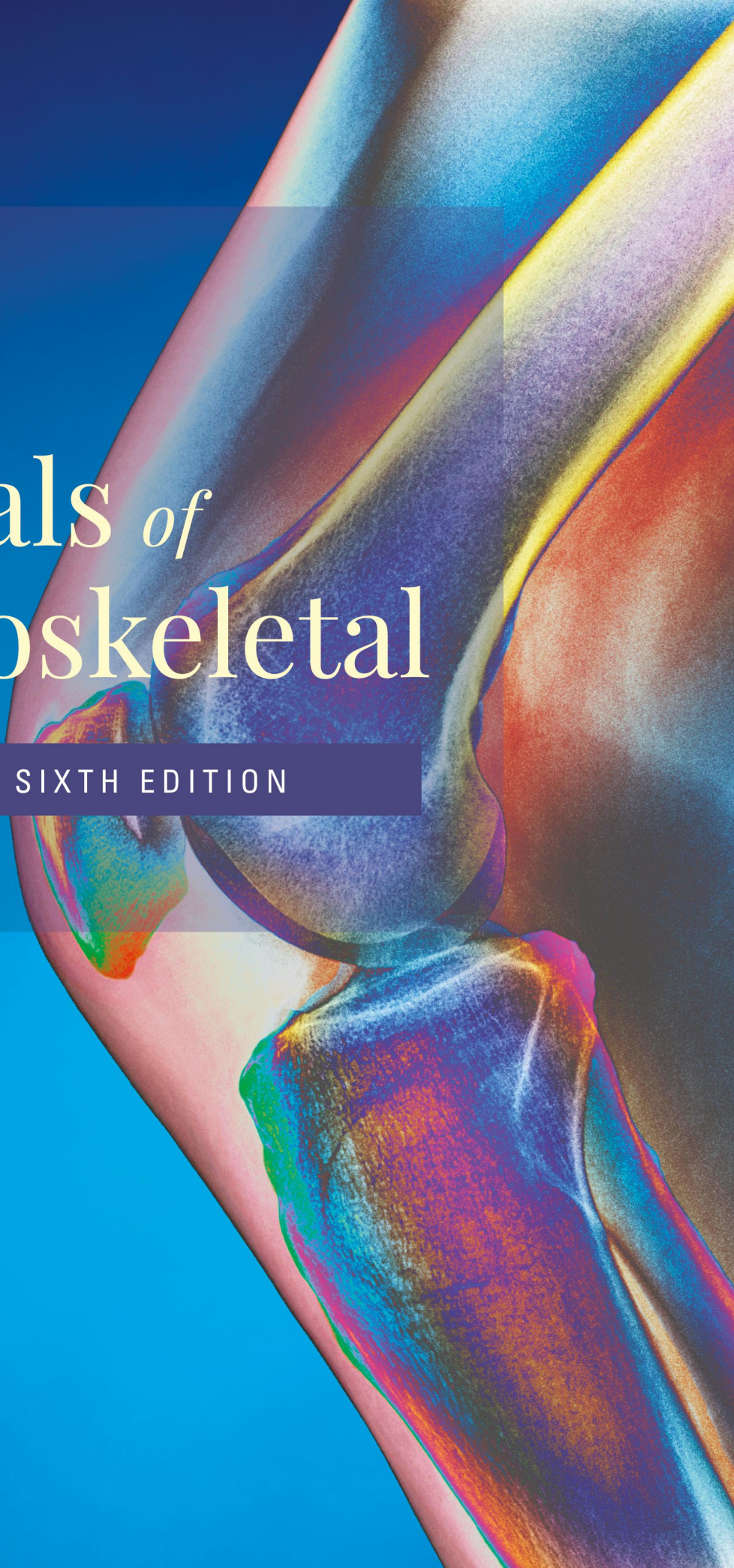
AAOS Essentials of Musculoskeletal Care

SIXTH EDITION



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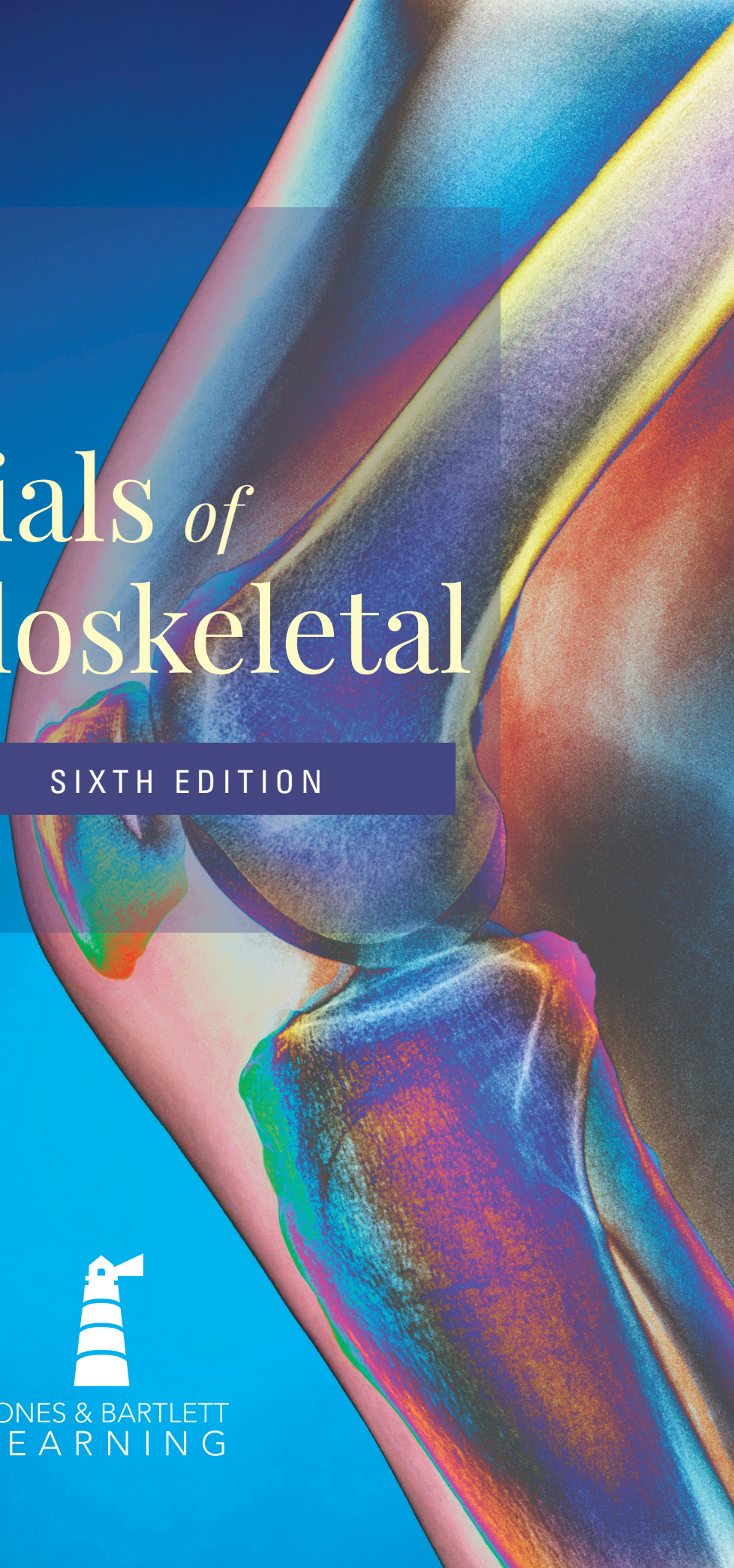

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Dedication

To health care providers everywhere—who devote their careers to the health and well-being of individual patients and families, both young and old.

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Preface

Essentials of Musculoskeletal Care, *Sixth Edition* is a robust educational resource focused on how to evaluate and manage common musculoskeletal conditions. This text is used for immediate, point-of-care guidance in decision making and intervention and is a powerful educational product for many health professions dealing with the care of the musculoskeletal system. The easy-to-understand content and crisp presentation appeal to health care professionals and students. It is also a powerful tool to help educate patients regarding conditions and treatment.

What's New in the Sixth Edition?

General New Features

- Added Learning Outcomes and Key Terms to the chapter opener for each section
- Added Clinical Case Studies to the end of each section
- Added Bibliography organized by section to the back matter

Section 1: General Orthopaedics

- Reorganized content into subcategories to make it easier to find related content
- Added new subcategory on regenerative medicine with subsections on orthopaedic biologics and cartilage
- Revised previous overuse syndromes subsection into two new subsections on soft-tissue injuries and stress fractures
- Moved all body part–specific home exercise programs into a new section on musculoskeletal conditioning
- Removed section on diffuse idiopathic skeletal hyperostosis

Section 2: Shoulder

- Added information on inferior glenohumeral dislocation and glenohumeral internal rotation deficit to Physical Examination of the Shoulder
- Updated information on clavicle fractures and the treatment of scapula fractures

Section 3: Elbow and Forearm

- Added the hook test to the physical examination of the biceps brachii
- Updated lateral radiograph of an elbow demonstrating an olecranon fracture
- Updated information on lateral and medial epicondylitis; the procedure for performing a tennis elbow injection; olecranon bursitis, including the procedure for an olecranon bursa aspiration; nerve compression syndromes; rupture of the distal biceps tendon; and ulnar collateral ligament tears

Section 4: Hand and Wrist

- Updated general overview of the hand and wrist, including evaluation of pain location, causes of stiffness, and diagnostic modalities used in evaluation
- Updated information on animal bite injuries; arthritis of the hand, thumb carpometacarpal joint, and wrist; de Quervain tenosynovitis; Dupuytren contracture; fingertip injuries/amputations; flexor tendon injuries; hook of hamate nonunion; diagnostic tests for scaphoid fracture; treatment of Kienböck disease; and nail bed injuries
- Updated information on performing a physical examination of the hand and wrist, a thumb carpometacarpal joint injection, and digital anesthetic block on the hand

Section 5: Hip and Thigh

- Moved Osteonecrosis of the Hip to appear after Dislocation of the Hip (Acute, Traumatic)
- Created new subsection on muscle contusion
- Updated information on trochanteric bursitis/greater trochanteric pain syndrome

Section 6: Knee and Lower Leg

- Updated overview of the knee and lower leg and information on performing a physical examination
- Updated information on anterior cruciate ligament tear, knee joint aspiration, arthritis of the knee, bursitis of the knee, claudication, collateral ligament tear, fractures, gastrocnemius tear, meniscal tear, osteonecrosis of the femoral condyle, patellar/quadriceps tendinopathy, patellofemoral maltracking, posterior cruciate ligament tear, and stress fracture
- Added new subsection on meniscus root avulsion

Section 7: Foot and Ankle

- Moved location of Shoe Wear to follow Physical Examination of the Foot and Ankle.
- Updated information on overview of foot and ankle; Achilles tendon tear; arthritis; corns and calluses; care of diabetic foot; fractures of the midfoot, ankle, metatarsals, and sesamoid; hallux rigidus; nail fungus infection; and plantar fasciitis

Section 8: Spine

- Updated information on overview of the spine, physical examination of the spine, cauda equina

syndrome, cervical spondylosis, acute low back pain, lumbar spinal stenosis, and spinal orthoses.

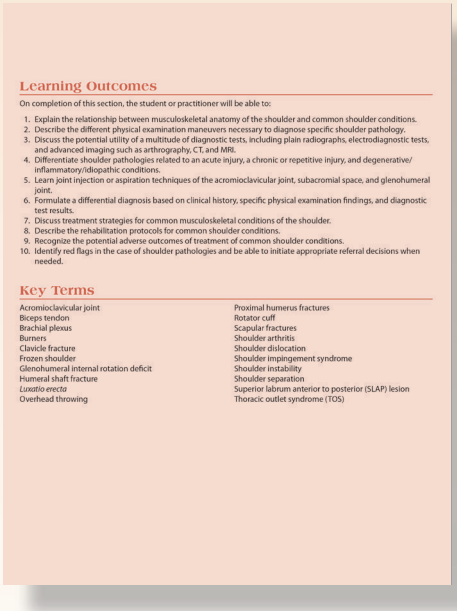
Section 9: Pediatric Orthopaedics

- Updated information on overview of pediatric orthopaedics and pediatric physical examination; pain in the anterior knee, elbow, foot, and ankle; calcaneal apophysitis; cavus foot deformity; concussion; developmental dysplasia of the hip; fractures; genu valgum; intoeing/outtoeing; Legg-Calvé-Perthes disease, little leaguer's elbow; osteochondritis dissecans; pediatric sports participation and preparticipation physical evaluation; scoliosis; and slipped capital femoral epiphysis
- Moved locations of section on pes planus and talipes equinovarus
- Removed Procedure on Hip Aspiration

How to Use This Text

Essentials of Musculoskeletal Care provides concise content in a practical and easy-to-use format.

Learning Outcomes and **Key Terms** open each section and help the reader focus on important takeaways and information.



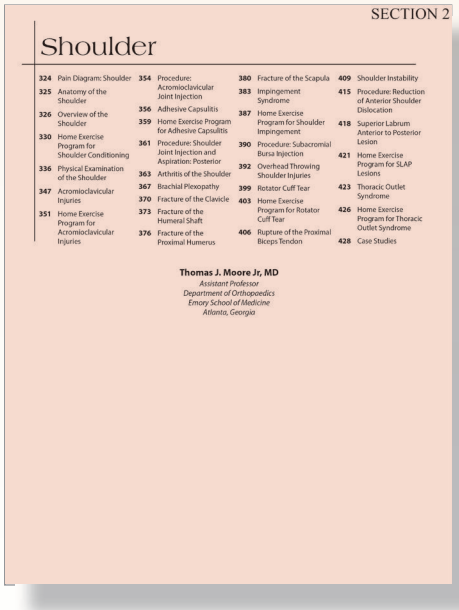
Learning Outcomes

On completion of this section, the student or practitioner will be able to:

1. Explain the relationship between musculoskeletal anatomy of the shoulder and common shoulder conditions.
2. Describe the different physical examination maneuvers necessary to diagnose specific shoulder pathology.
3. Discuss the potential utility of a multitude of diagnostic tests, including plain radiographs, electrodiagnostic tests, and advanced imaging such as arthrography, CT, and MRI.
4. Differentiate shoulder pathologies related to an acute injury, a chronic or repetitive injury, and degenerative/inflammatory/idiopathic conditions.
5. Learn joint injection or aspiration techniques of the acromioclavicular joint, subacromial space, and glenohumeral joint.
6. Formulate a differential diagnosis based on clinical history, specific physical examination findings, and diagnostic test results.
7. Discuss treatment strategies for common musculoskeletal conditions of the shoulder.
8. Describe the rehabilitation protocols for common shoulder conditions.
9. Recognize the potential adverse outcomes of treatment of common shoulder conditions.
10. Identify red flags in the case of shoulder pathologies and be able to initiate appropriate referral decisions when needed.

