Basic Athletic Training
Course Pack C

CHAPTER

18

Upper Arm, Elbow, and Forearm Conditions

STUDENT OUTCOMES

1. Identify the important bony and soft-tissue structures in the upper arm, elbow, and forearm.
2. Describe the major motions at the elbow and list the muscles that produce them.
3. Explain the general principles used to prevent injuries to the shoulder.
4. Describe the forces that produce the loading patterns responsible for common injuries to the upper arm, elbow, and forearm.
5. Describe a thorough assessment of the elbow region.
6. List the common acute injuries and conditions sustained

in the upper arm, elbow, and forearm regions by physically active individuals.

7. Describe the soft-tissue pathology in the upper arm, elbow, and forearm regions resulting from overuse.
8. Explain the management strategies for common injuries and conditions of the upper arm, elbow, and forearm.
9. Describe the various types of fractures found at the elbow and explain their management.
10. Explain the general principles and techniques used in developing a rehabilitation exercise program for the elbow region.

INTRODUCTION

The arms perform lifting and carrying tasks, cushion the body during collisions, and lessen body momentum during falls. In many sports, performance is contingent on the ability of the arms to effectively swing a racquet or club or the hands to position for throwing and catching. In collision sports such as football and rugby and in combative events such as judo and karate, acute elbow injuries are the most commonly occurring injuries.[1] Sports that involve high-speed activities such as skiing, skating, and cycling, as well as sports that require the athlete to perform at heights, such as gymnastics, pole vault, and high jump, also see a higher number of acute injuries of the elbow, wrist, and hand.[1] Muscular weakness and imbalance, decreased proprioception, inadequate muscle length and flexibility, improper conditioning, and training errors, as well as poor biomechanics, all contribute to developing chronic elbow, wrist, and hand injuries.[2,3]

This chapter begins with a review of anatomy and an overview of the kinematics and kinetics of the upper arm, elbow, and forearm. A discussion concerning prevention of injury is followed by the injury assessment process. Information regarding common injuries to the upper arm, elbow, and forearm is presented, followed by examples of rehabilitation exercises.

ANATOMY OF THE ELBOW

Although the elbow generally may be thought of as a simple hinge joint, the elbow actually is categorized as a trochoginglymus joint that encompasses three articulations: the humeroulnar, humeroradial, and proximal radioulnar joints.[4] The bony structure of the elbow and forearm is displayed in **Figure 18.1**. Several strong ligaments bind these articulations together, and a single-joint capsule surrounds all three. Twenty-three muscles associated with the elbow provide dynamic stability.[4]

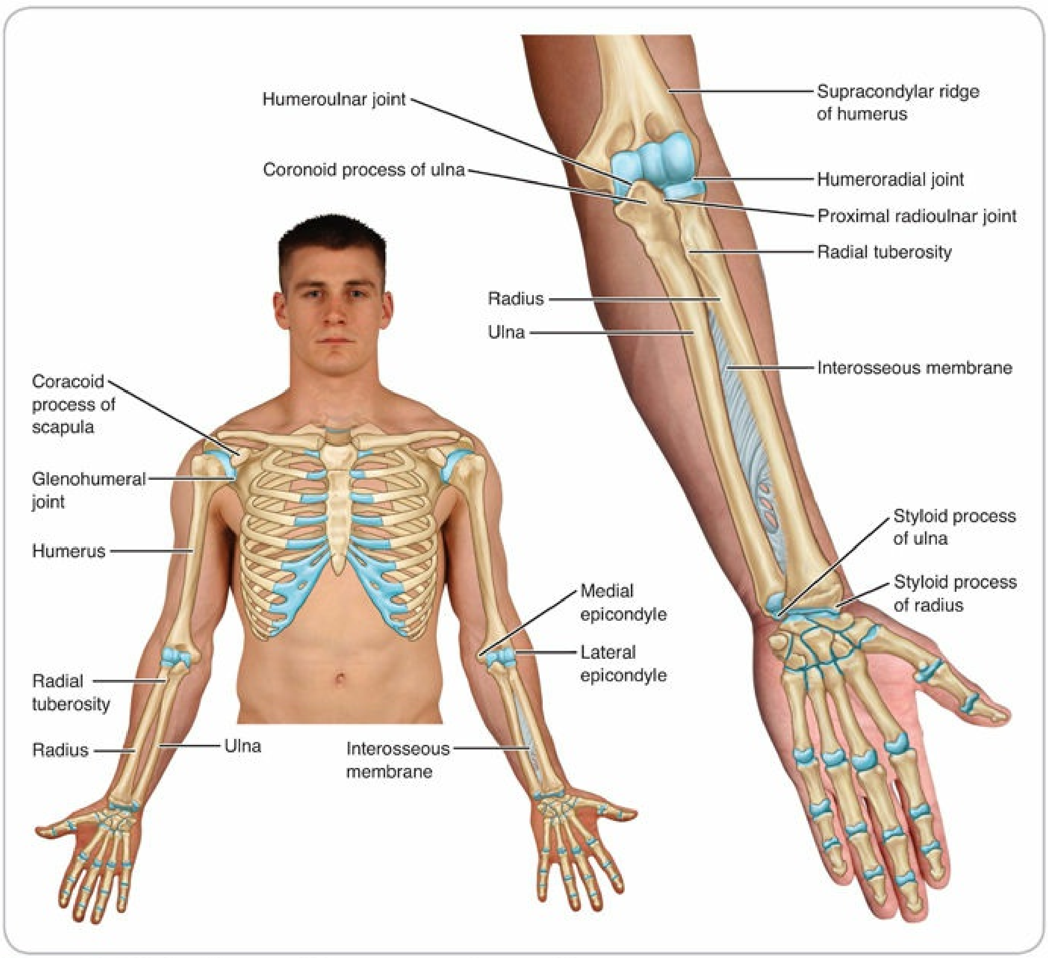


Figure 18.1. **Skeletal features of the upper arm, elbow, and forearm.**

Humeroulnar Joint

The humeroulnar joint at the elbow is a hinge joint. It is the articulation of the trochlea of the humerus with the reciprocally shaped trochlear fossa of the ulna. Motion capabilities primarily are flexion and extension. In some individuals, particularly women, however, a small amount (i.e., 5° to 15°) of hyperextension is allowed. The joint is most stable in the close-packed position of extension.

Humeroradial Joint

The humeroradial joint, which is lateral to the humeroulnar joint, is formed between the spherical capitellum of the humerus and the proximal radius. It is a gliding joint, with motion restricted to the sagittal plane by the adjacent humeroulnar joint. The close-packed position is with the elbow flexed at 90°, and the forearm is supinated approximately 5°.

Proximal Radioulnar Joint

The annular ligament binds the head of the radius to the radial notch of the ulna, forming the proximal radioulnar joint. It is a pivot joint that permits forearm pronation and supination to occur as the radius rolls medially and laterally over the ulna (**Fig. 18.2**). The close-packed position is at 5° of forearm supination.

Figure 18.2. Forearm movements. A, Supination occurs when the radius and ulna are parallel to each other. **B,** Pronation involves the rotation of the radius over the ulna.

Carrying Angle

The angle between the longitudinal axes of the humerus and the ulna when the arm is in anatomical position is known as the carrying angle. The angle is so named because it causes the forearm to angle away from the body when a load is carried in the hand. Given, however, that loads typically are carried with the forearm in a neutral rather than a fully supinated position, the functional significance of the carrying angle is questionable. Nevertheless, the size of the carrying angle at the elbow is one of the skeletal differences between females and males and is attributed to differences in the shape of the trochlea. When the elbow is fully extended and the forearm fully supinated, the carrying angle ranges from approximately 10° to 15° in adults and generally is greater in females than in males. The carrying angle changes with skeletal growth and maturity and is always greater on the side of the dominant hand.[5]

Ligaments of the Elbow

The elbow is reinforced by capsuloligamentous structures that are thickenings of the capsule. These form the medial and lateral ligamentous complexes (**Fig. 18.3**). The medial (ulnar) collateral ligament, the most important ligament for stability of the elbow joint, is divided into three oblique bands denoted by their anatomical location—namely, anterior, transverse, and posterior. The anterior oblique band is taut throughout the elbow's full range of motion (ROM) and is the primary restraint against valgus forces. The transverse oblique band provides little, if any, support to the medial elbow. The posterior oblique band is a fan-shaped, capsular thickening that generally is taut when the elbow is flexed beyond 90°.

