals in the joint
Signs and Symptoms	Pain, swelling, and deformity of affected joint (ankle; metatarsophalangeal [MTP], proximal interphalangeal [PIP], and distal interphalangeal [DIP] joints)	Usually bilateral pain, swelling, forefoot deformity	Pain, tenderness, redness, warmth of affected joint (MTP and ankle most common)
Imaging	Anteroposterior (AP) and lateral radiographs of affected joint (joint space narrowing, osteophytes, sclerosis)	AP and lateral radiographs Laboratory studies (including erythrocyte sedimentation rate [ESR], C-reactive protein [CRP], rheumatoid factor [RF])	AP and lateral radiographs often show bony erosions Laboratory studies (including crystal analysis of aspirated synovial fluid)
Treatment	Activity modification, nonsteroidal antiinflammatory drugs (NSAIDs), intraarticular injections, fusion, arthroplasty	Extra-depth shoes, bracing, surgical correction of significant deformity (arthrodesis)	Indomethacin, colchicine, avoidance of purine-rich foods

Identify each condition

1

2

3

4

5

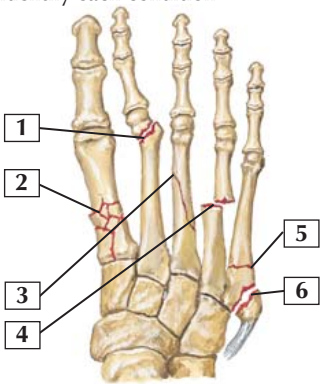
6

7

1. Homolateral dislocations of the Lisfranc joint (fracture of base 2nd metatarsal)
2. Isolated dislocation of the Lisfranc joint (involves 1 or 2 metatarsals)
3. Divergent dislocation of the Lisfranc joint (1st metatarsal medial, others lateral)
4. Dorsolateral dislocation
5. Classic mechanism of Lisfranc injury
6. Radiographic appearance of Lisfranc injury
7. Jones fracture

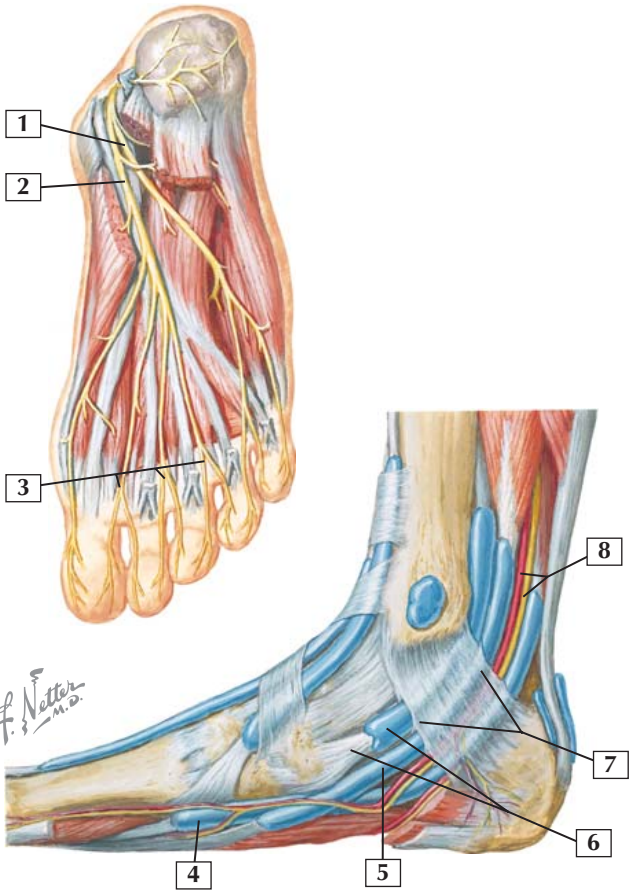
	Lisfranc Fracture-Dislocation	Jones Fracture (Base of 5th Metatarsal)
Mechanism	Indirect rotational force with axial load on plantar flexed foot	Plantar flexion/inversion
Signs and Symptoms	Midtarsal pain/tenderness/swelling	Focal pain and tenderness over base 5th metatarsal
Pattern	Based on direction of dislocation	Fracture of the metadiaphyseal junction, differentiated from avulsion fracture of the peroneus brevis tendon insertion
Imaging	Anteroposterior (AP), lateral, oblique radiographs Computed tomography (CT)	AP and lateral foot radiographs
Treatment	Closed reduction; open reduction, internal fixation (ORIF) if displacement is significant	Non–weight-bearing cast if fracture is nondisplaced ORIF with intramedullary screw if fracture is displaced or if patient is a competitive athlete (high rate of nonunion)

Identify each condition



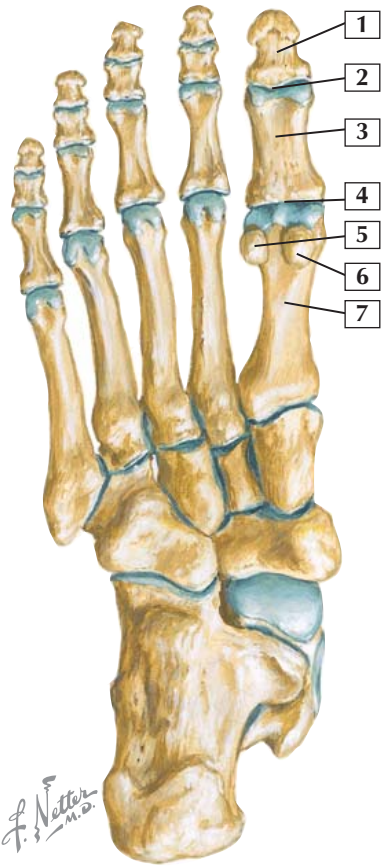
1. Displaced oblique fracture, 2nd metatarsal neck
2. Comminuted, non-displaced fracture, base 1st metatarsal
3. Oblique fracture of the body, 3rd metatarsal
4. Displaced transverse fracture of the body, 4th metatarsal
5. Fracture of the base of the 5th metatarsal (Jones fracture)
6. Avulsion fracture, base 5th metatarsal
7. Sesamoid fracture
8. Transverse fracture, 2nd proximal phalanx
9. Displaced fractures of 2nd and 3rd metatarsal necks
10. Freiberg infarction