Key Terms

Acromioclavicular joint
Biceps tendon
Brachial plexus
Burners
Clavicle fracture
Frozen shoulder
Glenohumeral internal rotation deficit
Humeral shaft fracture
Luxatio erecta
Overhead throwing
Proximal humerus fractures
Rotator cuff
Scapular fractures
Shoulder arthritis
Shoulder dislocation
Shoulder impingement syndrome
Shoulder instability
Shoulder separation
Superior labrum anterior to posterior (SLAP) lesion
Thoracic outlet syndrome (TOS)



SECTION 2

Shoulder

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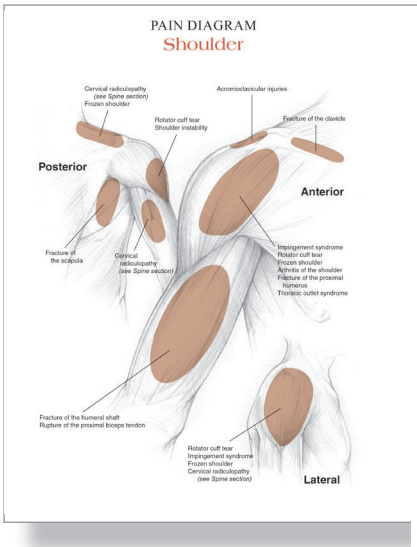
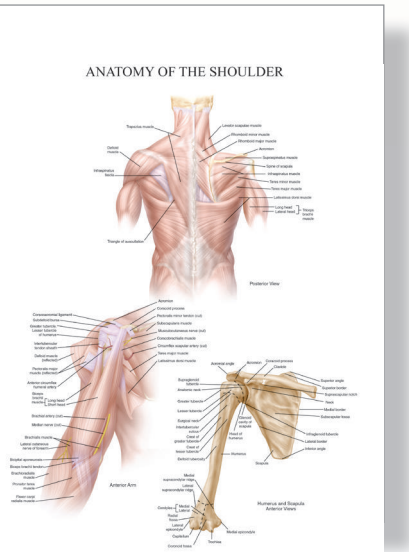
Table of Contents lists conditions in alphabetical order as well as Procedures and Home Exercise Programs.

Pain Diagram is found at the beginning of each section and shows areas of pain and identifies conditions typically associated with each pain location.

Anatomic art can be found at the beginning of each section for handy reference.





Physical Examination shows photographs and step-by-step descriptions of physical examination maneuvers: inspection and palpation, range of motion, muscle testing, and special tests. Icon indicates that an accompanying video is available on Navigate Premier.

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Physical Examination of the Shoulder

Inspection/Palpation

Anterior View

With the patient standing, inspect for abnormal contours and bony prominences. An acromioclavicular separation produces a "step-off" deformity with prominence of the distal clavicle. An anterior **shoulder dislocation** produces a prominent posterior acromion and anterior fullness of the deltoid, and the arm typically is held in slight abduction and external rotation. By contrast, with a posterior dislocation, the coracoid and anterior acromion are prominent, there is posterior fullness, and the arm is held in adduction and internal rotation. In the rare situation of an inferior glenohumeral dislocation, termed ***luxatio erecta***, the shoulder is held maximally abducted, fixed in place.

Acromioclavicular Joint

To evaluate the **acromioclavicular joint**, palpate the distal clavicle and the acromion for tenderness or spurs. Tenderness usually is most pronounced at the posterior joint interval and is exaggerated when the patient horizontally adducts the arm toward the opposite shoulder.

Subacromial Bursa

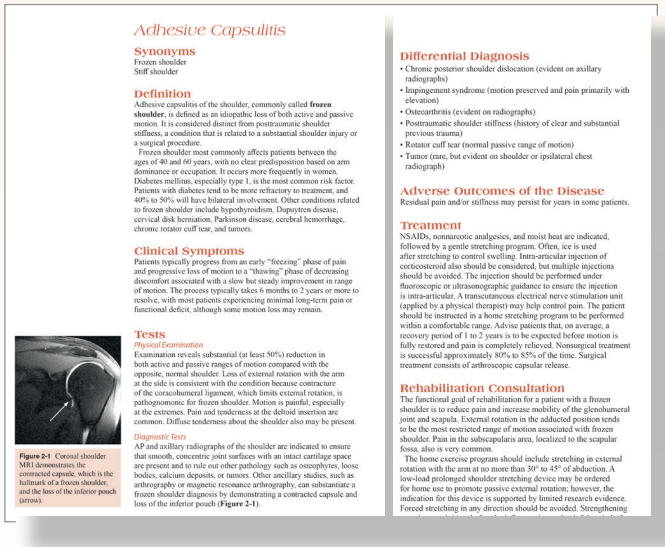
To evaluate the subacromial bursa, palpate the anterolateral portion of the acromion, moving down toward the deltoid until you feel the acromiohumeral sulcus. Tenderness in this area usually is related to subacromial bursitis or a rotator cuff tear (supraspinatus tendon).

Posterior View

With the patient standing, note symmetry of shoulder heights and contours. (The dominant shoulder often rests slightly lower than the opposite shoulder.) Look for muscle atrophy, particularly of the trapezius, deltoid, and infraspinatus muscles. Diminished posterior contour from neck to shoulder indicates atrophy of the trapezius. With atrophy of the supraspinatus/infraspinatus muscles, loss of lateral shoulder contour occurs at the deltoid, and a prominent scapular spine can be seen. While viewing the posterior shoulder, have the patient elevate both arms in the scapular plane and evaluate both sides for any scapula dyskinesia (not shown in the video).

Long Head of the Biceps Tendon

To evaluate the long head of the **biceps tendon**, palpate over the humeral head in the region of the bicipital groove. With tendinitis, there is tenderness and swelling, and the area of tenderness should move with the humeral head as the shoulder is rotated.



Adhesive Capsulitis

Synonyms
Frozen shoulder
Stiff shoulder

Definition
Adhesive capsulitis of the shoulder, commonly called **frozen shoulder**, is defined as an idiopathic loss of both active and passive motion. It is considered distinct from posttraumatic shoulder stiffness, a condition that is related to a substantial shoulder injury or a surgical procedure.
Frozen shoulder most commonly affects patients between the ages of 40 and 60 years, with no clear predisposition based on arm dominance or occupation. It occurs more frequently in women. Diabetes mellitus, especially type 1, is the most common risk factor. Patients with diabetes tend to be more refractory to treatment, and 40% to 50% will have bilateral involvement. Other conditions related to frozen shoulder include hypothyroidism, Dupuytren disease, cervical disk herniation, Parkinson disease, cerebral hemorrhage, chronic rotator cuff tear, and tumors.

Clinical Symptoms
Patients typically progress from an early "freezing" phase of pain and progressive loss of motion to a "thawing" phase of decreasing discomfort associated with a slow but steady improvement in range of motion. The process typically takes 6 months to 2 years or more to resolve, with most patients experiencing minimal long-term pain or functional deficit, although some motion loss may remain.

Tests
Physical Examination
Examination reveals substantial (at least 50%) reduction in both active and passive ranges of motion compared with the opposite, normal shoulder. Loss of external rotation with the arm at the side is consistent with the condition because contracture of the coracohumeral ligament, which limits external rotation, is pathognomonic for frozen shoulder. Motion is painful, especially at the extremes. Pain and tenderness at the deltoid insertion are common. Diffuse tenderness about the shoulder also may be present.

Diagnostic Tests
AP and axillary radiographs of the shoulder are indicated to ensure that smooth, concentric joint surfaces with an intact cartilage space are present and to rule out other pathology such as osteophytes, loose bodies, calcium deposits, or tumors. Other ancillary studies, such as arthrography or magnetic resonance arthrography, can substantiate a frozen shoulder diagnosis by demonstrating a contracted capsule and loss of the inferior pouch (**Figure 2-1**).

Figure 2-1 Coronal shoulder MRI demonstrates the contracted capsule, which is the hallmark of a frozen shoulder, and the loss of the inferior pouch (arrow).

Differential Diagnosis
- Chronic posterior shoulder dislocation (evident on axillary radiographs)
- Impingement syndrome (motion preserved and pain primarily with elevation)
- Osteoarthritis (evident on radiographs)
- Posttraumatic shoulder stiffness (history of clear and substantial previous trauma)
- Rotator cuff tear (normal passive range of motion)
- Tumor (rare, but evident on shoulder or ipsilateral chest radiograph)

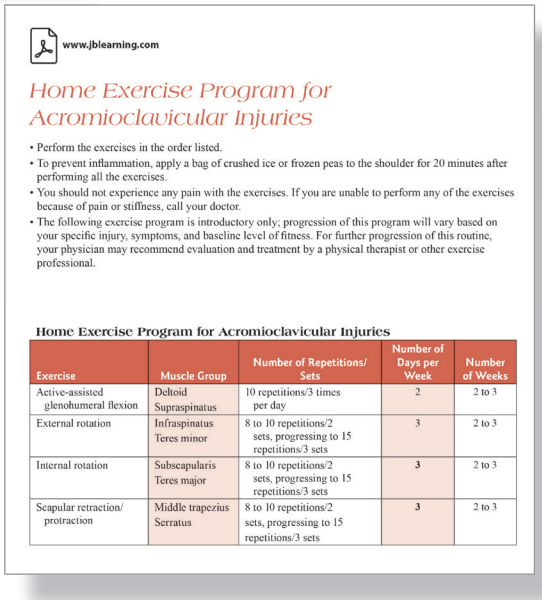
Adverse Outcomes of the Disease
Residual pain and/or stiffness may persist for years in some patients.

Treatment
NSAIDs, nonnarcotic analgesics, and moist heat are indicated, followed by a gentle stretching program. Often, ice is used after stretching to control swelling. Intra-articular injection of corticosteroid also should be considered, but multiple injections should be avoided. The injection should be performed under fluoroscopic or ultrasonographic guidance to ensure the injection is intra-articular. A transcutaneous electrical nerve stimulation unit (applied by a physical therapist) may help control pain. The patient should be instructed in a home stretching program to be performed within a comfortable range. Advise patients that, on average, a recovery period of 1 to 2 years is to be expected before motion is fully restored and pain is completely relieved. Nonsurgical treatment is successful approximately 80% to 85% of the time. Surgical treatment consists of arthroscopic capsular release.

Rehabilitation Consultation
The functional goal of rehabilitation for a patient with a frozen shoulder is to reduce pain and increase mobility of the glenohumeral joint and scapula. External rotation in the adducted position tends to be the most restricted range of motion associated with frozen shoulder. Pain in the subscapularis area, localized to the scapular fossa, also is very common.
The home exercise program should include stretching in external rotation with the arm at no more than 30° to 45° of abduction. A low-load prolonged shoulder stretching device may be ordered for home use to promote passive external rotation; however, the indication for this device is supported by limited research evidence. Forced stretching in any direction should be avoided. Strengthening

Conditions chapters include:
- Synonyms
- Clinical symptoms
- Physical examination notes
- Diagnostic tests
- Differential diagnosis
- Adverse outcomes of the disease
- Treatment
- Rehabilitation prescription
- Adverse outcomes of treatment
- Referral decisions/red flags

Home Exercise Program includes:
- Symbol indicating the availability of a customizable, printable PDF of the home exercise program
- Concise table of exercises
- Step-by-step instructions and illustrations



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Home Exercise Program for Acromioclavicular Injuries

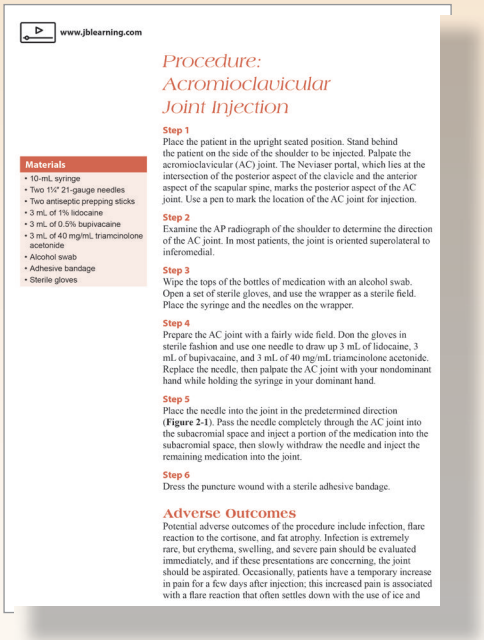
- Perform the exercises in the order listed.
- To prevent inflammation, apply a bag of crushed ice or frozen peas to the shoulder for 20 minutes after performing all the exercises.
- You should not experience any pain with the exercises. If you are unable to perform any of the exercises because of pain or stiffness, call your doctor.
- The following exercise program is introductory only; progression of this program will vary based on your specific injury, symptoms, and baseline level of fitness. For further progression of this routine, your physician may recommend evaluation and treatment by a physical therapist or other exercise professional.

Home Exercise Program for Acromioclavicular Injuries

Exercise	Muscle Group	Number of Repetitions/ Sets	Number of Days per Week	Number of Weeks
Active-assisted glenohumeral flexion	Deltoid Supraspinatus	10 repetitions/3 times per day	2	2 to 3
External rotation	Infraspinatus Teres minor	8 to 10 repetitions/2 sets, progressing to 15 repetitions/3 sets	3	2 to 3
Internal rotation	Subscapularis Teres major	8 to 10 repetitions/2 sets, progressing to 15 repetitions/3 sets	3	2 to 3
Scapular retraction/ protraction	Middle trapezius Serratus	8 to 10 repetitions/2 sets, progressing to 15 repetitions/3 sets	3	2 to 3

Procedures include:

- Symbol indicating video is available on Navigate Premier
- List of materials
- Step-by-step instructions



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Procedure: Acromioclavicular Joint Injection

Materials

- 10-mL syringe
- Two 1½" 21-gauge needles
- Two antiseptic prepping sticks
- 3 mL of 1% lidocaine
- 3 mL of 0.5% bupivacaine
- 3 mL of 40 mg/mL triamcinolone acetonide
- Alcohol swab
- Adhesive bandage
- Sterile gloves

Step 1
Place the patient in the upright seated position. Stand behind the patient on the side of the shoulder to be injected. Palpate the acromioclavicular (AC) joint. The Neviaser portal, which lies at the intersection of the posterior aspect of the clavicle and the anterior aspect of the scapular spine, marks the posterior aspect of the AC joint. Use a pen to mark the location of the AC joint for injection.

Step 2
Examine the AP radiograph of the shoulder to determine the direction of the AC joint. In most patients, the joint is oriented superolateral to inferomedial.

Step 3
Wipe the tops of the bottles of medication with an alcohol swab. Open a set of sterile gloves, and use the wrapper as a sterile field. Place the syringe and the needles on the wrapper.