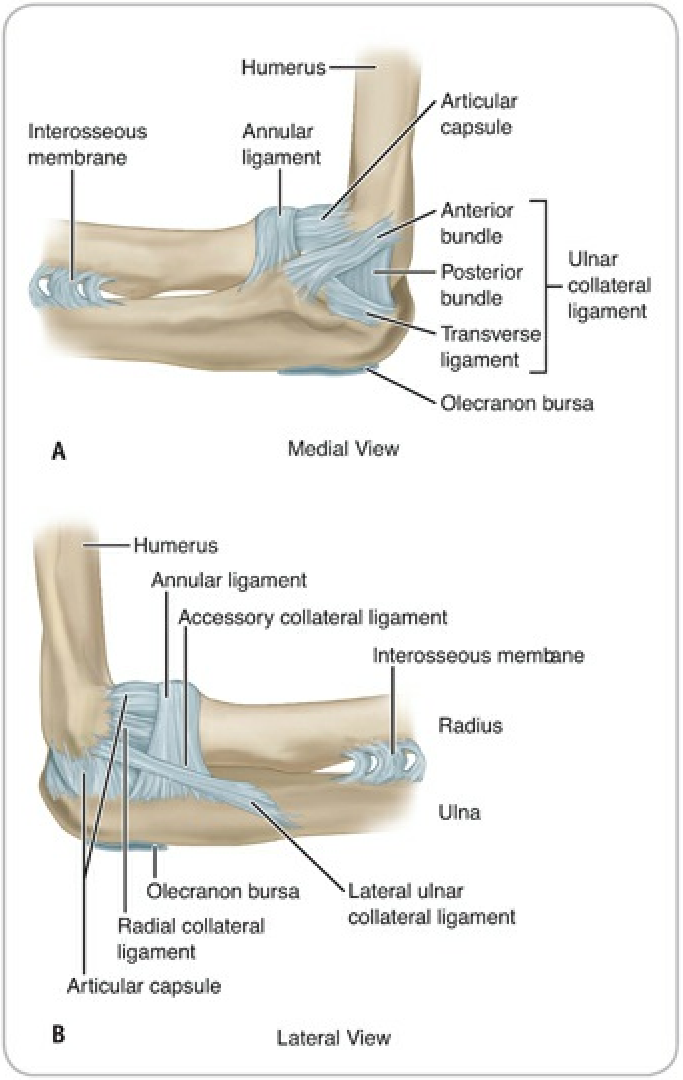


Figure 18.3. Major ligaments and the olecranon bursa of the elbow. A, Medial view. **B,** Lateral view.

The lateral (radial) collateral ligament complex consists of four components: the lateral ulnar collateral, radial collateral, annular, and accessory ligaments. The radial collateral ligament, which runs from the lateral epicondyle of the humerus and terminates at the annular ligament, resists varus forces. The posterior portion of this ligament, which is referred to as the lateral ulnar collateral ligament, extends distally to the lateral ulna.

The annular ligament fits tightly around the radial head and upper portion of the neck. It permits pronation and supination of the forearm as the radius rotates, internally and externally, on the ulna. Superior and inferior oblique bands of the annular ligament attach proximally and distally to the ulna.[6]

During extreme supination, the anterior fibers of the annular ligament are taut; during extreme pronation, the posterior fibers are taut. The accessory lateral collateral ligament is a superficial layer of fibers that blends with the annular ligament to insert onto the supinator tubercle of the ulna.

Bursae of the Elbow

Although the elbow has several small bursae, the most clinically relevant is the subcutaneous olecranon bursa located between the olecranon and the skin surface. The lubricating function of the bursa facilitates smooth gliding of the skin over the olecranon process during elbow flexion and extension.

Muscles of the Elbow

A large number of muscles cross the elbow (**Figs. 18.4** and **18.5**). Identifying the actions of these muscles is complicated by the fact that several muscles are two-joint muscles, which extend into the shoulder or the hand and fingers.

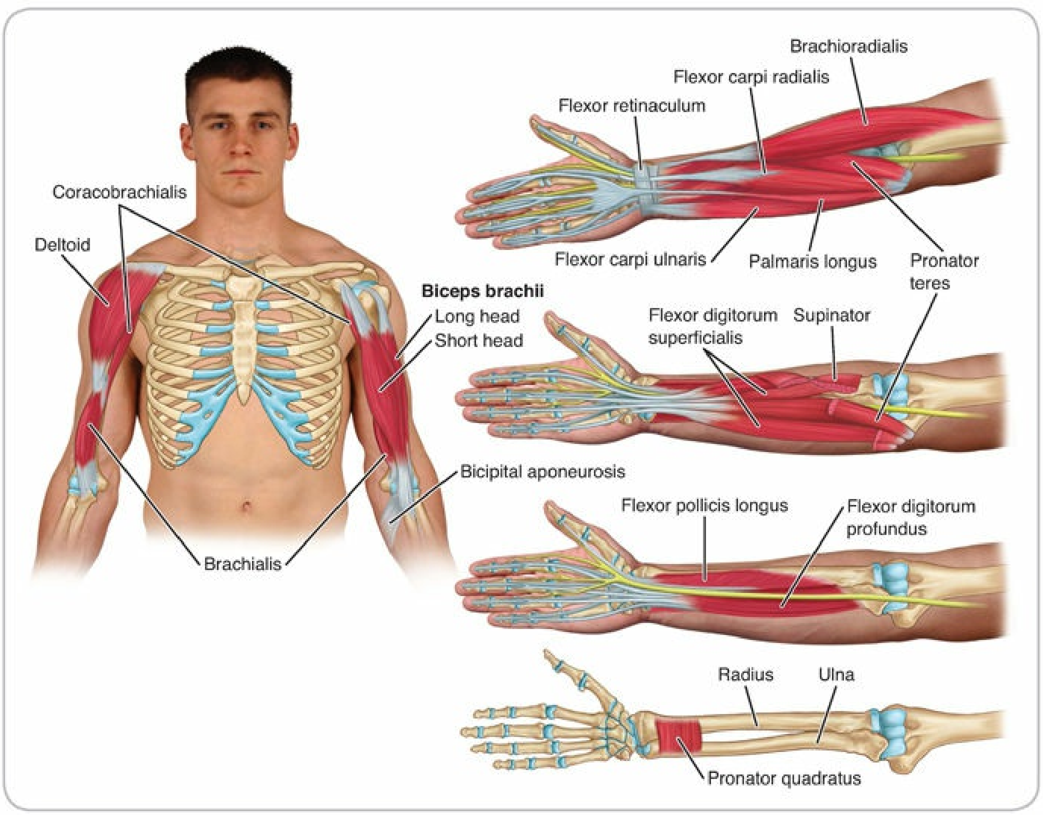


Figure 18.4. Muscles of the anterior arm and forearm.