	Metatarsal and Phalangeal Fractures	Freiberg Infarction	Metatarsalgia
Mechanism	Direct trauma, fall, stress fracture	Avascular necrosis of the 2nd metatarsal head caused by stress overload	Overuse especially related to impact activity
Signs and Symptoms	Focal tenderness, pain with weightbearing, ecchymosis	Pain with walking/ running, localized tenderness	Gradual onset of pain over one or more metatarsal heads with or without symptoms of interdigital neuroma
Imaging	Anteroposterior (AP), lateral, and oblique radiographs; magnetic resonance imaging (MRI) or bone scan for stress fractures	Standing AP, lateral, and oblique radiographs (flattening of 2nd metatarsal head)	AP, lateral, and oblique radiographs to rule out fracture
Treatment	Nondisplaced fracture: cast or fracture shoe Displaced fracture: surgical open reduction, internal fixation (ORIF)	Rest, padding, activity modification	Activity modification, metatarsal bar, orthotics, local digital nerve block


1
2
3
8
7
6
5
4
F. Netter M.D.

1. Lateral plantar nerve
2. Medial plantar nerve
3. Common plantar digital nerves
4. Tendinous sheath of flexor hallucis longus
5. Tendinous sheath of flexor digitorum longus
6. Tibialis posterior tendon and sheath
7. Flexor retinaculum
8. Posterior tibial artery and tibial nerve

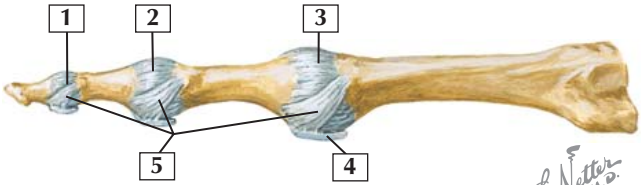
	Tarsal Tunnel Syndrome	Interdigital (Morton) Neuroma
Pathophysiology	Impingement of the posterior tibial neurovascular bundle as it passes under the flexor retinaculum (tarsal tunnel)	Enlargement of the common digital nerve, usually in the 3rd web space, from degeneration, repetitive trauma, or constricting footwear
Signs and Symptoms	Diffuse pain in ankle and foot, tenderness over tarsal tunnel	Diffuse pain, dysesthesia, and paresthesias usually in toes 3 and 4; tenderness in 3rd web space
Imaging	Radiographs are not usually helpful, but electromyography is useful	Radiographs to rule out fracture MRI is not necessary but can confirm
Treatment	Footwear and activity modification; surgical release for refractory cases	Wide-toe shoe, metatarsal bar or pad, steroid injection Surgical excision of neuroma for refractory cases



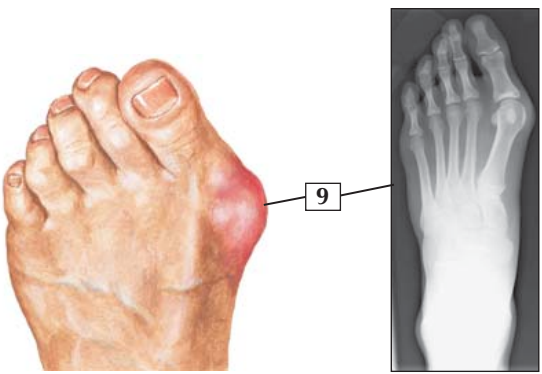
8

1. Great toe distal phalanx
2. 1st Distal interphalangeal joint
3. Great toe proximal phalanx
4. 1st Metatarsophalangeal (MTP) joint
5. Lateral sesamoid
6. Medial sesamoid
7. 1st Metatarsal
8. Radiographic appearance of sesamoid fracture

	Sesamoid Fractures	Turf Toe
Mechanism	Direct trauma, stress reaction	Hyperextension of the 1st MTP joint
Signs and Symptoms	Focal pain and tenderness	Pain worse with "toe-off"; local tenderness
Imaging	Anteroposterior (AP), lateral, and oblique radiographs of the foot; bone scan to rule out bipartite sesamoid (present in 10% of population)	AP, lateral, and oblique radiographs may reveal sesamoid fracture or proximal displacement of the sesamoid
Treatment	Rest and padding; surgery (partial excision) for refractory cases	Rest, ice, taping, hard shoe insert



Identify each condition



1. Distal interphalangeal (DIP) joint
2. Proximal interphalangeal (PIP) joint
3. Metatarsophalangeal (MTP) joint
4. Plantar plate
5. Collateral ligaments
6. Hammer toe
7. Mallet toe
8. Claw toe
9. Hallux valgus (bunion)

Lesser Toe Deformities	Affected Joint	Joint Deformity
Mallet Toe	DIP	Flexion
Hammer Toe	PIP	Flexion
Claw Toe	MTP	Hyperextension

	Hallux Valgus (Bunion)
Pathophysiology	Increase in the valgus angle of the 1st MTP joint
Mechanism	Multifactorial, including genetics, footwear, individual anatomy
Signs and Symptoms	Obvious deformity; redness/tenderness over medial MTP
Imaging	Weight-bearing anteroposterior (AP) and lateral radiographs
Treatment	Footwear and activity modification with metatarsal osteotomy for refractory or severely deformed cases