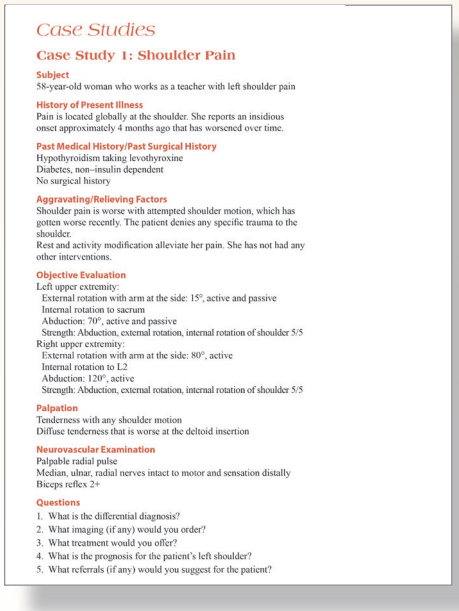
Step 4
Prepare the AC joint with a fairly wide field. Don the gloves in sterile fashion and use one needle to draw up 3 mL of lidocaine, 3 mL of bupivacaine, and 3 mL of 40 mg/mL triamcinolone acetonide. Replace the needle, then palpate the AC joint with your nondominant hand while holding the syringe in your dominant hand.

Step 5
Place the needle into the joint in the predetermined direction (**Figure 2-1**). Pass the needle completely through the AC joint into the subacromial space and inject a portion of the medication into the subacromial space, then slowly withdraw the needle and inject the remaining medication into the joint.

Step 6
Dress the puncture wound with a sterile adhesive bandage.

Adverse Outcomes

Potential adverse outcomes of the procedure include infection, flare reaction to the cortisone, and fat atrophy. Infection is extremely rare, but erythema, swelling, and severe pain should be evaluated immediately, and if these presentations are concerning, the joint should be aspirated. Occasionally, patients have a temporary increase in pain for a few days after injection; this increased pain is associated with a flare reaction that often settles down with the use of ice and



Case Studies

Case Study 1: Shoulder Pain

Subject
58-year-old woman who works as a teacher with left shoulder pain

History of Present Illness
Pain is located globally at the shoulder. She reports an insidious onset approximately 4 months ago that has worsened over time.

Past Medical History/Past Surgical History
Hypothyroidism taking levothyroxine
Diabetes, non–insulin dependent
No surgical history

Aggravating/Relieving Factors
Shoulder pain is worse with attempted shoulder motion, which has gotten worse recently. The patient denies any specific trauma to the shoulder.
Rest and activity modification alleviate her pain. She has not had any other interventions.

Objective Evaluation
Left upper extremity:
External rotation with arm at the side: 15°, active and passive
Internal rotation to sacrum
Abduction: 70°, active and passive
Strength: Abduction, external rotation, internal rotation of shoulder 5/5
Right upper extremity:
External rotation with arm at the side: 80°, active
Internal rotation to L2
Abduction: 120°, active
Strength: Abduction, external rotation, internal rotation of shoulder 5/5

Palpation
Tenderness with any shoulder motion
Diffuse tenderness that is worse at the deltoid insertion

Neurovascular Examination
Palpable radial pulse
Median, ulnar, radial nerves intact to motor and sensation distally
Biceps reflex 2+

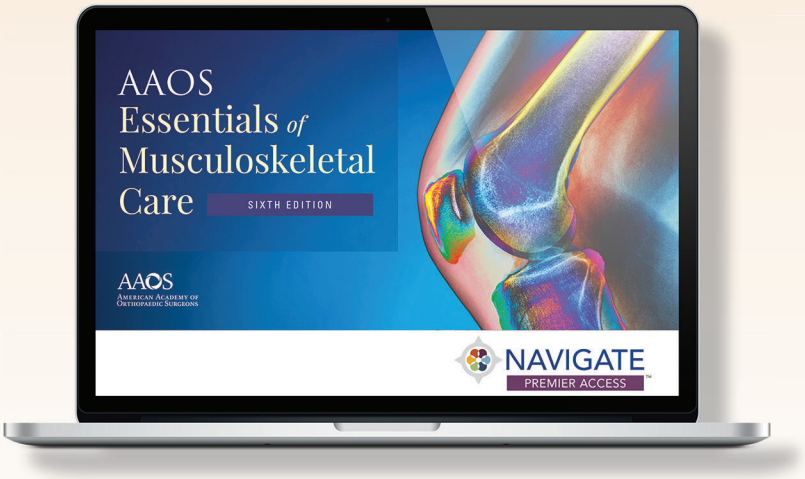
Questions
1. What is the differential diagnosis?
2. What imaging (if any) would you order?
3. What treatment would you offer?
4. What is the prognosis for the patient's left shoulder?
5. What referrals (if any) would you suggest for the patient?

Clinical Case Studies can be found at the end of each section. They allow the reader to apply the knowledge they have learned in a realistic case scenario.

Resources

Navigate Premier Access

Every new print copy of *Essentials of Musculoskeletal Care, Sixth Edition* includes Navigate Premier Access, which unlocks a complete interactive eBook with nearly 250 embedded Procedure Videos and Home Exercise step-by-step instructions in PDF format. It also includes slides in PowerPoint format to provide additional review material in each section and Skills Checklists that can be used to assess the knowledge of the competencies outlined in the videos. Additional Instructor Resources include a Test Bank that contains questions that assess the student's understanding of the content.



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Learning Outcomes

On completion of this section, the student or practitioner will be able to:

1. Discuss the components of a comprehensive orthopaedic examination.
2. Discuss common chronic inflammatory conditions that affect the musculoskeletal system.
3. Explain rehabilitation techniques and principles of musculoskeletal conditioning.
4. Discuss the types and causes of orthopaedic tumors.
5. Identify drugs, anesthesia principles, and pain management techniques in orthopaedics.
6. Identify orthopaedic injuries and conditions that commonly affect older adults.
7. Explain the principles of evaluation and treatment of orthopaedic trauma.

Key Terms

Anesthesia (orthopaedic)
Arthritis
Biologic agents
Deep vein thrombosis (DVT)
Fractures
Gout
Multimodal analgesia
Nonsteroidal anti-inflammatory drugs (NSAIDs)
Orthopaedic pain management
Overuse injuries
Regenerative medicine
Rehabilitation
Sports nutrition
Sprains
Strain

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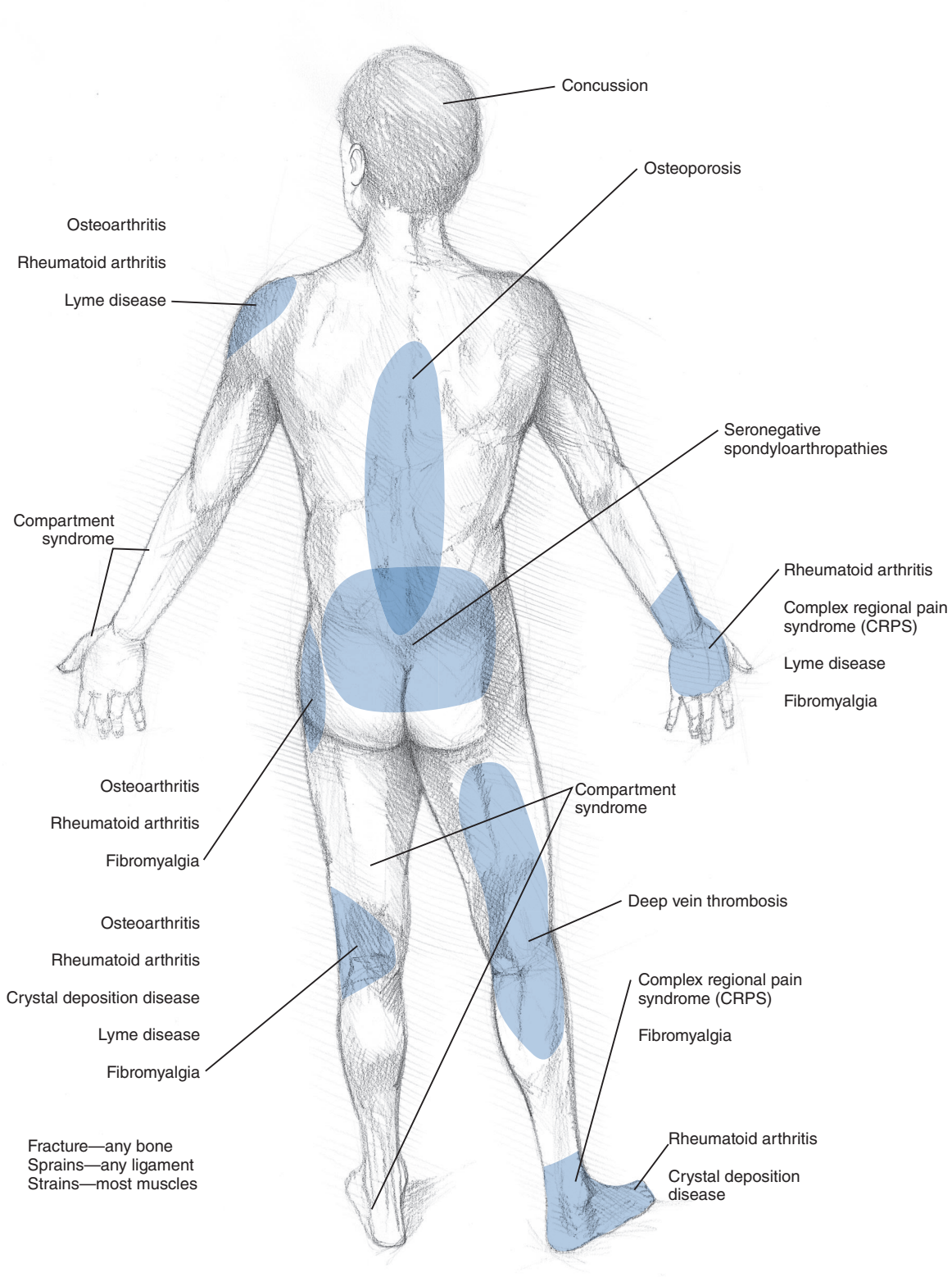
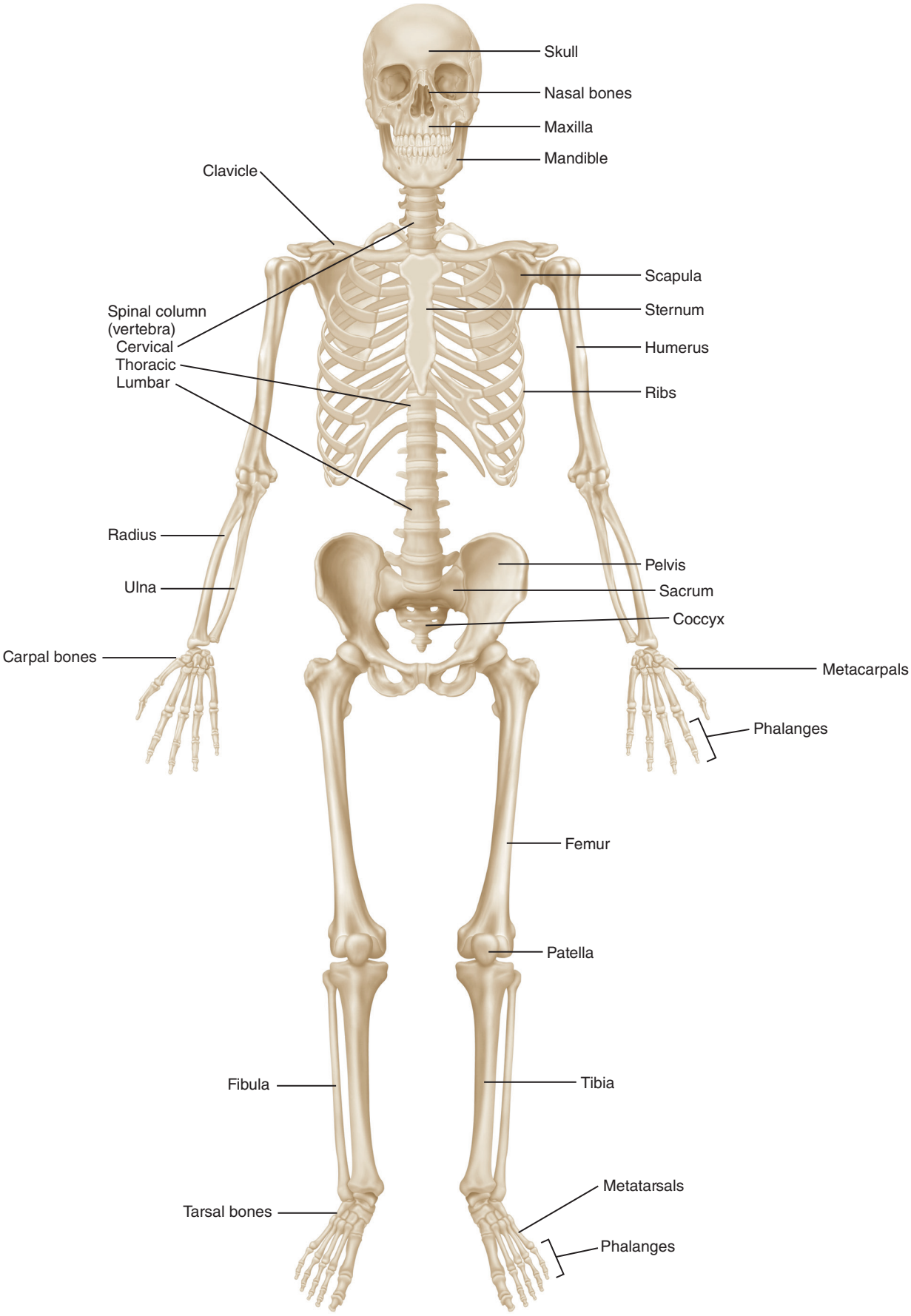
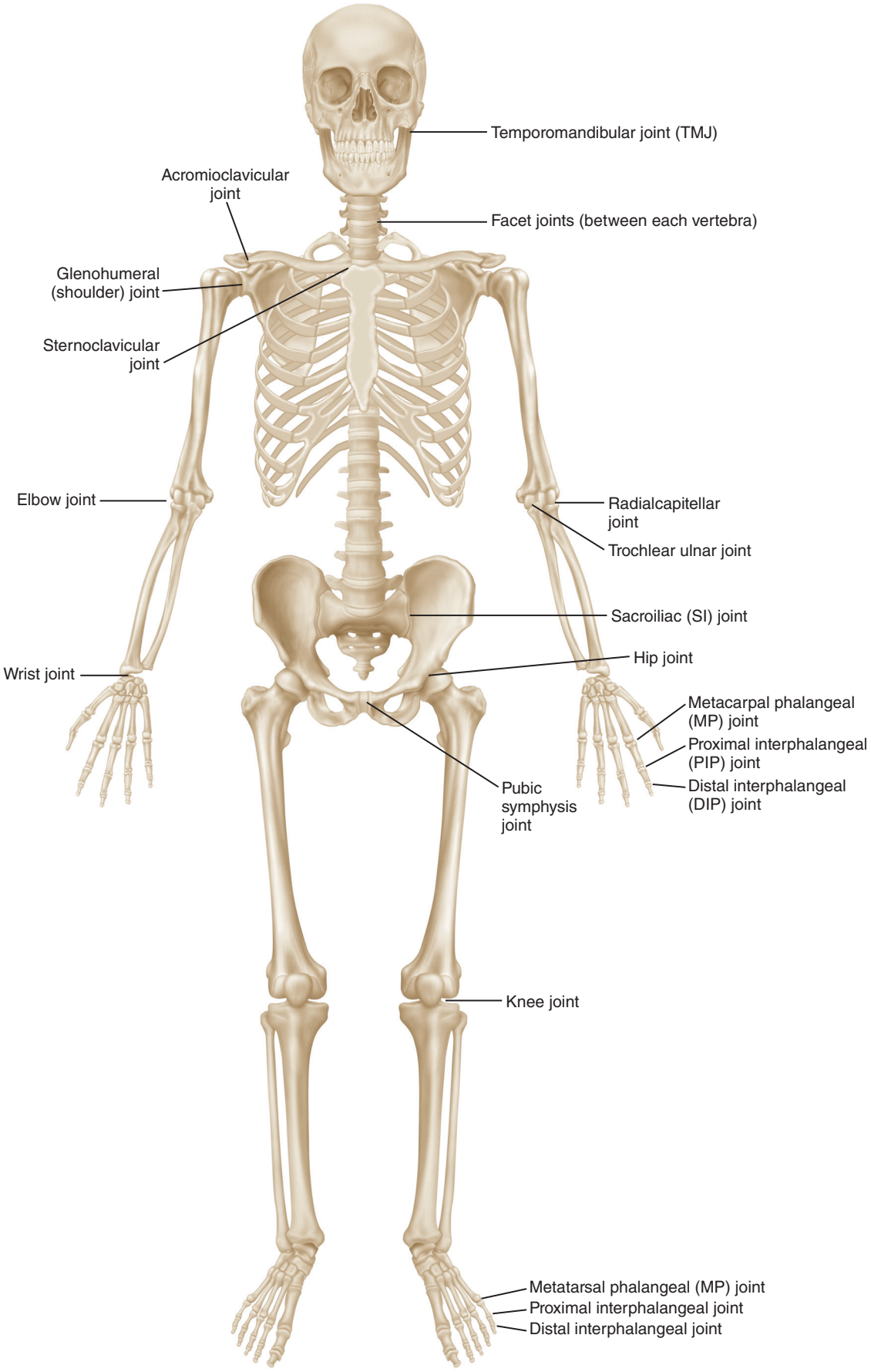
PAIN DIAGRAM
General Orthopaedics