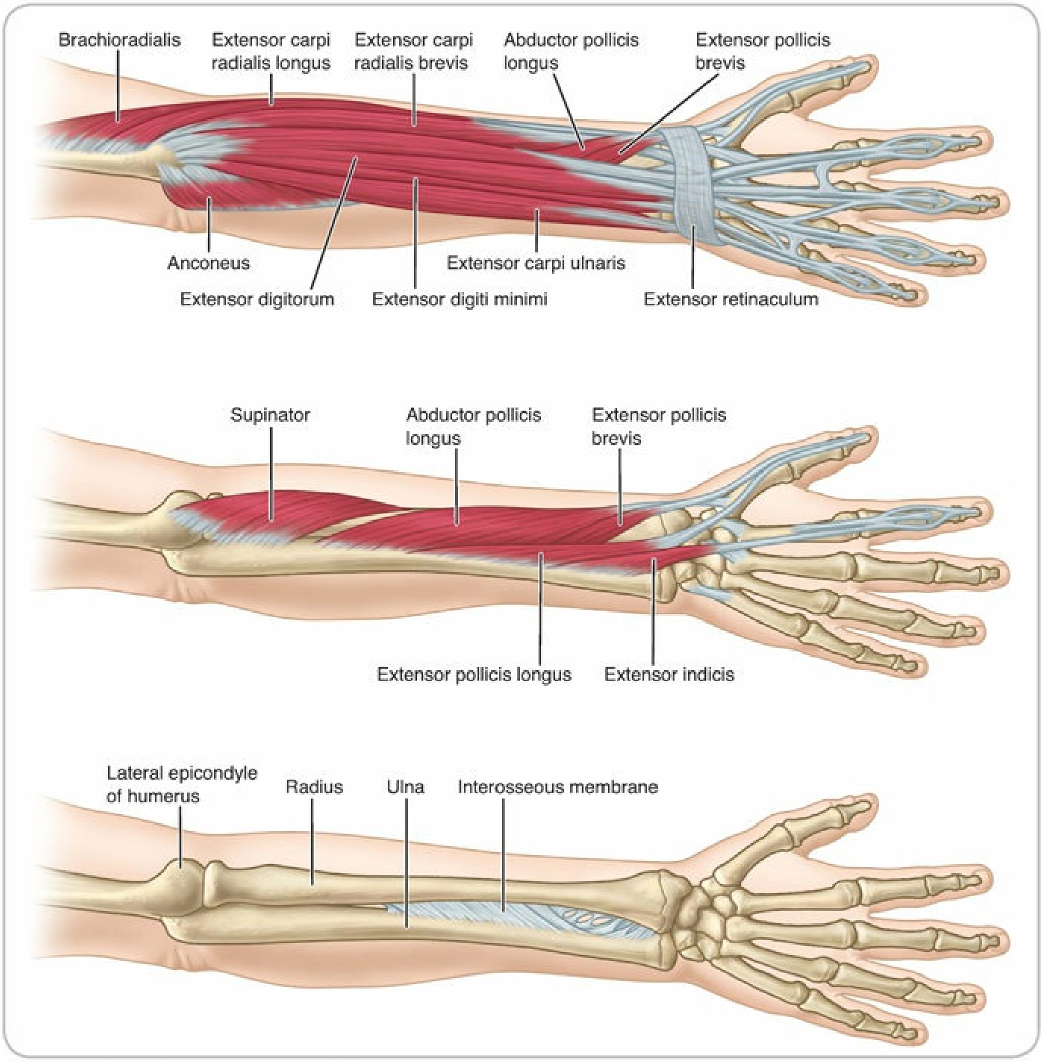


Figure 18.5. **Muscles of the posterior arm and forearm.**

Nerves of the Elbow

The major nerves of the elbow and forearm descend from the brachial plexus and include the musculocutaneous (C5 through C7), median (C5 through T1), ulnar (C8 through T1), and radial nerves (C5 through T1) (Fig. 18.6). The musculocutaneous nerve provides motor supply to the flexor muscles of the anterior arm and sensory innervation to the skin of the lateral forearm. The median nerve supplies most of the flexor muscles of the anterior forearm and the skin on the palmar aspect of the hand, including the thumb, index finger, and middle finger, and the lateral half of the ring finger. The ulnar nerve provides innervation to the flexor carpi ulnaris and the medial half of the flexor digitorum profundus and to the skin on the medial border of the hand, including the little finger and the medial half of the ring finger. The radial nerve, which is the largest branch of the brachial plexus, passes anteriorly to the lateral epicondyle at the elbow and then divides into superficial and deep branches to continue along the posterolateral aspect of the forearm. The radial nerve supplies the arm and forearm extensor muscles and the skin on the posterior aspect of the arm and forearm.

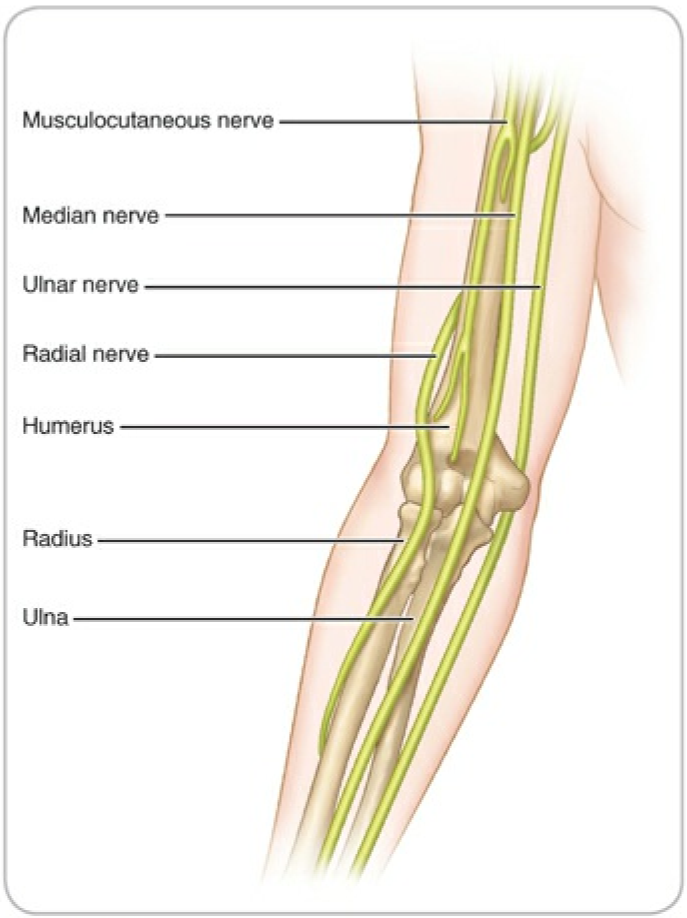


Figure 18.6. Nerves of the elbow region.

See **Muscles of the Elbow**, available on the companion Web site at thePoint, for a summary of these muscles, including attachments, primary actions, and innervation.

Blood Vessels of the Elbow

The major arteries of the elbow and forearm region are the brachial, ulnar, and radial arteries (Fig. 18.7). The brachial artery courses down the medial side of the arm, providing blood supply to the flexor muscles of the arm. The deep brachial artery branches off to supply the triceps brachii. In the elbow, the brachial artery forms an anastomosis, or a network of communicating blood vessels, to supply the elbow joint. The main branch of the brachial artery crosses the anterior aspect of the elbow, where the brachial pulse can be readily palpated.

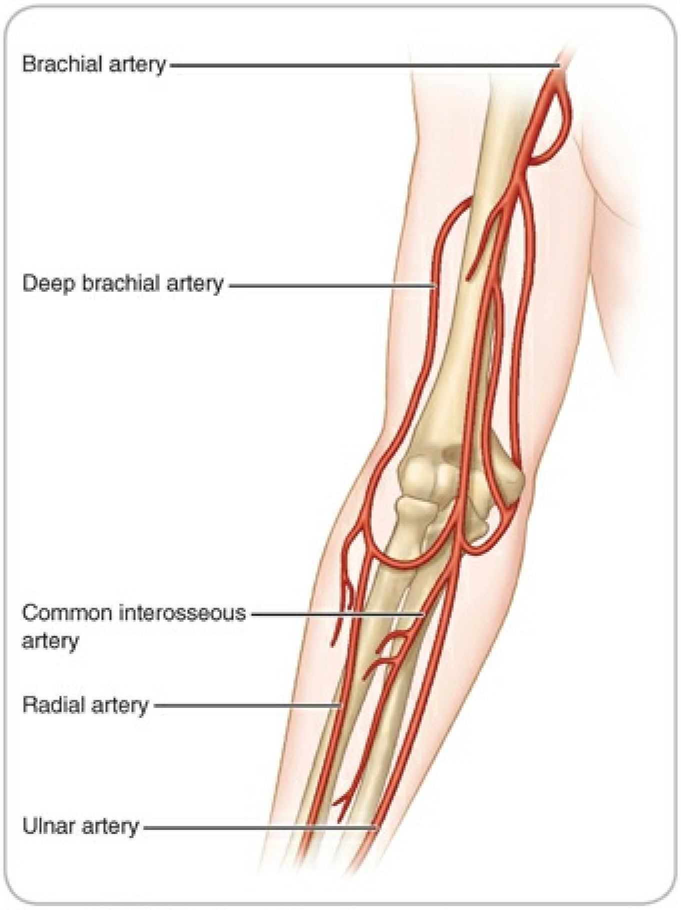


Figure 18.7. Arteries of the elbow region.

Distal to the elbow, the brachial artery splits into the ulnar and radial arteries. The ulnar artery supplies the medial forearm, and, via one of its branches, the common interosseous artery supplies the deep flexors and extensors of the forearm. The radial artery, which courses along the anterior aspect of the radius, supplies the lateral forearm muscles. Pulses can be taken for both arteries on the anterior aspect of the wrist (see Fig. 6.3).

KINEMATICS AND MAJOR MUSCLE ACTIONS OF THE ELBOW

The three associated joints at the elbow allow motion in two planes. Flexion and extension are sagittal plane movements that occur at the humeroulnar and humeroradial joints; pronation and supination are longitudinal rotational movements that take place at the proximal radioulnar joint.

Flexion and Extension

The elbow flexors include those muscles that cross the anterior side of the joint. The primary elbow flexor is the brachialis. Because the distal attachment of the brachialis is the coronoid process of the ulna, the muscle is equally effective when the forearm is in supination or in pronation. Another elbow flexor, the biceps brachii, has both long and short heads attached to the radial tuberosity via a single common tendon. When the forearm is supinated, the biceps contributes effectively to flexion, because it is slightly stretched. When the forearm is pronated, the muscle is less taut and, consequently, less effective. The brachioradialis, which also is an elbow flexor, is most effective when the forearm is in a neutral position (i.e., midway between full pronation and full supination). Other flexor muscles that cross the elbow are important dynamic stabilizers of the joint. In particular, the flexor carpi ulnaris and flexor digitorum superficialis provide significant stability to the medial elbow during a variety of activities, including throwing.

The triceps is the major elbow extensor. Although the three heads have separate origins, they attach to the olecranon process of the ulna through a common distal tendon. The small anconeus muscle also assists with extension at the elbow.

Pronation and Supination

Pronation and supination of the forearm occur when the radius rotates around the ulna. Three radioulnar articulations exist: the proximal, middle, and distal radioulnar joints. The proximal and distal joints are pivot joints. The middle radioulnar joint is a syndesmosis, with an elastic, interconnecting membrane that permits supination and pronation but prevents longitudinal displacement of one bone with respect to the other. The primary pronator muscle is the pronator quadratus, which attaches to the distal ulna and radius. The pronator teres, which crosses the proximal radioulnar joint, assists with pronation. As the name suggests, the supinator is the muscle primarily responsible for supination. During resistance or elbow flexion, the biceps also participates in supination.

KINETICS OF THE ELBOW

Although the elbow is not considered to be a weight-bearing joint, it sustains significant loads during daily activities. For example, it has been estimated that the compressive load at the elbow reaches 300 N (67 lb) during activities such as dressing and eating, 1,700 N (382 lb) when the body is supported by the arms when rising from a chair, and 1,900 N (427 lb) when pulling a table across the floor.[7] During performance of a one-handed push-up, compression at the elbow ranges around 65% of body weight.[8] Extremely large forces are generated by muscles crossing the elbow during forceful pitching and throwing motions as well as during weight lifting and many resistance training exercises. In fact, during an activity such as pitching, valgus stress at the elbow during the late cocking and acceleration phases of the throw can exceed the strength of the ulnar collateral ligament, resulting in microscopic tears within it.[9] The triceps, wrist flexor–pronator muscles, and anconeus must develop tension to assist the ulnar collateral ligament in resisting the valgus load. Greater valgus loads at the elbow have been associated with higher maximum pitch velocity as well as with a sidearm delivery.[10,11] When falling onto an outstretched hand with the elbow extended, varus–valgus loads are increased 1.4 times with the arm externally rotated and 2.7 times with the arm internally rotated.[12] During the execution of many skills in gymnastics and wrestling, the elbow functions as a weight-bearing joint.

Because the attachment of the elbow extensors to the ulna is closer to the joint center than the attachments of the elbow flexors on the radius and ulna, the extensor moment arm is shorter than the flexor moment arm. This means that the elbow extensors must generate more force than the elbow flexors to produce the same amount of joint torque. This translates to greater joint compression forces during extension than during flexion, when movements with comparable speed and force requirements are executed.

PREVENTION OF ELBOW CONDITIONS

The elbow often is subjected to compressive forces when the arm is placed in a position to cushion a fall or lessen the body's impact with another object. Limiting the height to which cheerleaders may stack and drop team members and the degree to which competitors in sports such as judo and wrestling may torque the elbow may contribute to a decrease in traumatic injury.[1] And while protective padding has been found to be one of the few methods for preventing some acute injuries, few sports require protective equipment at the elbow.[1] Microtraumatic forces caused by repetitive valgus and varus stresses can lead to overuse injuries, many of which are related to poor skill technique. Therefore, physical conditioning and proper skill technique are major factors in preventing injury to this region.

Early warning signs of impeding overuse injury in youth sport athletes include arm pain or soreness, fatigue, and decrease in quality or ability to throw.[13] Youth sport athletes should be encouraged to participate in only one overhead throwing sport at a time and avoid playing that one sport year round. Limiting time engaged in repetitive sport activity to no more than 16 hours per week and establishing pitching limits is thought to decrease the incidence and severity of overuse injuries for youth sport athletes.[13] Pitching limits are age-based: For pitchers between the ages of 9 and 14 years, the suggested limit is 75 pitches per game, 600 pitches per season, and between 2,000 and 3,000 pitches per year. For pitchers aged 15 to 18 years, the limit is set at 90 pitches per game with no more than two games per week.[13]

Protective Equipment

A variety of equipment types can be advantageous in preventing injury to the elbow. Because standard shoulder pads may not extend far enough to protect the upper arm, many football players attach an additional biceps pad to the shoulder pads to protect this vulnerable area. Special pads are available to protect the elbow during falls and collisions. Padded elbow sleeves or neoprene sleeves are worn in many sports to protect the olecranon from direct trauma and abrasions, particularly when playing on artificial turf. Counterforce braces, which commonly are used by participants in racquet sports, are intended to reduce muscle tensile forces that can lead to medial or lateral epicondylitis. Finally, hinged braces can add compression and support to the elbow to reduce excessive varus and valgus forces.

Physical Conditioning

The physical condition program should include a preseason and in-season component. Because throwing power and speed originates in the trunk and not the upper extremity, it is important to include exercises and training sessions that focus on neuromuscular control, balance, coordination, flexibility, and strengthening of the lower extremities.[13] This is especially true among pediatric athletes and those with a history of past injury.[13] Furthermore, when working with the youth sport athlete, the intensity, load, time, and distance the athlete is required to achieve should only be increased by about 10% each week to avoid overloading and breakdown.[13]

Many of the muscles that move the elbow also move the shoulder and wrist. Therefore, flexibility and strengthening exercises must focus on the entire arm. General flexibility exercises for the shoulder can be used in conjunction with warm-up exercises that mimic specific sport skills. For example, a tennis player may begin the warm-up session with slow, controlled forehand and backhand strokes that gradually increase in intensity. A pitcher or outfielder may begin with short, controlled throws, increasing the distance and intensity as the arm is warmed up. Strengthening exercises for the shoulder can be combined with those listed in **Application Strategy 18.1**. These exercises are designed to improve general strength in elbow flexion and extension, forearm pronation and supination, wrist flexion and extension, and radial and ulnar deviation. Physical conditioning programs should begin with light resistance and progress to a heavier resistance.

APPLICATION STRATEGY 18.1

Exercises to Prevent Injury to the Elbow Region

Begin all exercises with light resistance using dumbbells or surgical tubing.

1. **Biceps curl.** Support the involved arm on the leg and fully flex the elbow. This also can be performed bilaterally in a standing position with a barbell.

2. **Triceps curl.** Raise the involved arm over the head and extend the involved arm at the elbow. This also can be performed bilaterally in a supine or standing position with a barbell.

3. **Wrist flexion.** Support the involved forearm on a table or your leg with the hand off the edge. With the palm facing up, slowly do a full wrist curl and then return to the starting position.

4. **Wrist extension.** Support the involved forearm on a table or your leg with the hand off the edge. With the palm facing down, slowly do a full reverse wrist curl and then return to the starting position.