ANATOMY: MAJOR BONES OF THE BODY



ANATOMY: MAJOR JOINTS OF THE BODY



Overview of General Orthopaedics

Bone, cartilage, muscle, tendon, ligament, and their supporting nerve and vascular supplies are the specialized structures that make up the musculoskeletal system. In combination, these structures provide remarkable strength, movement, durability, and efficiency. Disease or injury to any of these tissues may adversely affect function and the ability to perform daily activities. This General Orthopaedics section of the *Essentials of Musculoskeletal Care* describes conditions that affect multiple joints, bones, or regions and conditions that have broad systemic effects; it also contains a section on sports medicine concerns. **Table 1-1** includes a list of conditions or treatments that affect multiple joints, bones, or regions. **Table 1-2** presents conditions or treatments that have a systemic effect, and **Box 1-1** includes principles in sports medicine.

Table 1 1

Conditions or Treatments That Affect Multiple Joints, Bones, or Regions

Imaging studies	Sprains and strains
Orthobiologics	Overuse injuries
Cartilage restorative techniques	Musculoskeletal infections
Chronic inflammatory conditions	Traumatic amputations
Compartment syndrome	Tumors
Fracture management	Conditioning and rehabilitation
Falls in the elderly	Exercise fitness programs

Table 1 2

Conditions or Treatments That Have a Systemic Effect

Deep vein thrombosis	Anesthesia
Alternative medical therapies	Pain management in orthopaedics
Drugs	

Box 1-1

Important Aspects of Sports Medicine

Basic responsibilities of the team physician
Preparticipation examination
On-field management
Sports nutrition
Bracing, splinting, and taping
Return-to-play criteria
Medical/legal considerations

Principles of Musculoskeletal Evaluation

Patients presenting with musculoskeletal problems may report pain, stiffness, deformity, or weakness. General principles for evaluating these patients are described here.

History

The history of the presenting condition should include onset, location, duration, aggravators/relievers, character, and temporal factors tailored to the specific symptom or symptoms (**Table 1-1**). Additional questions about the patient's medical history, social history, and family history, and a review of systems may reveal clues that suggest the correct diagnosis. For example, substantial weight loss in a person who smokes may suggest that low back pain is secondary to metastatic disease, whereas back pain in a postmenopausal woman with a history of a fragility fracture may suggest a vertebral compression fracture. In an individual with unexplained significant joint swelling (ie, no traumatic event), a family history of inflammatory arthritis or other autoimmune diseases is important to note. In persons with musculoskeletal disorders, it is also important to understand the patient's level of function before the injury or illness.

Table 1 1

History Questions Pertinent to Musculoskeletal Conditions

Pain	Joints	Back
Nature: sharp, dull, achy, radiating, associated with fatigue or weakness?	Decreased range of motion?	Radiation to buttocks or legs?
Timing: increasing, decreasing, intermittent, related to time of day, related to activity, related to injury, and/or prior history of similar pain?	Swelling?	Midline versus paravertebral?
	Warmth/erythema?	Sharp or aching?
	Morning or activity-related pain/stiffness?	Postural or height change?
	Catching or giving way?	Paresthesias?
	Instability?	Night pain?
	Loss of function?	Bowel or bladder incontinence?
	Unilateral or bilateral?	
	Crepitus?	
	Related to deformity?	

Physical Examination

The general principles of examining the musculoskeletal system, including inspection, palpation, range of motion, muscle testing, motor and sensory evaluation, and special tests, are described in this section. The specific techniques are detailed in subsequent anatomic sections. When examining the extremities, comparison with the opposite, asymptomatic extremity often is helpful in defining the specific abnormalities in the symptomatic extremity.

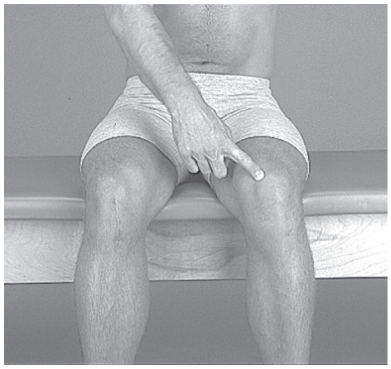


Figure 1-1 Photograph shows a patient pointing to the one spot that hurts the most; that is, localizing the point of maximal tenderness.

Inspection/Palpation

Inspect the patient's standing posture. Compare the affected extremity with the opposite extremity for any difference in symmetry or length. Note if the patient has any abnormal spine curvature or axial asymmetry. Watch the patient walk. Analyze the stance and swing phases of gait. Look for an antalgic gait, which is characterized by limited stance phase on the affected extremity. Watch for weakness of the swing-phase muscles—for example, weakness of the ankle dorsiflexors (peroneal nerve dysfunction)—which is manifested by a foot drop gait.

Ask the patient to place one finger on the one spot that hurts the most to localize the problem and narrow the differential diagnosis (**Figure 1-1**). After exposing the area, look for swelling, erythema, ecchymosis, and muscular atrophy.

Palpate the affected area for tenderness, abnormal masses, fluctuance, crepitus, or temperature changes.

Range of Motion

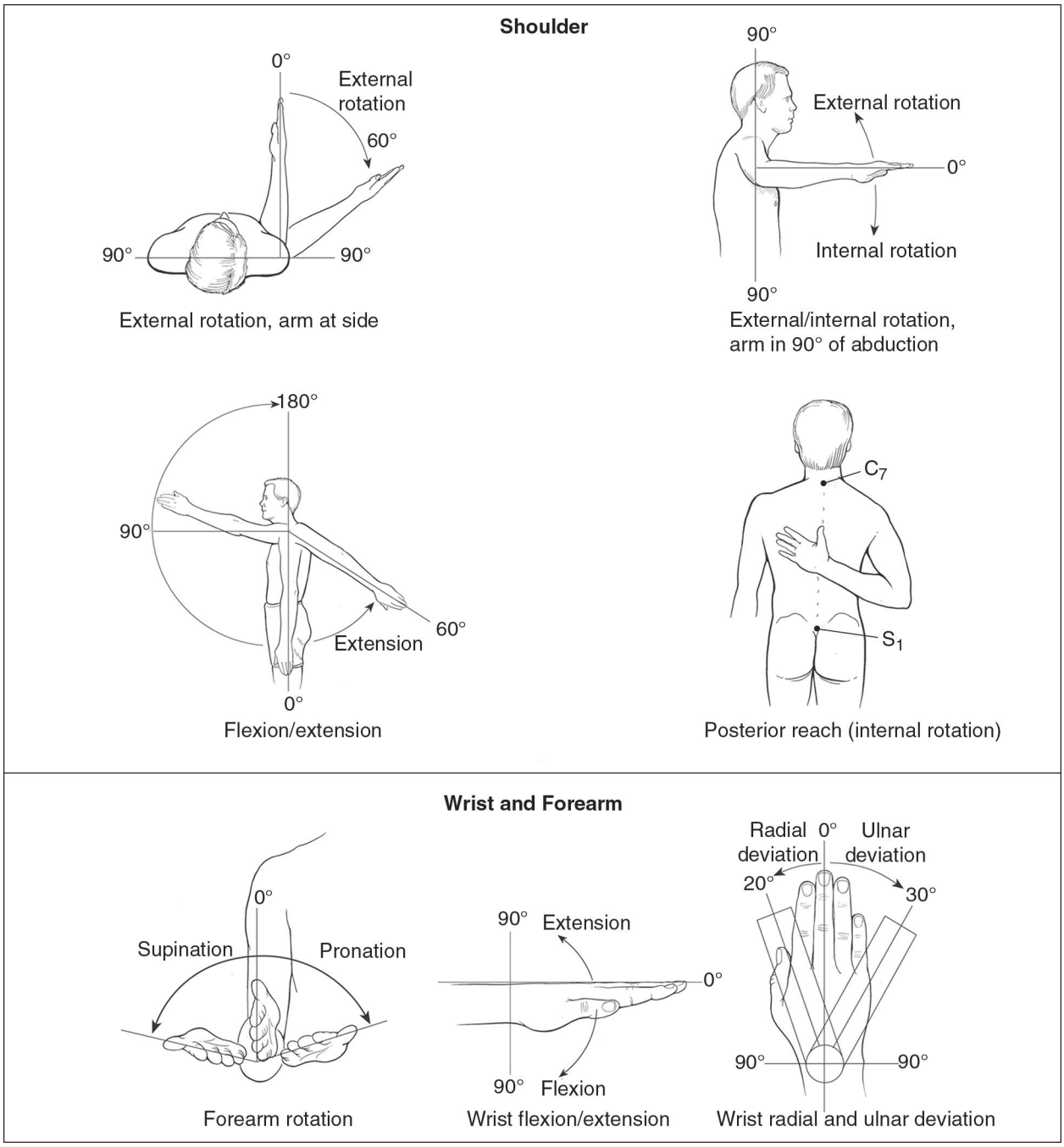
Measure the motion of the joints in the affected extremity or spine and compare with normal range of motion measurements on the unaffected side. Restricted joint motion may herald trauma, infection, arthritis, or another inflammatory process. Measure both passive and active range of motion. A discrepancy between active and passive range of motion may indicate joint injury or may represent an underlying muscle weakness.

Basic Principles

Joint range of motion is an objective measurement but can be influenced by subjective guarding. The parameters for rating musculoskeletal disability, whether for government or other agencies, are partially based on the degree to which joint motion is impaired. Joint motion can be estimated visually, but a goniometer enhances accuracy.

Zero Starting Position

Describing joint motion with reference to the accepted zero starting position for each joint is necessary to provide consistent



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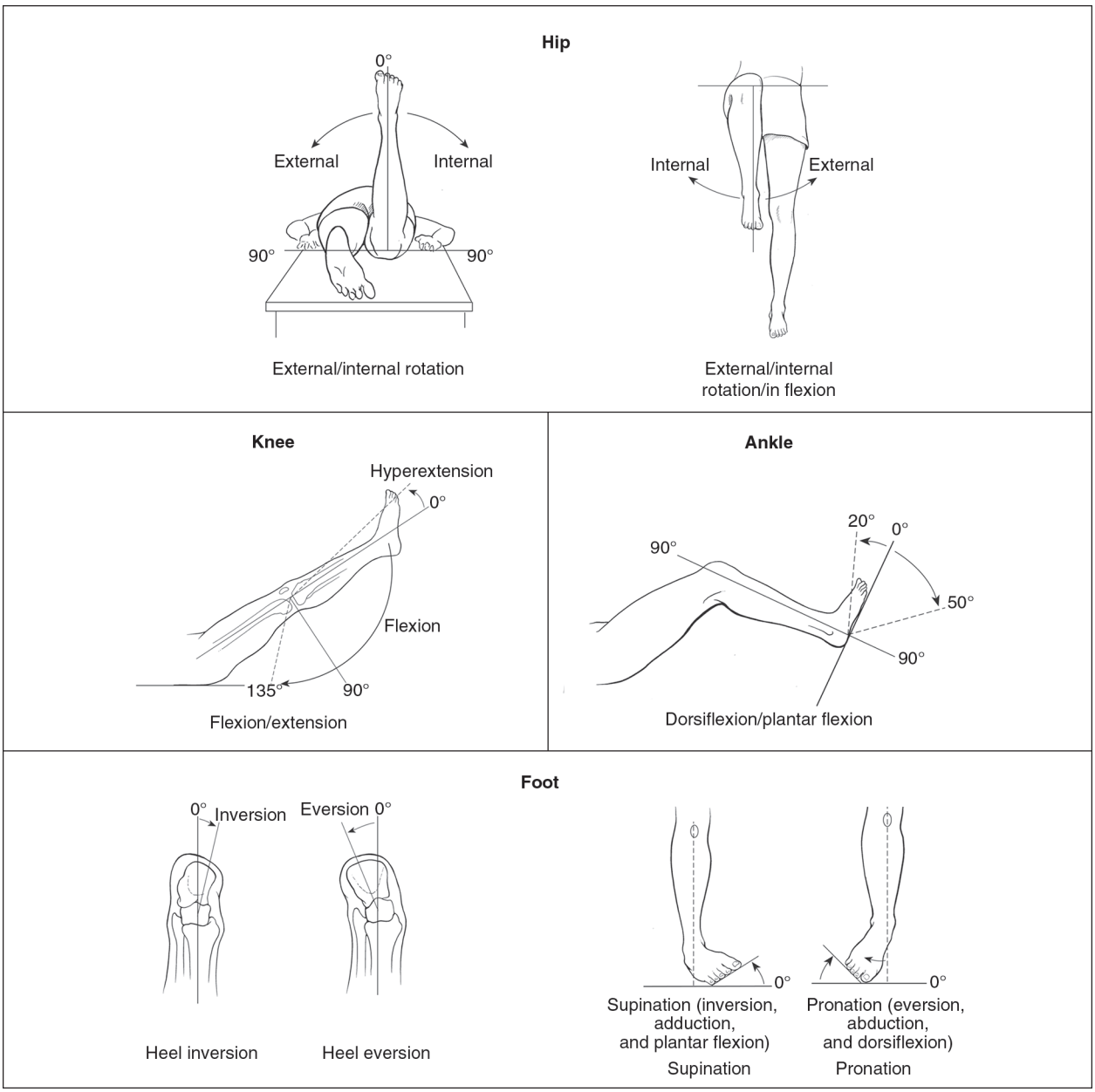
communication between observers. The zero starting position for each joint is described in the examination chapter of each section and in **Figures 1-2** and **1-3**. For most joints, the zero starting position is the anatomic position of the extremity in extension.

To measure joint motion, start by placing the joint in the zero starting position. Place the center of the goniometer at the center



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of the joint. Align one arm of the goniometer with the bony axis of the proximal segment and the other end of the goniometer with the bony axis of the distal segment (**Figure 1-4**). Hold the upper end of the goniometer in place while the joint is moved through its arc of motion. When the joint is at the farthest extent of the arc of motion, realign the distal arm of the goniometer with the axis of the distal segment and read the degree of joint motion from the goniometer.

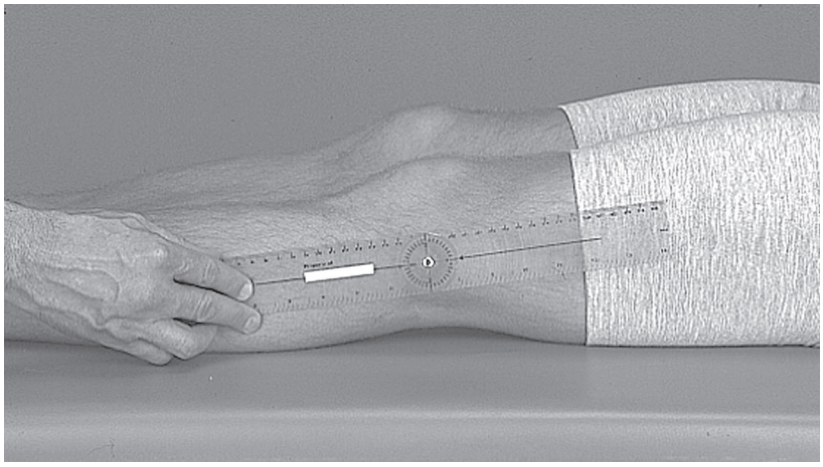

Figure 1-4 Photograph shows use of a goniometer to measure joint motion.

Definitions of Limited Motion

The terminology for describing limited motion is illustrated in **Figure 1-5**. The knee joint depicted in this photograph can be neither fully extended nor fully flexed. The restricted motion is recorded as either "The knee flexes from 30° to 90° (30° → 90°)," or "The knee has a 30° flexion contracture with further flexion to 90° (30° FC → 90° or 30° FC W/FF 90°)."

Range of motion is slightly greater in children, particularly those younger than 10 years. Decreased motion occurs as adults age, but the loss of motion is relatively minimal in most joints. Except for motion at the distal finger joints, it is safe to say that any substantial loss of mobility should be viewed as abnormal and not attributable to aging.

Motion of an injured or diseased joint may be painful. In such a situation, it is better to observe active motion first. The examiner will then know how much support to provide the limb when the passive arc of motion is analyzed.

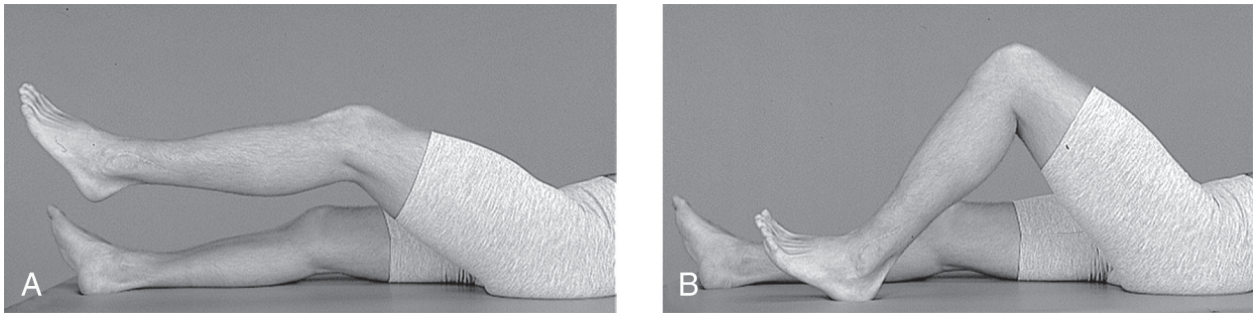

Figure 1-5 Photographs depict the terminology for describing restricted range of motion in a joint. This patient has both restricted extension (**A**) and restricted flexion (**B**) of the knee.

Table 1 2

Grading of Manual Muscle Testing

Numeric Grade	Descriptive Grade	Description
5	Normal	Contracts normally against full resistance.
4	Good	Muscle strength is reduced, but muscle contraction can still move joint against resistance.
3	Fair	Muscle strength is further reduced such that the joint can be moved only against gravity with the examiner's resistance completely removed. As an example, the elbow can be moved from full extension to full flexion starting with the arm hanging down at the side but cannot be moved if the examiner adds resistance as the joint is moving against gravity.
2	Poor	Muscle can move only if the resistance of gravity is removed. As an example, the elbow can be fully flexed only if the arm is maintained in a horizontal plane.
1	Trace	Only a trace or flicker of movement is seen or felt in the muscle or fasciculations are observed in the muscle.
0	Zero	No evidence of muscle function, and no joint movement is observed when muscle activity is attempted.

Muscle Testing

Manual muscle testing provides a semiquantitative measurement of muscle strength (**Table 1-2**). Commonly, a grading scale of 0 to 5 is used with a grade of 5 equating to normal muscle activity; that is, the muscle contracts normally against full resistance. A grade of 3 equates to the patient being able to move the joint against gravity with no additional resistance, and a grade of 0 is equivalent to no muscle movement observed.

Motor and Sensory Evaluation

Nerve root function should be tested if the patient's presenting symptoms suggest a neck or back problem. Peripheral nerve function should be tested if the disorder is localized to the extremities. This is most efficiently accomplished by evaluating one muscle and one area of sensation for each nerve root or peripheral nerve in question. In the case of hand injuries, two-point discrimination is used to evaluate for digital nerve injury. Two-point discrimination should be less than or equal to 5 mm at the fingertips. If the examiner does not have access to a formal discriminator wheel, then a paperclip can be fashioned to perform the test (**Figure 1-6**). The guidelines for assessing nerve root function are presented in the Spine section under Physical Examination of the Spine. A guide to the evaluation of the peripheral nerves is outlined in **Table 1-3**.

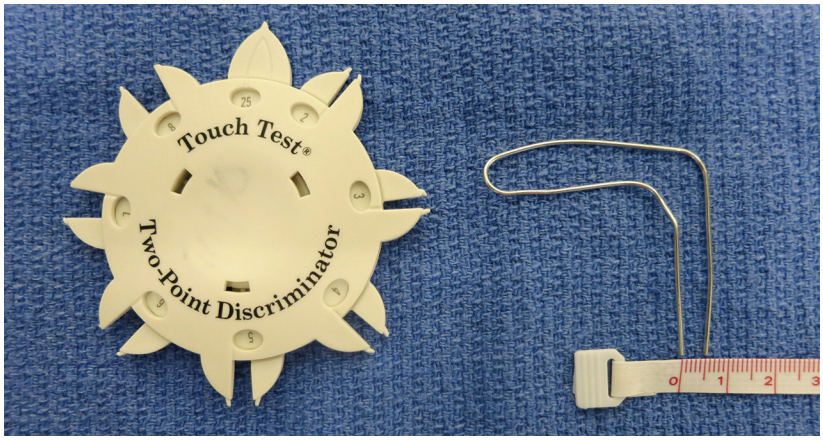

Figure 1-6 Photograph shows a two-point discriminator wheel (left) and a paperclip fashioned to test two-point discrimination at 5 mm (right).

Table 1 3

Evaluation of Peripheral Nerves

Nerve	Muscle	Sensory
Upper Extremity		
Axillary	Deltoid—shoulder abduction	Lateral aspect, arm
Musculocutaneous	Biceps—elbow flexion	Lateral proximal forearm
Median	Flexor pollicis longus—thumb flexion	Tip of thumb, volar aspect
Ulnar	First dorsal interosseous—abduction	Tip of little finger, volar aspect
Radial	Extensor pollicis longus—thumb extension	Dorsum thumb web space
Lower Extremity		
Obturator	Adductors—hip adduction	Medial aspect, midthigh
Femoral	Quadriceps—knee extension	Proximal to medial malleolus
Peroneal		
Deep branch	Extensor hallucis longus—great toe extension	Dorsum first web space
Superficial branch	Peroneus brevis—foot eversion	Dorsum lateral foot
Tibial	Flexor hallucis longus—great toe flexion	Plantar aspect, foot

Other Considerations

Tests specific to individual anatomic injuries are described in the anatomic sections of this book.

Amputations of the Lower Extremity

Definition

Limb amputation is the removal of all or part of an extremity through the level of a bone. Disarticulation is the removal of all or part of an extremity through the level of a joint.

Indications, Incidence, and Prevalence

Certain disease states, particularly diabetes mellitus, severe infections, and peripheral vascular disease, are the cause of approximately 70% of all lower extremity amputations. In fact, these conditions account for more than 100,000 lower extremity amputations performed annually in the United States. Each year, trauma accounts for approximately 20% of lower extremity amputations and tumors for another 5%; another approximately 5% of amputations are related to congenital limb deficiency. Prevalence data, obtained through surveys of all persons living with limb loss, show that approximately 55% of persons who underwent lower limb amputation and 85% of persons who underwent upper limb amputation experienced limb loss as a result of trauma (**Table 1-1**). The differences between the incidence and prevalence data can be explained by understanding that traumatic amputations more often occur in younger individuals, who typically live with the amputation for many more years than do individuals who undergo amputation because of chronic disease.

Table 1 1

Causes and Associated Percentages of Lower Extremity Amputations in the United States

Causes	%
Disease States	**70**
Diabetes mellitus	
Severe infections	
Peripheral vascular disease	
Trauma	**20**
Tumors	**5**
Congenital limb deficiency	**5**

Importance of Attitude

Amputations frequently are performed after the patient has undergone extensive medical or surgical intervention to salvage the limb. In these situations, the patient and even the medical team may have a negative attitude concerning the amputation and subsequent rehabilitation, regarding it as a sign of failure. This attitude is inappropriate, however, because most persons who undergo lower extremity amputation regain functional ambulation. Almost 90% of patients treated with transtibial (also referred to as below-knee) amputation achieve a functional ambulatory capacity that approaches their preamputation level. Therefore, the physician should maintain a positive attitude and aggressively pursue early rehabilitation, including prosthesis fitting, to allow patients to resume their normal daily activities.

Determining the Level of Amputation

The energy requirements of walking generally increase with more proximal levels of amputation. Therefore, amputations usually should be performed at the most distal level possible; residual limb (formerly referred to as stump) length is sometimes sacrificed, however, to create a soft-tissue envelope that will optimize prosthetic limb

Box 1-1

Determining the Level of Amputation

- Most distal level possible
- Occasionally sacrifice length for:
  - Skin coverage
  - Prosthetic function

fitting and comfortable ambulation for the patient. For example, an amputation performed at the hindfoot often compromises prosthetic function. In this case, an amputation at the next higher level (ankle disarticulation) may provide better function (**Box 1-1**).

Amputation Levels and Prosthetic Considerations

Toe Amputation

Patients with dysvascularity note no substantial loss of function after toe amputation because of their low baseline activity level. Young, active adults with traumatic hallux (great toe) amputations lose some propulsive power and walking stability but are able to walk reasonably well. Little disability is associated with the loss of the lesser toes. Isolated amputation of the second toe should retain the base of the proximal phalanx whenever possible to prevent hallux valgus. In elderly patients, toe amputations often indicate a foot at high risk for ulceration or pressure problems from standard shoes because of poor vascular perfusion and difficulty healing minor injuries and wounds. Therefore, shoes for these individuals should include extra depth and extra width and, often, custom-molded insoles to accommodate and protect a high-risk foot. Following trauma, patients typically are most comfortable in shoes with a more rigid sole and wide toe box to minimize pressure on the amputation site (**Box 1-2**).

Ray Resection

A ray resection includes a toe and all or part of the corresponding metatarsal. A foot with a single-ray resection of the second, third, fourth, or fifth ray will function well in either standard shoes or

Box 1-2

Shoe Considerations for a Foot With an Amputation

- Extra depth
- Extra width
- Custom orthotic
- If traumatic amputation, consider:
  - Rigid sole
  - Wider toe box

footwear for individuals with diabetes mellitus, depending on the shape and size of the remaining foot. Amputation of the first ray or resection of more than one ray leads to a residual foot that is more difficult to manage. A custom-molded, multidurometer orthosis is required to load the remaining metatarsal shafts and to unload the amputation site and the remaining metatarsal heads; use of this type of orthosis can improve comfort and lessen the chance of reulceration. Use of a custom-molded, multidurometer orthosis almost always requires footwear with extra depth and extra width.

Midfoot Amputation

Midfoot amputation is performed at either the transmetatarsal or tarsometatarsal level. Muscle rebalancing at the time of surgery and postoperative rehabilitation can help prevent the two most common postoperative contractures of the foot—equinus and varus. Prosthetic requirements vary tremendously at this level. A widened foot at the amputation site is almost universal, and tenderness at the end of the amputation site is common. Because of the increased width of the foot, accommodative footwear and prosthetic or orthotic management usually are needed. A low-profile prosthetic device that cups the heel and provides a long footplate will prevent the shoe from folding and putting pressure on the amputation site. If the foot is hypersensitive, or if balance and weakness are major symptoms, a prosthetic device that encloses the calf may improve function.