5. **Forearm pronation–supination.** Support the involved forearm on a table or your leg with the hand off the edge. With surgical tubing or a hand dumbbell, roll the forearm into pronation and then return to supination. Adjust the surgical tubing and reverse the exercise, stressing the supinators. The elbow should remain stationary.

6. **Ulnar–radial deviation.** Support the involved forearm on a table or your leg with the hand off the edge. With surgical tubing or a hand dumbbell, perform ulnar deviation. Reverse directions and perform radial deviation. An alternate method is to stand with the arm at the side while holding a hammer or a weighted bar. Raise the wrist in ulnar deviation. Repeat in radial deviation.

7. **Wrist curl-ups.** Exercising the wrist extensors is performed by gripping the bar with both palms facing down. Slowly wind the cord onto the bar until the weight reaches the top and then slowly unwind the cord. Reverse the hand position to work the wrist flexors.

Proper Skill Technique

Nearly all overuse injuries are directly related to repetitive, throwing-type motions that produce microtraumatic tensile forces on the surrounding soft-tissue structures. Children who use a sidearm throwing motion are threefold more likely to develop problems compared with those who use a more traditional overhead technique. Movement analysis can detect improper technique in the acceleration and follow-through phase that contributes to these excessive tensile forces. High-speed photography may aid in this analysis.

Teaching sport participants the shoulder-roll method of falling is another preventive measure. Falling on an extended hand or flexed elbow is the most common mechanism for acute injuries in the upper extremity. Excessive compressive forces can be transmitted along the long axis of the bones, leading to a fracture or dislocation.

ASSESSMENT OF ELBOW CONDITIONS

A Little League Baseball player is complaining of pain on the medial elbow during pitching. How should the assessment of this injury progress to determine the extent and severity of injury?

The elbow's primary role is to place the forearm and hand in the most appropriate position to perform efficient motion. Biomechanical errors in throwing technique at the shoulder can place additional stress at the elbow. Because use of equipment often is associated with overuse problems, it is important to determine if the individual uses a bat, racquet, field hockey or lacrosse stick, or other implement. Assessment of skill technique to rule out possible contributing factors also is advisable.

See **Application Strategy: Elbow Evaluation**, available on the companion Web site at thePoint, for a summary of the assessment of the upper arm, elbow, and forearm.

Because of the severity of the trauma, recognizing possible fractures and dislocations early in an assessment is essential. It also is important to understand that pain may be referred from the cervical region, shoulder, or wrist to the arm. As in any assessment, both arms should be fully visible to allow bilateral comparison.

HISTORY

The injury assessment of the Little League Baseball player should begin with a history. What questions need to be asked to identify the cause and extent of this injury?

The onset and location of symptoms are two of the most critical facts surrounding elbow trauma. This information forms the basis for determining the cause-and-effect relationship between the mechanism and the onset of injury. In gathering information about the primary complaint, questions should focus on the individual's perception of pain, weakness, or sensory changes. It also is important to note if the nature of the injury is acute or overuse. Specific questions should be asked related to equipment, technique, and recent changes in training intensity, frequency, or duration.

See **Application Strategy: Developing a History of the Injury**, available on the companion Web site at thePoint, for specific questions that should be included in an elbow evaluation.

The Little League Baseball player should be asked questions that address the following: when, where, and how; throwing technique and training regimen; phase of throwing motion in which pain occurs; intensity, location, and type of pain; actions that relieve pain; and any previous injury, treatment, and medication.

OBSERVATION AND INSPECTION

The history of the Little League player reveals that an aching pain has been present for 2 to 3 days. The pain intensifies during the acceleration phase of throwing and has started to affect his performance. Explain the observation component in the ongoing assessment of the Little League player.

If the history has indicated an insidious onset of elbow trauma, the individual's full-body posture, especially of the neck and shoulder area, should be observed. In an acute injury, if the individual is in great pain or is unable or unwilling to move the elbow, the assessment should be completed in the position that is most comfortable for the individual.

Initially, the arm should be observed from an anterior position for any noticeable deformity and possible holding of the arm. If swelling is present in the joint, the individual may be unable to fully extend the elbow, resulting in a slightly flexed position. This **resting position** allows the joint to have maximal volume to accommodate intra-articular swelling. The carrying angle of the arms should be noted. A normal angle is slight valgus, with the forearm fully supinated and the elbow extended. Angles of greater than 20° are referred to as **cubital valgus**; angles of less than 10° are referred to as **cubital varus**. Baseball pitchers may exhibit cubital valgus in the throwing arm as an adaptation to repeated valgus loading during the throwing motion. The alignment of the forearm and humerus normally is fully extended, although extension beyond 0° (**cubital recurvatum**) is common, especially in females.

In the next portion of the observation, the elbow should be observed in the position of function, namely 90° of flexion, with the hand being held halfway between supination and pronation. The entire region should be assessed for symmetry and any abnormal deformity, muscle atrophy, hypertrophy, swelling, discoloration, or previous surgical incisions. In particular, the cubital fossa, which is a triangular area bounded laterally by the brachioradialis muscle and medially by the pronator teres muscle, should be inspected. The biceps brachii tendon, median nerve, and brachial artery pass through the fossa. The presence of swelling in the fossa can place pressure on the neurovascular structures as they pass through the area.

Next, the medial aspect of the arm should be inspected. The medial epicondyle of the humerus should be prominent rather than obscured by excessive swelling. The wrist flexor muscle mass should appear bilaterally equal in terms of muscle tone and mass. Atrophy of the mass may result from disuse associated with long-term tendinitis or prolonged immobilization.

Observation should then move to the lateral aspect of the arm. The wrist extensor muscle mass on the lateral aspect of the elbow also should appear bilaterally equal in terms of muscle tone and mass. Atrophy of the mass may result from disuse associated with long-term tendinitis, prolonged immobilization, or radial nerve pathology.

Finally, the arm should be observed from a posterior position. It is important to note the position of the olecranon relative to the epicondyles of the humerus. In a flexed position, the olecranon process and epicondyles should form an isosceles triangle; in an extended position, the olecranon process and epicondyles should form a straight line. The olecranon process should be clearly visible rather than obscured by excessive swelling.

Observation of the Little League player should include the following: full-body posture; carrying angle and position of function; and inspection at the site for swelling, discoloration, deformity, muscle hypertrophy, atrophy, and other signs of trauma.

PALPATION

Observation of the Little League player reveals minor swelling over the medial epicondyle. No other visible signs are apparent. Explain palpation specific to the injury sustained by the player.

The injured arm should be supported during palpation. Bilateral palpation should determine temperature, swelling, point tenderness, crepitus, deformity, muscle spasm, and cutaneous sensation. In general, palpation should move from proximal to distal, leaving the areas that are anticipated to be the most painful for last. Pulses can be taken at the radial and ulnar arteries at the wrist and at the brachial artery in the cubital fossa. The following structures should be palpated:

Anterior Palpation

1. Cubital fossa, biceps brachii tendon, median nerve, and brachial artery
2. Coracoid process and head of radius

Lateral Palpation

1. Lateral supracondylar ridge and brachioradialis muscle
2. Lateral epicondyle, common wrist extensors, and supinator muscle
3. Radial collateral ligament
4. Annular ligament and head of the radius (this is facilitated by supination and pronation of the forearm and should only be performed if no deformity

is present)

Posterior Palpation

1. Triceps muscle
2. Olecranon process and olecranon fossa (this is facilitated by positioning the elbow in 45° of flexion to relax the triceps and should only be performed if no deformity is present)
3. Olecranon bursa (the skin overlying the olecranon process should be grasped, which permits palpation to note any thickening or presence of loose bodies)
4. Ulnar nerve in the cubital tunnel
5. Ulnar border distal to the styloid process at the wrist

Medial Palpation

1. Medial supracondylar ridge
2. Medial epicondyle and common wrist flexor–pronator tendons and muscles
3. Ulnar collateral ligament

During the assessment of the Little League player, the following structures should be palpated for point tenderness, swelling, deformity, skin temperature, sensation, and other signs of trauma: medial supracondylar ridge, medial epicondyle, proximal attachment of wrist flexors and pronators, ulnar collateral ligament, ulna, olecranon, and ulnar nerve.