Hindfoot Amputation

Poor function and difficult prosthetic management are common after amputations in the hindfoot (**Figure 1-1**). The retained talus and calcaneus frequently are pulled into equinus, and attempts at weight bearing put excessive pressure directly on the amputation site. Surgical muscle rebalancing consists of reattachment of the anterior tendons and a complete release of the Achilles tendon. Advances in prostheses have improved function, especially for elderly individuals, and household ambulation and transfer skills can be very successful. Even with state-of-the-art prostheses, however, aggressive walking and impact activities are still very compromised with a hindfoot amputation.

Ankle Disarticulation

Syme ankle disarticulation consists of disarticulation of the entire foot at the ankle and use of the heel pad to cover the amputation site. Surgical revision of the bony malleoli flush with the articular cartilage creates a very smooth weight-bearing surface. When combined with durable heel pad coverage, the resulting residual limb usually can tolerate direct pressure and end weight bearing. A prosthesis is required for routine walking, but the amputation site usually can tolerate transfer pressure and the pressure required for a limited number of steps for bathroom activities without a prosthesis, which is a benefit to many patients. The prosthesis socket extends up to the proximal tibia region, very similar to a transtibial or below-knee prosthesis. The foot component must be very low profile

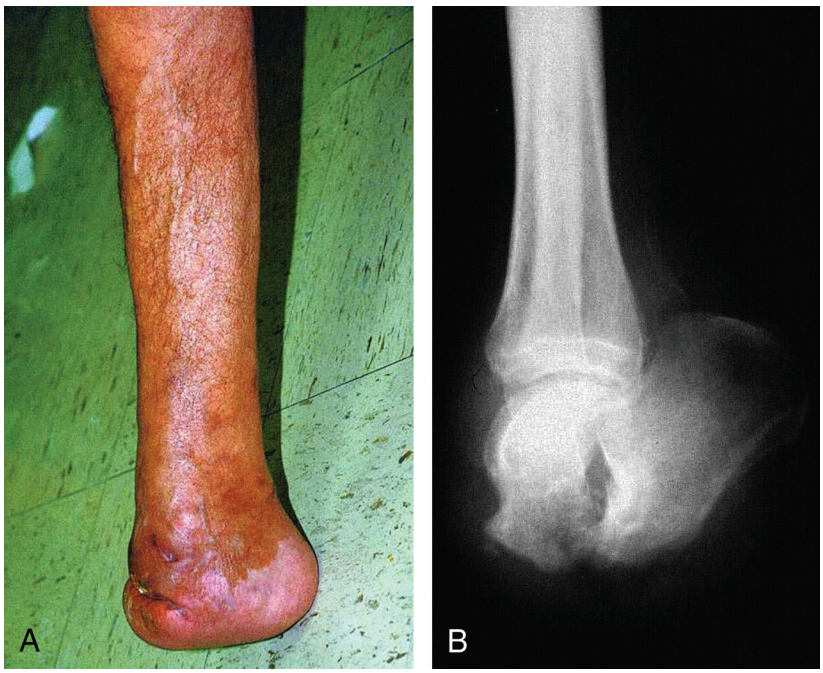

Figure 1-1 Images show the outcome of hindfoot amputation. **A,** Postoperative photograph obtained following hindfoot amputation performed at the level of the talonavicular joint. Even a successful hindfoot amputation, as shown here, provides a very small surface area for weight bearing and requires custom footwear to prevent the shoe from falling off. The patient also will have an apropulsive gait because of the loss of the forefoot lever arm, which, in the normal foot, is used during the terminal stance phase of gait. **B,** Lateral radiograph obtained following a hindfoot amputation demonstrates a too-common result, hindfoot equinus. Bearing weight on the plantar surface of the residual foot is painful and is likely to be associated with skin breakdown.

because the amputated limb is almost as long as the nonamputated limb. The gait pattern is stable and requires minimal training (**Figure 1-2**).

Transtibial Amputation

As noted previously, transtibial amputation also is referred to as a below-knee amputation. Various surgical methods are used, but a long posterior flap usually results in more durable padding over the distal end of the tibia and a cylindrical shape, which tolerates prosthetic fitting better than does a dramatically tapered residual limb. This durable padding can be very important for minimizing residual limb ulcerations, particularly in patients with diabetes mellitus or peripheral vascular disease. The optimal functional length of the remaining tibia is 12 to 15 cm below the knee joint. Some experts recommend longer transtibial amputations in patients with adequate vascular status and skin condition. Amputation in the lower third of the tibia is not recommended because the padding is not adequate below the level of the calf muscle.

Even if walking is expected to be minimal, outfitting the patient with a simple prosthesis and a wheelchair can enhance functional

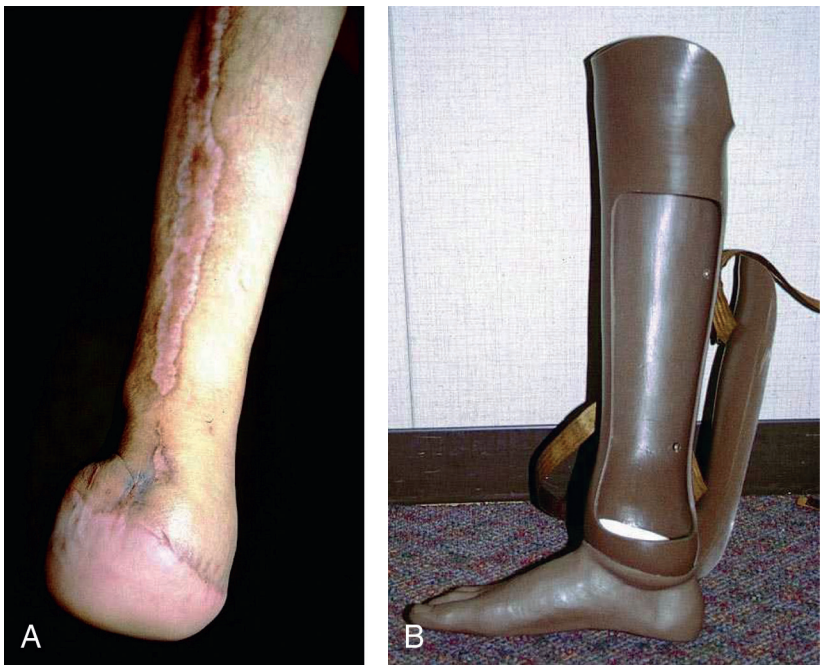

Figure 1-2 The Syme ankle disarticulation creates an excellent weight-bearing platform. By removing the talus and calcaneus, room is created to place a dynamic elastic-response (that is, energy-storing) prosthetic foot. **A,** Photograph shows the appearance of a lower limb after a Syme ankle disarticulation. **B,** Photograph of the Canadian Syme prosthesis.

independence following transtibial amputation provided that safe transfer skills can be achieved. New developments in flexible sockets are providing a more comfortable fit and better proprioception through improved suspension. The spring-like design of dynamic elastic-response feet both absorbs the shock and rotation of impact and returns energy at the end of each stride.

Knee Disarticulation

A knee disarticulation extends through the knee joint itself. Like the Syme ankle disarticulation, the goal of knee disarticulation is to create a smooth surface that can tolerate direct end weight bearing, improving function. Early knee disarticulation prostheses had two major drawbacks: they were bulky around the knee area, and the prosthetic knee joint attached below the socket at a level lower than that of the contralateral, unaffected knee. Newer prosthetic knee joints minimize these disadvantages and have greatly improved the walking function of patients with knee disarticulations. For individuals who are nonambulatory because of paraplegia, neurologic conditions, or other chronic diseases, knee disarticulation is preferable to a more proximal amputation because the disarticulation maintains a full-length thigh to maximize sitting support and can improve function. It also minimizes the risk of skin problems associated with more distal amputations.

Transfemoral Amputation

A transfemoral (through the thigh) amputation is also referred to as an above-knee amputation. Contractures are common following this surgery because the muscle attachments at the hip pull the residual thigh into flexion and abduction. Rebalancing the muscles surgically by attaching the adductor muscle and hamstrings can minimize postoperative problems associated with severe hip joint contractures. Aggressive rehabilitation also is helpful. The energy requirements of walking are substantially higher with this level of amputation than with more distal amputations, and after transfemoral amputation, many patients with dysvascularity do not have adequate cardiac function for functional ambulation using a prosthesis. In addition, the power of the knee joint is lost with transfemoral amputation, and the prosthesis cannot replace it. Therefore, many patients who undergo transfemoral amputation never become very proficient with a prosthesis, and they may find wheelchair ambulation to be more efficient.

The weight of a transfemoral prosthesis acts as an anchor and makes transfer more difficult. Therefore, to be a candidate for a prosthetic limb, patients who undergo high-level amputation should have three skills: (1) the ability to independently transfer from bed to chair; (2) the ability to independently rise from sitting to standing; and (3) the ability to ambulate up and down parallel bars with a one-legged gait (**Box 1-3**). Many such patients master these skills within days or weeks of surgery, but others cannot. The ability to go a short distance on the parallel bars without a prosthesis or with a walker is an excellent indication that the patient who undergoes transfemoral amputation will have the energy to use a prosthesis safely.

Hip Disarticulation

Amputations and disarticulations at the level of the hip and pelvis lead to substantial loss of function. For many individuals, sitting balance and sitting support to prevent decubitus ulcers are the first priority, followed by learning independent transfer and safe toileting skills. The patient should be educated about the importance of mastering the three vital independence skills previously discussed for transfemoral amputation before the decision is made to proceed with a prosthesis. Even young adults with this level of amputation find the use of a prosthesis very challenging because of the high energy requirements and the need to control three joints (hip, knee, and ankle). Many individuals with amputations at this level prefer walking with crutches rather than using a prosthesis.

Box 1-3

Skills Needed by Those Who Undergo a High-Level (Transfemoral) Amputation in Order to Use a Prosthetic Limb

- Ability to independently transfer from bed to chair
- Ability to independently rise from sitting to standing
- Ability to ambulate up and down parallel bars with one-legged gait

Principles of Prosthesis Fitting

The soft-tissue envelope over the end of the amputation site is the interface, or cushion, between the bone of the residual limb and the prosthetic socket (**Figure 1-3**). Disarticulations at the level of the ankle and the knee can allow weight bearing directly through the end of the residual limb because the bone surface is broad and smooth (**Figure 1-4**). The soft-tissue envelope acts as a cushion, and the sole function of the prosthetic socket is to prevent the prosthesis from falling off.

In transtibial and transfemoral amputations, the bone is transected through the diaphysis and cannot accept much direct force at the end. With these amputations, the socket distributes the load over the entire surface of the residual limb. With transtibial amputations, much more load is directly proximal to the amputation site over the sides of the residual limb and the contours of the knee; with transfemoral amputation, the load is placed on the hip area (**Figure 1-5**). Intimate fit of the prosthetic socket is crucial. If the patient loses weight or the residual limb atrophies, the limb will "bottom out," or drop down in the socket, resulting in the development of a pressure ulcer caused by increased end-bearing pressure. In many cases, a prosthetist can add pads inside the socket to improve the fit of a socket that is too big. Conversely, if the patient gains weight, the residual limb will not fit down into the socket and the end of the limb will swell into the void and create tender, weeping skin lesions from lack of any distal contact. A socket that is too small cannot be modified easily and needs to be replaced.

Perfect, intimate prosthetic fit is impossible; therefore, every patient who uses a prosthesis after amputation experiences pistoning within

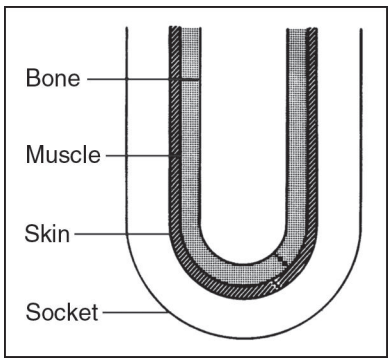

Figure 1-3 Illustration shows an ideal soft-tissue envelope over the end of the amputation site in a lower limb. This envelope consists of a mobile, nonadherent muscle mass and full-thickness skin that will tolerate the direct pressures and pistoning within the prosthetic socket.

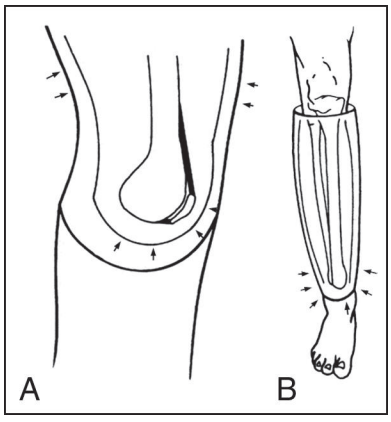

Figure 1-4 Illustrations depicting load transfer (arrows) in knee disarticulation and Syme ankle disarticulation. Weight bearing is accomplished directly through the end of the residual limb in knee disarticulations (**A**) and Syme ankle disarticulations (**B**).

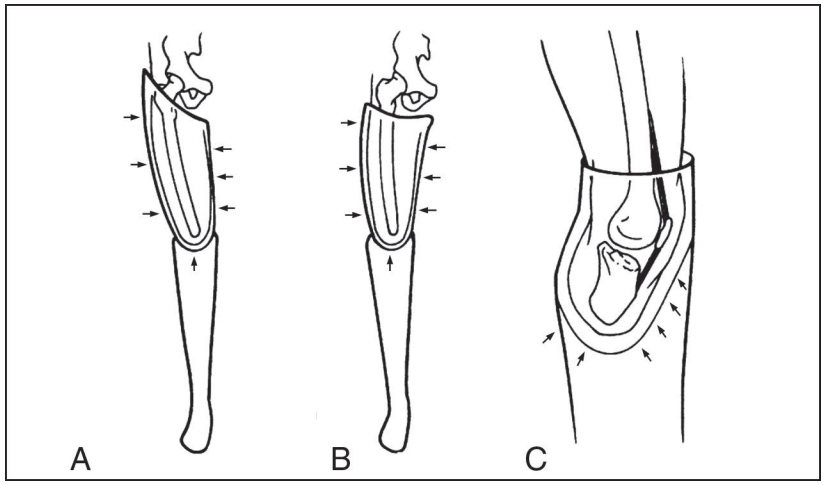

Figure 1-5 Illustrations depicting load transfer (arrows) in transfemoral and transtibial amputations. The indirect load transfer that is required in transfemoral amputations is accomplished with either a standard quadrilateral socket (**A**) or an adducted, narrow, medial-lateral socket (**B**). The transtibial amputation socket transfers weight indirectly with the knee flexed approximately 10º (**C**).