PHYSICAL EXAMINATION TESTS

> ? Palpation of the Little League player revealed point tenderness and swelling directly on the medial epicondyle. Based on the information obtained through the history, observation, and palpation, what tests should be performed as part of the physical examination of Little League player?

If a fracture or dislocation is suspected, testing should not be performed. Instead, the arm should be immobilized in an appropriate splint, and the emergency action plan should be activated. In some settings, summoning emergency medical services (EMS) may be warranted. Only those tests that are necessary to assess the current injury should be performed.

Functional Tests

The available ROM in elbow flexion–extension, forearm pronation–supination, and wrist flexion–extension should be determined. If trauma to the ulnar, median, or radial nerves is suspected, ROM testing of the thumb and fingers also should be performed.

Active Movements

The clinician should stabilize the upper arm against the body to prevent muscle substitution. As with previous assessments, bilateral comparison with the uninvolved arm is necessary. Active movements that are anticipated to be painful should be performed last to prevent painful symptoms from overflowing into the next movement.

The motions that should be assessed and the normal ROM for each are as follows:

- Flexion at the elbow (140° to 150°)
- Extension at the elbow (0° to 10°)
- Supination of the forearm (90°)
- Pronation of the forearm (90°)
- Flexion of the wrist (80° to 90°)

- Extension of the wrist (70° to 90°)

During elbow extension, it is important to recognize that some females can extend as much as 5° to 15° below the straight line. Bilateral comparison verifies whether this extra motion is normal for the individual. In performing active pronation and supination, the individual should be instructed to flex the elbow to 90° and then secure the elbow next to the body to avoid any glenohumeral motion. Goniometry measurements are demonstrated in **Figure 18.8**.

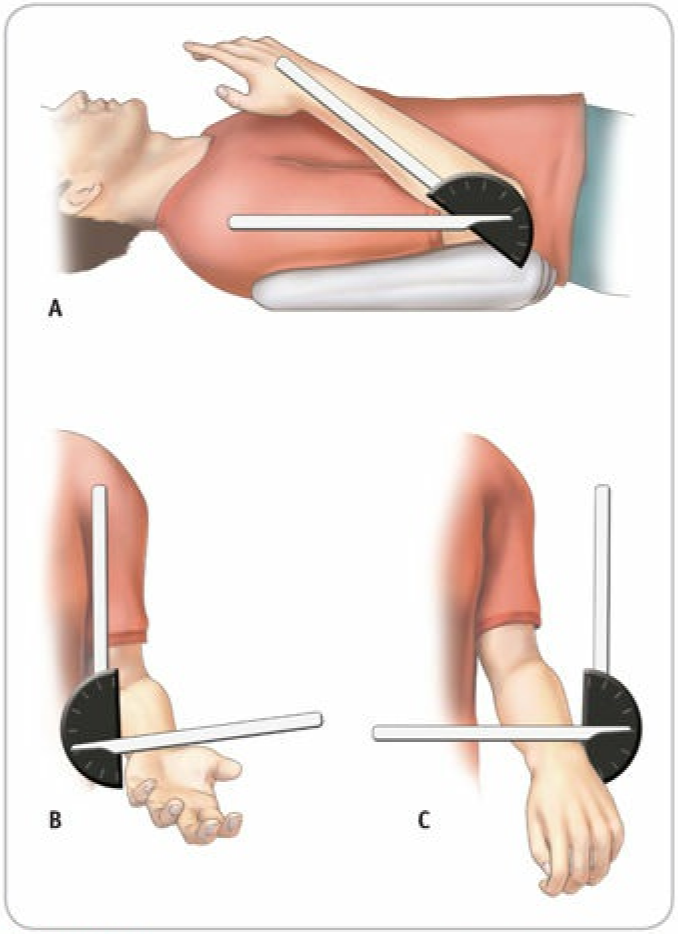


Figure 18.8. Goniometry measurement. A, Elbow flexion and extension. The fulcrum is centered over the lateral epicondyle of the humerus. The proximal arm is aligned along the humerus, using the acromion process for reference. The distal arm is aligned along the radius, using the styloid process for reference. **B, Forearm supination.** The fulcrum is centered medial to the ulnar styloid process. The proximal arm is parallel to the midline of the humerus, and the distal arm is placed across the palmar aspect of the forearm just proximal to the styloid processes of the radius and ulna. **C, Forearm pronation.** The fulcrum is centered lateral to the ulnar styloid process. The arms are placed in the same position but on the dorsal aspect of the forearm.

Passive Movements

If the individual is able to perform full ROM during active movements, gentle overpressure should be applied at the extremes of motion to determine end feel. The normal end feels are as follows:

- Tissue stretch—elbow flexion; supination; pronation
- Tissue approximation—shoulder adduction

- Bone to bone—elbow extension

Resisted Muscle Testing

The elbow should be stabilized against the body during muscle testing to prevent any muscle substitution. The testing begins with the clinician placing the muscle on a stretch. When performing the various motions, the clinician should apply gentle resistance proximal to the wrist throughout the full ROM. To avoid allowing finger flexors or extensors to assist during movement, instruct the patient to keep the thumb and fingers relaxed. Motion should be assessed several times to note any weakness or fatigue. Any sudden or jarring motions should be avoided, because this may lead to undue pain. Any lag or muscle weakness should be noted. Muscle actions that may cause extreme pain should be delayed until the final phase of muscle testing. Figure 18.9 demonstrates motions that should be tested.

Figure 18.9. Resisted manual muscle testing for the elbow. The myotomes for each motion are listed in parentheses. **A,** Elbow flexion (C6). **B,** Elbow extension (C7). **C,** Forearm supination. **D,** Forearm pronation. **E,** Wrist flexion (C7). **F,** Wrist extension (C6).

Manual Muscle Testing

If pain or weakness is found during resisted ROM, the clinician may decide to perform a manual muscle test to determine which muscle is damaged. To correctly apply the manual muscle testing techniques to the shoulder complex, the torso must be properly stabilized.[14] See **Table 18.1** for manual muscle testing procedures for the shoulder.

TABLE 18.1 Manual Muscle Testing of Selected Muscles of the Elbow

MUSCLE	JOINT POSITIONING	APPLY PRESSURE
Pronator teres	The patient is supine with upper arm resting on plinth and pressed against torso, forearm pronated, and elbow in partial flexion.	To the lower forearm, above the wrist, in the direction of supination
Supinator	The patient is supine with GH and elbow joints both flexed to 90°. The forearm is supinated.	To the distal end of the forearm, just proximal to the wrist, in the direction of pronation
Biceps brachii	Patient is seated, with upper arm beside torso, and elbow flexed to 90° and supinated.	To the distal aspect of the forearm, in the direction of elbow extension
Brachioradialis	Patient is seated, with upper arm beside torso, elbow flexed to 90°, and forearm in neutral.	To the distal aspect of the forearm, in the direction of elbow extension
Brachialis	Patient is seated, with upper arm beside torso, elbow flexed to 90°, and forearm in pronation.	To the distal aspect of the forearm, in the direction of elbow extension
Triceps brachii and anconeus	Patient is supine with GH joint flexed to 90° and elbow just shy of full extension with forearm in neutral position.	To the distal aspect of the forearm in the direction of flexion

GH, glenohumeral.

For more in depth descriptions and illustrations, see Kendall FP, McCreary EK, Provance PG, et al, eds. *Muscles: Testing and Function with Posture and Pain.* 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2005.

Stress Tests

In using stress tests, only those tests that are absolutely necessary should be performed. In moving through the tests, the clinician should begin by applying gentle stress. The force should be applied several times with increasing overpressure. The presence of pain or joint laxity should be noted.

Ulnar Collateral Ligament Stress Test (Valgus Stress Test)

Because of the amount of rotation that occurs at the shoulder, it is difficult to get an accurate valgus stress at the elbow. As such, tests should be performed at multiple angles, from full extension to 20° to 30° of flexion. When the olecranon is “unlocked” from the olecranon fossa, the ligamentous structures are isolated. While the individual is seated, the arm should be stabilized and a valgus or abduction force applied to the distal forearm to stress the ulnar collateral ligament (**Fig. 18.10A**). The diagnostic value of the valgus stress test is 65% sensitivity and 50% specificity.[15] A more clinically relevant test for assessing the integrity of the ulnar collateral ligament is the moving valgus stress test.

Figure 18.10. **Ligamentous instability tests. A,** The ulnar collateral ligament: a valgus force at multiple angles. **B,** The moving valgus stress test. **C,** The radial collateral ligament: a varus force at multiple angles.

Moving Valgus Stress Test

With 100% sensitivity and 75% specificity, the moving valgus stress test is performed with the patient either seated or standing and shoulder abducted to 90°.[16] Starting position is with the patient's elbow fully flexed while the clinician exerts moderate valgus pressure at the elbow. While keeping a valgus force at the elbow, the clinician passively moves the elbow into extension (**Fig. 18.10B**). The test is considered positive if the maneuver replicates the pain the patient experiences with activity and the pain is most intense between 70° and 120° of extension. Positive findings imply the possibility that the deep anterior bundles of the medical collateral ligament have been damaged which may lead to "chronic valgus extension overload."[16]

Radial Collateral Ligament Test (Varus Stress Test)

The radial collateral ligament test is also referred to as the varus stress test or the lateral collateral ligament stress test and is used to assess the integrity of the radial collateral (lateral) ligament of the elbow. To perform the test, the patient's arm is placed in the anatomical position while the clinician places a hand over the medial epicondyle with one hand the lateral aspect of the wrist with the other. A varus force is applied in the anatomical position and in slight flexion (**Fig. 18.10C**). Pain or gapping on the lateral aspect of the elbow implies damage to the radial collateral ligament. No data has been found on the diagnostic accuracy of this test.

Milking Test

With the patient seated and the elbow flexed at 90° and the shoulder abducted to 90°, the clinician grasps the patient's thumb and passively forces the patient's shoulder into the end range of glenohumeral external rotation. Pain at the medial elbow is considered a positive test for ulnar collateral ligament injury.

Special Tests

Several special tests can be used for detecting injury or related pathology (e.g., epicondylitis and neuritis).

Common Extensor Tendinitis Test (Cozen Test or Tennis Elbow Tests)

The Cozen test is a highly relevant clinical test for replicating pain in patients with lateral epicondylalgia, with reported 91% sensitivity.[17] The clinician stabilizes the patient's flexed elbow and palpates the lateral epicondyle. The patient is instructed to make a fist and pronate the forearm. Next, the patient attempts to radially deviate and extend the wrist while the clinician applies resistance (**Fig. 18.11A**). A positive sign is indicated if severe pain is present over the lateral epicondyle of the humerus. The same results can be elicited through passively stretching the extensor muscles by simultaneously pronating the forearm, flexing the wrist, and extending the elbow (**Fig. 18.11B**). In some cases, discomfort also can be produced by testing the extensor digitorum communis of the 3rd digit through the application of resistance distal to the proximal interphalangeal joint with the wrist extended (**Fig. 18.11C**).

Figure 18.11. Tests for common extensor tendinitis. A, Resisted extension and radial deviation of the wrist (Cozen test). **B,** Passive stretching of the wrist extensors. **C,** Resisted extension of the extensor digitorum communis in the middle finger with the wrist extended.

Medial Epicondylitis Tests

Initially, the flexed elbow is stabilized against the body, and the forearm is supinated. The clinician palpates the medial epicondyle. Next, the clinician extends the wrist and elbow while the patient resists the movement. A positive sign is indicated by pain over the medial epicondyle of the humerus.

Tinel Sign for Ulnar Neuritis

The cubital tunnel is tapped on the posteromedial side of the elbow. A positive sign is indicated by a tingling sensation that runs down the ulnar aspect of the forearm into the medial half of the fourth finger and the entirety of the fifth finger (**Fig. 18.12**). The Tinel sign has very strong sensitivity (98%) as well as strong specificity (70%).[18]

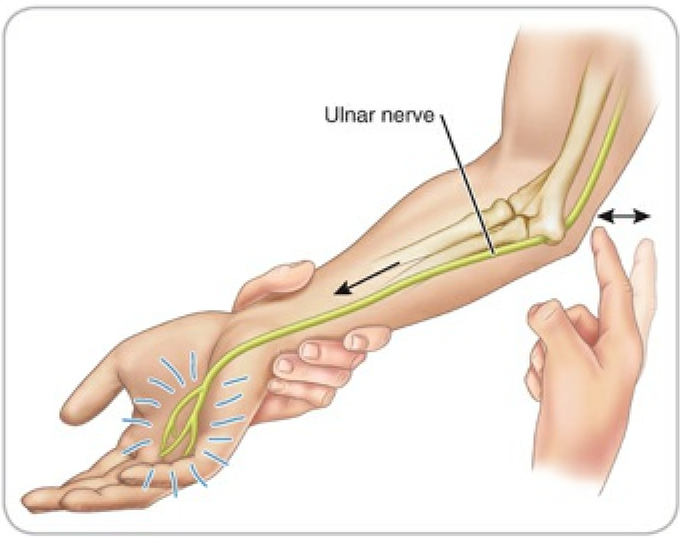


Figure 18.12. Tinel sign. Tapping over the cubital tunnel produces a tingling sensation down the ulnar nerve into the forearm and hand. A positive Tinel sign indicates ulnar nerve entrapment.

Elbow Flexion Test for Ulnar Neuritis

This test also has high diagnostic accuracy, with 75% sensitivity and 99% specificity.[18] This test is used to identify if the ulnar nerve is entrapped in the cubital tunnel. The patient is instructed to flex the elbow completely and hold it in that position for 5 minutes. A positive test is indicated by tingling or numbness in the ulnar nerve distribution pattern of the forearm and hand.

Test for Pronator Teres Syndrome

The patient sits with the elbow flexed at 90°. The clinician strongly resists forearm pronation while the elbow is extended. A positive test is indicated by tingling or paresthesia in the median nerve distribution of the forearm and hand.

Pinch Grip Test

The patient is instructed to pinch the tip of the index finger and thumb together (Fig. 18.13). Normally, there should be a tip-to-tip pinch. If an abnormal pulp-to-pulp pinch is performed, the anterior interosseous nerve, which is an extension of the median nerve, may be entrapped at the elbow as it passes between the two heads of the pronator teres.

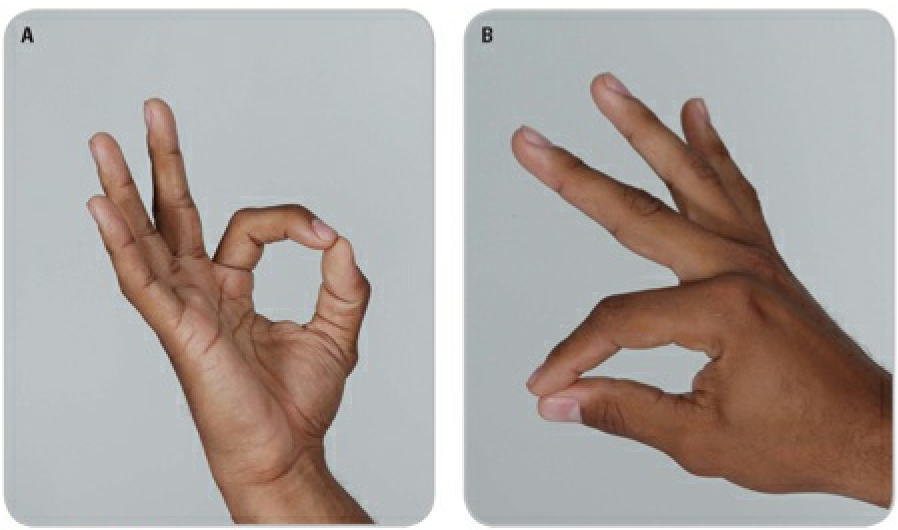


Figure 18.13. **Pinch grip test.** The patient is instructed to make a "O" with the thumb and forefinger. **A,** Normal tip-to-tip. **B,** Abnormal pulp-to-pulp, which signifies entrapment of the interior interosseous nerve.

Neurological Tests

Neurological integrity can be assessed with the use of myotomes, reflexes, and cutaneous patterns, which include both segmental dermatomes and peripheral nerve patterns.