Box 1-4

Caution With All Amputations

- With all levels of amputation, good surgical technique is needed to produce a residual limb composed of mobile muscle and durable skin.
- An inadequate soft-tissue envelope on the residual limb or poor prosthetic fit results in blisters, ulcers, and infection.
- The initial approach for most pain and pressure problems in an amputee is to adjust the limb–prosthesis interface.

the prosthetic socket, which produces shear forces. Good surgical technique produces a residual limb composed of mobile muscle and durable skin; however, if the soft-tissue envelope is thin (composed of split-thickness skin graft, or adherent to bone), blisters and shearing ulcers will develop. In this situation, the prosthetist attempts to compensate by using pressure- and shear-dissipating materials and by maximizing the suspension of the prosthesis to the residual limb. **Box 1-4** summarizes cautions necessary for all amputations.

A prosthetic socket can be expected to last 18 months to 3 years, but it should be modified or replaced sooner if the fit is poor. Socket liners do not last as long as the socket itself, and they should be replaced when torn or worn out. Liners made of foam may last 6 to 24 months, but the new elastomeric and silicone liners often tear within 3 to 4 months of normal use. Prosthetic components such as feet, ankle units, and knee units should be replaced when they are broken or show signs of fatigue failure. Typically, the components should last 3 to 5 years, and many have warranties for this time span.

Adverse Outcomes

If pressure problems occur or pain develops, referral to a clinic that specializes in treating patients who have undergone amputation, a certified prosthetist, or a rehabilitation physician should be considered. The initial approach for most pain- and pressure-related problems is to adjust the residual limb/prosthesis interface by modifying the socket (see Box 1-4). If problems persist, the cause may be heterotopic bone, bone spurs, increased pressure or bruising of the residual nerve ending, or the formation of symptomatic neuromas.

Residual Limb Ulcers or Infection

Most blisters, ulcers, and infections are caused by an inadequate soft-tissue envelope on the residual limb or poor prosthetic fit. If these problems develop, the patient should stop wearing the prosthesis until it can be adjusted. Often, simply modifying the socket will relieve pressure points, and this modification, combined with the use of simple, nonbulky dressings, will allow the wounds to heal. Antibiotics are necessary only if the patient has signs of local or systemic infection. Surgical revision of the amputation is indicated when superficial wounds fail to heal

within 4 to 8 weeks following prosthetic modification; infection fails to resolve with appropriate antibiotics; or wounds become deep, exposing muscle, tendon, or bone.

Skin Conditions

The prosthetic socket is a closed environment, so excessive sweating or poor hygiene will lead to dermatologic eruption on the residual limb. To prevent this, the prosthetic socket and residual limb should be kept clean and dry. Absorbent powders (other than talcum powder) or creams should be used for this purpose.

Folliculitis, which typically develops in the groin following transfemoral amputation or in the popliteal area following transtibial amputation, may be just a nuisance or it may be painful, and it can compromise prosthetic fit. Good hygiene, including keeping the prosthesis clean, can help minimize folliculitis. Treatment with warm soaks and topical agents resolves many mild cases. If cellulitis is present, oral antibiotics may be required. When folliculitis becomes chronic or when cystic lesions develop, surgical excision of the involved skin may be required.

Extreme swelling of the residual limb, which is similar in appearance to severe venous insufficiency disease, may develop if the socket fit is not intimate. The hyperemic, weeping skin may become very painful, and superficial infection may develop. Treatment includes topical agents and antibiotics as well as improving the fit of the socket.

Amputation-Related Sensation

Various types of sensation are experienced by persons with limb loss, including nonpainful phantom limb sensations, phantom limb pain, residual limb pain, and back and neck pain (**Box 1-5**).

Nonpainful phantom limb sensations may include a feeling that the missing foot is wrapped in cotton or that the missing limb is present. These sensations can take a variety of forms such as touch, pressure, temperature, itch, posture, or location in space. They also can involve feelings of movement in the phantom limb. Telescoping, the sensation that the distal part of the phantom limb is moving progressively closer to the residual limb, sometimes occurs. Initially, phantom limb sensations may be frightening or annoying, but most patients adjust to these sensations, and they rarely require treatment.

Phantom limb pain refers to painful sensations in the phantom, or missing, portion of the amputated limb. Early reports in the literature suggested that the incidence of chronic phantom limb pain was low,

Box 1-5

Sources of Pain in an Amputation

- Nonpainful phantom limb
- Phantom limb
- Residual limb
- Back or neck

but it is now thought that as many as 55% to 85% of persons who have undergone limb amputation continue to experience phantom limb pain from time to time. Severe, persistent phantom limb pain is unusual. Phantom limb pain tends to be more episodic and more intense than nonpainful phantom limb sensations. Persistent symptoms are best controlled with antiseizure membrane-stabilizing drugs, such as pregabalin and gabapentin. Modalities such as transcutaneous electrical nerve stimulation have been reported as helpful for some individuals, especially for short-term flare-ups, but surgery has not been successful. As in many chronic pain syndromes, treatment often requires multiple modalities. Unrelenting phantom limb pain is best managed as major causalgia with guidance from a specialist in pain management.

Residual limb pain is pain in the portion of the amputated limb that is still physically present. Existing studies disagree regarding the prevalence of chronic residual limb pain after wound healing. Localized residual limb pain may be caused by poor prosthetic socket fit or alignment, and evaluation and adjustment by a prosthetist often resolves the problem. When persistent residual limb pain is caused by bone spurs, which can be seen on radiographs, surgical excision is indicated. Painful nodules or masses that cause an electrical sensation when palpated or tapped may indicate symptomatic nerve endings or neuromas. Prosthetic modification to relieve local pressure should be tried initially, but if it is not successful, surgical excision with repositioning of the end of the nerve can help.

Back and neck pain are common following amputation of an extremity. Likely contributing factors are asymmetric pelvic motion, weight shifts, and shoulder motion during gait; asymmetric standing posture; and overuse of the remaining extremities. Such back and neck pain is often more functionally limiting than is phantom limb pain or residual limb pain. A careful examination for spine-related causes of pain is necessary. Treatment typically consists of rehabilitation, stretching, and other physical modalities.

Referral Decisions/Red Flags

Referral for amputation may be required for vascular disease, trauma, diabetes-related ulceration or infection, or complications at the amputation site. Orthopaedic surgeons, vascular surgeons, general surgeons, and plastic surgeons all may have training in amputation-related care. Orthopaedic surgeons and rehabilitation medicine specialists typically have the most experience with prosthetic rehabilitation and complications. The choice between these two specialists will depend on the individual specialist's particular interests in the care and management of limb loss.

Chronic Inflammatory Conditions of the Musculoskeletal System

Crystal Deposition Disease

Synonyms

Gout
Pseudogout
Calcium pyrophosphate deposition (CPPD) disease

Definition

Crystal deposition disease is an **arthritis** characterized by abrupt episodes of severe joint pain and swelling, typically involving a single joint. The pain and swelling result from the lysis of polymorphonuclear cells triggered when these cells engulf crystals deposited in synovium, cartilage, and other tissues.

Gout

Gouty arthritis is caused by inflammation in the joint due to monosodium urate crystals. The solubility of uric acid in the serum is 6.8 mg/dL; any value above this puts a patient at risk for **gout**. It is important to note that not all patients with hyperuricemia (elevated serum levels of uric acid) have gout. Rather, gouty arthritis is confirmed by finding intracellular monosodium urate crystals and white blood cells in joint fluid. In one out of three patients with gout, the serum uric acid level may be normal. Reasons for this include uric acid mobilization during a gout attack. Uric acid is a by-product of purine metabolism. Urine excretion levels are used to categorize patients as overproducers or underexcretors of uric acid. Collection of urine over a 24-hour period can determine uric acid excretion over 24 hours. Patients with more than 1,000 mg of uric acid excretion in 24 hours are overproducers. In certain patients with hyperuricemia, the excess monosodium urate crystals deposit in tissue, causing the inflammatory process of gout. Gout is relatively common, and its prevalence increases with age. The most frequent manifestation of gout is recurrent attacks of acute inflammatory arthritis, but the uric acid crystals may also be deposited in other tissues. Accumulation of urate crystals causes the formation of tophaceous deposits, or tophi (soft-tissue masses from urate crystal deposition noted several years after the onset of gout [**Figure 1-1**]), and renal manifestations, such as uric acid nephrolithiasis and chronic nephropathy.

Calcium Pyrophosphate Deposition Disease

Calcium pyrophosphate deposition (CPPD) disease, which is caused by the precipitation of calcium pyrophosphate dihydrate crystals in connective tissues, has a wide spectrum of clinical manifestations.

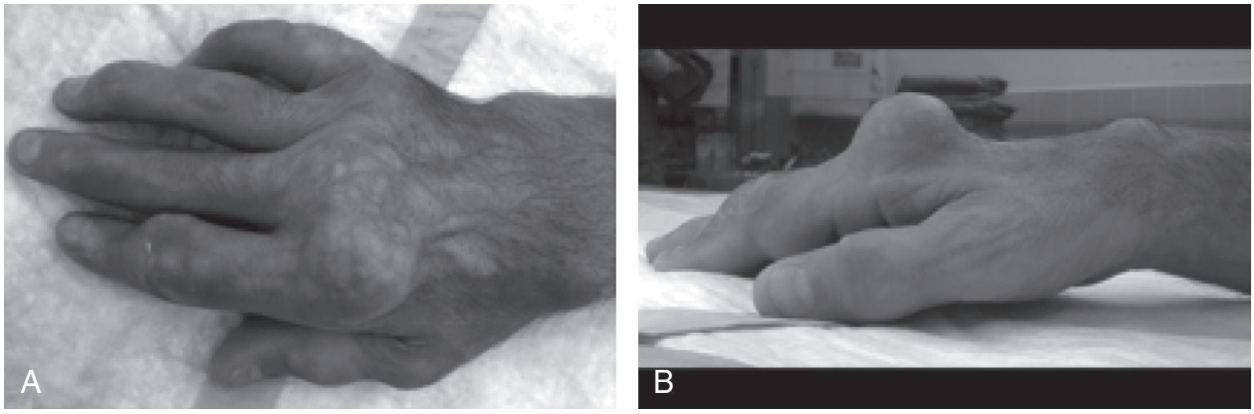

Figure 1-1 Dorsal (**A**) and lateral (**B**) photographs of tophi affecting the hand, primarily the metacarpophalangeal joints.
Reproduced from Fitzgerald BT, Setty A, Mudgal CS: Gout affecting the hand and wrist. *J Am Acad Orthop Surg* 2007;15(10):625-635.

Table 1 1

Characteristics of Crystal Deposition Diseases

Disease	Crystals	Arthritis	Commonly Affected Joints	Treatment
Gout	Monosodium urate monohydrate, negative birefringence	Acute monoarticular	First metatarsophalangeal joint, ankle, knee	Colchicine, indomethacin, NSAIDs, allopurinol, Febuxostat, Pegloticase
Pseudogout	Calcium pyrophosphate, positive birefringence	Acute monoarticular or oligoarticular	Knee, wrist	Joint aspiration, intra-articular steroids, NSAIDs, colchicine

The clinical spectrum includes asymptomatic disease, pseudogout (**Table 1-1**), pseudorheumatoid arthritis, pseudoosteoarthritis, and pseudoneuropathic joint disease. Most patients with radiographic evidence of crystal deposition resulting from CPPD disease are asymptomatic.

Clinical Symptoms

Gout

Acute gouty arthritis, intercurrent gout, and chronic tophaceous gout represent three stages of progressive urate crystal deposition. Acute gouty arthritis occurs after years of asymptomatic hyperuricemia. At least 80% of initial attacks involve a single joint. The metatarsophalangeal joint of the great toe is most commonly affected (podagra), accounting for approximately 50% of the initial episodes of gouty arthritis. Other common sites of involvement include the

ankle, the tarsal joints, and the knee. Gout can also occur in the spine and sacroiliac joints, although those presentations are much less common than is peripheral involvement. Most proven cases of gouty back pain have been associated with the tophaceous type.

Patients with acute gouty arthritis report severe pain, redness, and swelling in the affected joint, with maximal severity of symptoms reached over several hours. The overlying erythema may be confused with cellulitis and/or a septic joint. During the acute event, serum uric acid concentrations are often normal or low. After resolution of the acute attack, patients are often asymptomatic for a variable period of time, with most patients experiencing another attack within 2 years. Tophi develop in only approximately 5% of patients who are compliant with antihyperuricemic therapy. Tophi can develop in many locations, including the olecranon bursa, the extensor surface of the forearm, the Achilles tendon, or the tendon sheaths in the hand. Tophi may be confused with rheumatoid nodules.

CPPD Disease

CPPD disease commonly affects patients older than 65 years. It is characterized by acute or subacute attacks of arthritis and radiographic evidence of crystal deposition. Chondrocalcinosis is the calcification of articular cartilage or menisci caused by deposition of calcium pyrophosphate crystals. Most patients with chondrocalcinosis are asymptomatic or have only mild arthritic symptoms. This disorder is more common in women and increases with age, affecting approximately one-half of the population older than 80 years.

Patients with pseudogout experience acute or subacute attacks of arthritis, usually in one joint. The knee joint is affected in more than 50% of patients, and calcium pyrophosphate crystals are found on examination of synovial fluid aspirate.

Progressive joint degeneration in a pattern similar to osteoarthritis, called pseudo-osteoarthritis, affects 50% of patients with symptomatic CPPD disease. The knees are the most commonly affected joints, followed by the wrist, metacarpophalangeal joints, hips, shoulders, elbows, and spine. Evidence of CPPD crystals in synovial fluid and radiographic evidence of CPPD crystal deposition help distinguish this clinical entity from osteoarthritis. Approximately half of the patients with pseudo-osteoarthritis experience intermittent acute inflammatory attacks typical of pseudogout; the other half progress similar to osteoarthritis.

CPPD arthropathy may be confused with rheumatoid arthritis, but patients with CPPD disease do not have bony erosions or other features of rheumatoid arthritis, such as tenosynovitis. CPPD crystal deposition has been associated with severe neuropathic joint degeneration, but patients with severe neuropathic joint degeneration typically present with underlying conditions such as diabetes mellitus or tabes dorsalis.

Tests

Physical Examination

In both gout and pseudogout, examination of the affected joint reveals marked tenderness to palpation, swelling, erythema, and limited motion.

Diagnostic Tests

A definitive diagnosis of gout or pseudogout is made by examining crystals and white blood cells obtained from synovial fluid. In pseudogout, the crystals will be weakly positive birefringent and rod shaped. In gout, the crystals will be negatively birefringent and needle shaped. After the diagnosis of pseudogout, appropriate patients may be screened for associated diseases. In this case, laboratory serum analysis includes calcium, phosphorus, magnesium, alkaline phosphatase, ferritin, iron, transferrin, parathyroid hormone, and thyroid-stimulating hormone to screen for the following related diseases: hemochromatosis, hyperparathyroidism, hypophosphatasia, and hypomagnesemia.

Gout

The clinical picture of acute gouty arthritis is similar to that of acute septic arthritis. Common findings include fever with accompanying leukocytosis and elevated erythrocyte sedimentation rate and C-reactive protein. Serum uric acid levels should be checked; however, these levels may be normal during an acute episode. Joint aspiration and analysis of synovial fluid with white blood cell count, Gram stain, and culture are critical in distinguishing gout from septic arthritis.

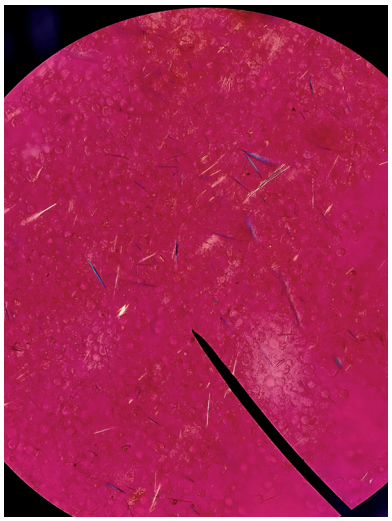

Figure 1-2 Microscopic image of monosodium urate crystals as seen under polarized light. These crystals are characteristic of gout and are found in the fluid of the inflamed joint and in other affected tissues.
© Yonlada Rithitham/ Shutterstock.

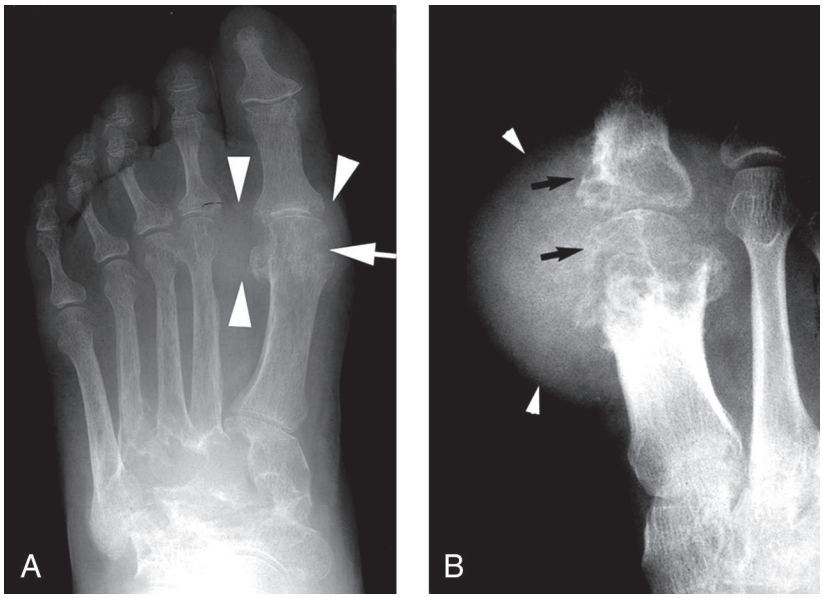

Figure 1-3 **A,** AP radiograph of the foot of a patient with gout. Note the erosions with sharp margins, the overhanging edge in the metatarsophalangeal joint of the great toe (arrow), and a soft-tissue mass around the first metatarsal consistent with a deposit of sodium urate (arrowheads). **B,** AP radiograph of the great toe of a patient with advanced gout. The black arrows indicate large, well-marginated erosions on both sides of the metatarsophalangeal joint, and the white arrowheads indicate a large soft-tissue mass. These findings are consistent with advanced gout.
Reproduced from Johnson TR, Steinbach LS, eds: *Essentials of Musculoskeletal Imaging*. Rosemont, IL, American Academy of Orthopaedic Surgeons, 2004, p 627.

Ultrasonography of joints and adjacent soft tissues is useful for guiding fluid aspiration and can aid in identifying urate crystal deposition. Examination of joint fluid under polarized microscopy reveals the characteristic negatively birefringent urate crystals (**Figure 1-2**). Early in the disease, radiographs are normal except for soft-tissue swelling. Radiographs of established gout are characterized by subchondral bony erosions and periarticular spurs (**Figure 1-3**).

CPPD Disease

Patients with inflammatory arthritis as a result of acute CPPD disease present with a clinical picture similar to that of an acute gout attack, hence the name pseudogout. Common findings include fever with accompanying leukocytosis and elevated erythrocyte sedimentation rate and C-reactive protein. Joint aspiration and synovial fluid analysis with cell count, Gram stain, culture, and polarized microscopy help distinguish this clinical entity from gout or a septic joint. Calcium pyrophosphate crystals in synovial fluid appear as weakly positive, birefringent rhomboid-shaped crystals (see Figure 1-2, B). The deposition of calcium pyrophosphate crystals in soft tissues can cause chondrocalcinosis, which is seen on radiographs as punctate or linear calcification of articular cartilage and internal joint structures, such as menisci in the knee or the triangular fibrocartilage in the wrist (**Figure 1-4**). Some metabolic disorders, such as hyperparathyroidism, hemochromatosis, hypophosphatasia, and hypothyroidism, are associated with CPPD disease.

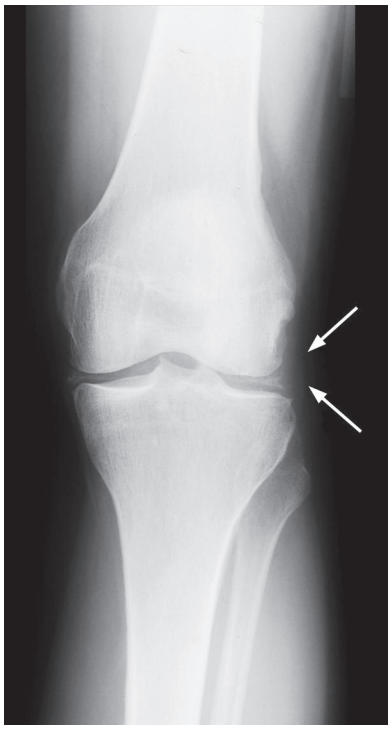

Figure 1-4 AP radiograph of the knee of a 48-year-old patient with pseudogout. The crystals in the meniscal cartilage demonstrate the linear calcifications characteristic of chondrocalcinosis (arrows).

Differential Diagnosis

- Cellulitis (joint not involved and motion only mildly affected by overlying skin infection)
- Lyme disease (chronic fatigue, memory loss, history of rash, immunoglobulin M [IgM] or immunoglobulin G [IgG] antibody titer)
- Neuropathic arthropathy (underlying neurologic disorder such as diabetes, insignificant pain)
- Osteoarthritis (less acute, pain proportionate to activity)
- Rheumatoid arthritis (younger age, multiple joints involved, associated tenosynovitis; note that gout in postmenopausal women has a periarticular presentation similar to rheumatoid arthritis)
- Septic arthritis (severe pain, systemic signs, positive Gram stain and culture)
- Trauma (history, hemarthrosis, or fracture)

Adverse Outcomes of the Disease

Before effective control of hyperuricemia was common, the development of tophi and chronic gouty arthritis was the expected course. Chronic hyperuricemia can lead to nephropathy and renal stones. End-stage arthritis may occur with CPPD disease, but this is infrequent.

Treatment

Gout

Treatment of individuals experiencing acute episodes of gout should focus on relieving pain and inflammation; management of acute attacks; and, more importantly, the long-term management of gout and the lowering of serum uric acid levels to a goal of <6 mg/dL (0.360 mmol/L) or treating to target. Treating to a target serum uric acid goal is an opportunity to decrease morbidity and improve the quality of care of every patient with gout. **NSAIDs** are first-line agents. Indomethacin is a commonly used NSAID; it is dosed at 50 mg every 8 hours until symptoms subside. Naproxen 500 mg twice daily has yielded similar relief. The use of oral NSAIDs is limited in patients with gastrointestinal complications. NSAIDs are most effective when treatment is initiated within 48 hours of the onset of symptoms. Use caution when administering anti-inflammatory agents in patients with diabetes or renal disease.

Colchicine is a second-line agent in treating patients with acute gouty arthritis because side effects such as nausea, diarrhea, and bone marrow suppression often limit administration of therapeutic doses. Oral glucocorticoids are also second-line agents and should be used cautiously in patients with diabetes mellitus. Intra-articular corticosteroid injections can be used to manage acute gout in a single joint. The goal of long-term management of gout is to treat to target, meaning a serum uric acid below 6 mg/dL; if the patient continues to have gouty arthritis, then the serum uric acid must be brought

below 5 mg/dL using drugs such as probenecid and allopurinol. Probenecid increases the urinary excretion of uric acid and should not be administered to patients with renal insufficiency with an estimated glomerular filtration rate lower than 50.

Allopurinol is a xanthine oxidase inhibitor that decreases production of uric acid in purine metabolism. Allopurinol should be used with caution in patients with an estimated glomerular filtration rate lower than 50 because they are more prone to adverse reactions. Gout is a disease that occurs over decades. In these patients, it is best to start at a low dose and increase slowly over weeks, after the acute attack has resolved. Patients also must be warned that their gout may get worse when the uric acid level drops due to uric acid–lowering treatment. Allopurinol should not be used in the acute setting because it can exacerbate symptoms.

CPPD Disease

Joint aspiration serves both a diagnostic and therapeutic role in pseudogout. Joint aspiration is commonly followed by intra-articular corticosteroid injections if one or two joints are involved. Oral NSAIDs or colchicine are administered during acute attacks if multiple joints are affected. Short-term joint immobilization plays a role in reducing pain and inflammation. In patients who have experienced three or more attacks of pseudogout, prophylaxis with colchicine has yielded decreased frequency of subsequent attacks.

Adverse Outcomes of Treatment

NSAIDs can interfere with drugs used concomitantly to control hypertension and often produce gastrointestinal side effects. In 2015, the FDA strengthened its warning linking NSAIDs with the risk of heart attack or stroke, even in the first weeks of use of an NSAID. Complications of corticosteroid use include osteonecrosis, osteoporosis, glaucoma, and elevated blood glucose levels. These complications are dose and time dependent, and are more commonly seen with long-term treatment of more than 5 mg daily equivalent.

Referral Decisions/Red Flags

Joint deformity or destruction, large tophaceous masses, or drainage of tophaceous material may require surgical attention. Whenever possible, institution of urate-lowering therapy should precede surgery in order to increase the likelihood of prompt postoperative healing. Exceptions to this approach are nerve compression and active infection, due to greater urgency. Local surgery is not a substitute for effective systemic control of serum urate levels. Pegloticase can reduce the size of tophi rapidly.

Chronic Inflammatory Conditions of the Musculoskeletal System

Fibromyalgia Syndrome

Definition

Fibromyalgia syndrome (FMS) is a chronic, non–life-threatening condition characterized by widespread pain, fatigue, and tender areas in the soft tissues. The joints, however, are spared. This syndrome is commonly encountered by rheumatologists, and it can accompany any rheumatologic disease or stand alone. Women between ages 20 and 60 years are primarily affected. The exact cause of FMS is unknown. Historically, many physicians questioned the validity of a diagnosis of FMS, resulting in a delay in care. Increasing evidence suggests, however, that genetic and environmental factors (**Table 1-1**) are responsible for FMS, and the diagnosis is becoming more widely accepted. Unfortunately, no cure is available for this often debilitating disease.

Clinical Symptoms

FMS can be associated with females who report "pain all over," making the diagnosis challenging. A careful history and thorough examination are much more valuable than advanced imaging and laboratory tests in arriving at the correct diagnosis. Patients typically report “hurting all over all the time.” In 1990, the American College of Rheumatology established the following criteria for the diagnosis of FMS:

- Widespread pain in all four quadrants of the body, usually waxing and waning, that has been present continuously for 3 months. Pain is considered widespread when all of the following are present: pain in the left side of the body, pain in the right side of the body, pain above the waist, and pain below the waist. In addition, axial skeletal pain must be present (neck, anterior chest, or thoracic or low back). Low back pain is considered pain below the waist.
- Pain and tenderness at 11 or more of 18 tender point sites (9 pairs) on digital palpation with an approximate force of 4 kg (enough force to cause the examiner’s nail bed to blanch). A dolorimeter is an examination tool that applies exactly 4 kg of pressure. For a tender point to be considered positive, the patient must state that the palpation was “painful” in contrast to “tender” (**Table 1-2**).

Table 1 1

Current Theories of Causation for Fibromyalgia Syndrome

Hyperexcitability of central nervous system pain receptors, termed *central sensitization*
Abnormal central processing of nociceptive input
Dysfunction of hypothalamic-pituitary-adrenal axis, specifically dopaminergic neurotransmission

Table 1 2

Tender Point Sites

Location	Characteristics
Posterior	
Occiput	Bilateral, at the occipital muscle insertions
Supraspinatus	Bilateral, at origins, above the scapular spine near the medial border
Trapezius	Bilateral, at the midpoint of the upper border
Gluteal	Bilateral, in upper outer quadrants of buttocks in anterior fold of muscle
Greater trochanter	Bilateral, posterior to the trochanteric prominence
Anterior	
Low cervical	Bilateral, at the anterior aspects of the intertransverse spaces at C5–7
Second rib	Bilateral, at the second costochondral junctions, just lateral to the junctions on upper surfaces
Lateral epicondyle	Bilateral, 2 cm distal to the epicondyles
Knee	Bilateral, at the medial fat pad proximal to the joint line

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Table 1 3

Symptoms and Conditions Associated With Fibromyalgia Syndrome

Associated Symptoms	Associated Conditions
Sleep disturbances	Restless legs syndrome
Stiffness	Temporomandibular joint syndrome
Bursitis and tendinitis	Silicone breast implant syndrome
Short-term memory loss	Irritable bowel syndrome
Fatigue	Premenstrual syndrome
Mood changes: depression, anxiety	Dysmenorrhea
Headaches: migraines, tension	Cystitis
Substernal chest pain	Mitral valve prolapse
Urinary frequency and urgency	Myofascial pain syndrome
Paresthesias in hands/feet	

A wide variety of symptoms and conditions can accompany FMS (**Table 1-3**). The history should always include questions about a patient's exercise regimen, medication list, allergies, and perpetuating factors.

An important distinction should be made between FMS and myofascial pain syndrome (MPS). MPS involves trigger points, which, like FMS tender points, have reproducible tenderness with pressure at the muscular and fascial sites; unlike FMS, however, with MPS, pain also is experienced distally, at a zone of referred pain. Trigger points are found in firm, elongated bands in muscle fibers and are associated with a local twitch response. This response is an involuntary, transient contraction of the bands and can be elicited