Myotomes

Isometric muscle testing should be performed in the following motions to test specific myotomes in the upper extremity:

- Scapular elevation (C4)
- Shoulder abduction (C5)
- Elbow flexion and/or wrist extension (C6)
- Elbow extension and/or wrist flexion (C7)
- Thumb extension and/or ulnar deviation (C8)
- Abduction and/or adduction of the hand intrinsics (T1)

Reflexes

Reflexes in the upper extremity include the biceps (C5 through C6), brachioradialis (C6), and triceps (C7). The patient should be relaxed, with the elbow flexed. Testing procedures are explained in **Figure 17.29**.

Cutaneous Patterns

The segmental nerve dermatome patterns for the elbow region are demonstrated in **Figure 18.14**. The peripheral nerve cutaneous patterns are demonstrated in **Figure 18.15**. Testing is performed bilaterally for altered sensation with sharp and dull touch by running the open hand and fingernails over the neck, shoulder, and anterior and posterior chest walls as well as down both sides of the arms and hands.

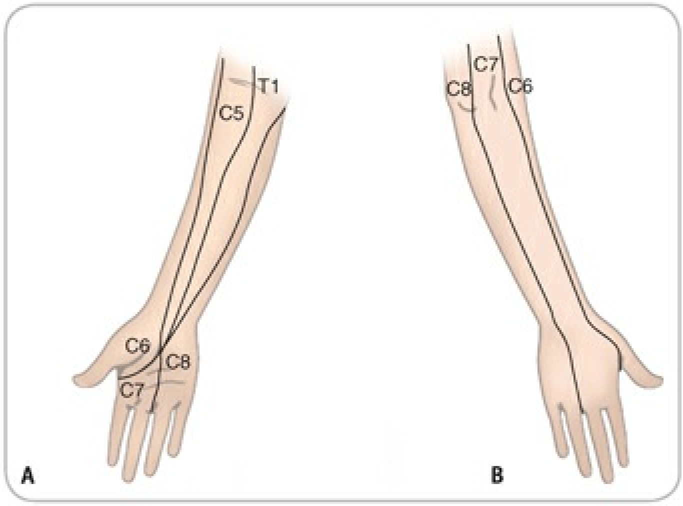


Figure 18.14. **Dermatome patterns for the elbow region.**
A, Anterior view. **B,** Posterior view.

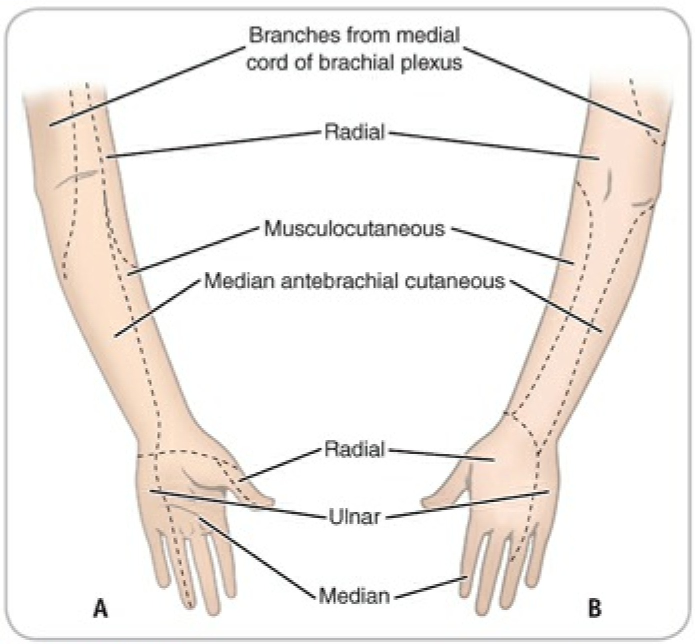


Figure 18.15. **Cutaneous patterns for the peripheral nerves.**
A, Anterior view. **B,** Posterior view.

Activity-Specific Functional Tests

The elbow is in the middle of the upper extremity kinetic chain. Therefore, it must function properly to position the hand so that daily activities can be performed smoothly and efficiently. Activities such as combing the hair, throwing a ball, lifting an object, or pushing an object should be performed without pain. The individual should be instructed to perform the skills that are needed to complete activities of daily living and sport-specific tasks. Each movement should be pain-free and fluid. If any of the conditions listed in Box 18.1 are present, the individual should be referred to a physician.

BOX 18.1 Signs and Symptoms That Necessitate Immediate Referral to a Physician

- Possible epiphyseal or apophyseal injuries
- Weakness in a myotome
- Tingling or numbness in the forearm or hand
- Gross joint instability
- Obvious deformity suggesting a dislocation or fracture
- Abnormal or absent reflexes
- Excessive joint swelling
- Absent or weak pulse
- Significantly limited ROM
- Any unexplained pain

Bilateral testing of the Little League player should include active ROM, passive ROM, and resistive ROM for elbow flexion, elbow extension, pronation, supination, wrist flexion, and wrist extension; medial epicondylitis test; Tinel sign for ulnar neuritis; elbow flexion test for ulnar neuritis; pronator teres syndrome test; grip strength; and varus stress.

CONTUSIONS

? Following practice, a lacrosse player is complaining of pain in his right arm after being struck by another player's stick. He reports receiving several blows to the area over the past week. Palpation reveals a hardened mass of soft tissue over the distal anterior arm that is very tender and sore. Bilateral strength is good. What potentially serious condition might develop, and how should this condition be managed?

Etiology

Direct blows to the arm and forearm frequently occur in contact and collision sports. Contusions result from a compressive force sustained from a direct blow. Such injuries vary in severity according to the area and depth over which blood vessels are ruptured. Contusions occur more frequently over bony prominences.

Signs and Symptoms

Ecchymosis may be present if the hemorrhage is superficial. Significant trauma can lead to internal hemorrhage, rapid swelling, and hematoma formation that can limit ROM. Chronic blows to the anterior arm can result in the development of ectopic bone either in the belly of the muscle (i.e., **myositis ossificans**) or as a bony outgrowth (i.e., **exostosis**) of the underlying bone. The belly of the deltoid and brachialis muscles is the common site for the development of myositis ossificans after trauma. A particularly vulnerable site is just proximal to the deltoid's insertion on the lateral aspect of the humerus, where the bone is least padded by muscle tissue. Standard shoulder pads do not extend far enough to protect the area, and the edge of the pad itself may contribute to the injury. The developing mass can become painful and disabling if the radial nerve is contused, leading to transitory paralysis of the extensor forearm muscles.

Tackler's exostosis, also known as blocker's spur and commonly seen in football linemen, is not a true myositis ossificans, because the ectopic formation is not infiltrated into the muscle but, rather, is an irritative exostosis arising from the bone. A painful bony mass, usually in the form of a spur with a sharp edge, can be palpated on the anterolateral aspect of the humerus.

Management

Treatment involves standard acute care with ice, compression, and protected rest. Activity modification, nonsteroidal anti-inflammatory drugs (NSAIDs) after the first 24 to 48 hours, and a gradual, active ROM and strengthening exercise program should be initiated as tolerated. Aggressive stretching and strengthening exercises should be avoided to prevent further injury to muscle tissue.

If conservative measures do not alleviate the condition, the individual should be referred to a physician for further care, because a more serious condition may have developed. Visible radiograph changes in the muscle can be noted after 2 to 3 weeks. As the condition progresses and becomes chronic, a painful **periostitis** and **fibrositis** may develop. Surgical excision of the calcification is seldom necessary, because function usually is not impaired. If function is adversely affected, however, surgery should be delayed until the calcification is mature (usually 12 to 18 months), because it may redevelop. The area should be protected with a special pad during participation.

> The lacrosse player may be developing myositis ossificans in the brachialis muscle. Standard acute care should be followed, with referral to a physician for further assessment and possible radiography.

OLECRANON BURSITIS

> ? A football player has acute swelling of approximately 1 in in diameter on the proximal posterior ulna. His history reveals constant friction to the area, attributed to contact with artificial turf. What condition might be suspected, what anatomical structures are involved, and how should this condition be managed?

The subcutaneous olecranon bursa is the largest bursa in the elbow region. The superficial location predisposes the bursa to either direct macrotrauma or cumulative microtrauma by repetitive elbow flexion and extension. The bursitis can be acute or chronic, aseptic or septic. Common mechanisms of olecranon bursa injury include the following:

- A fall on a flexed elbow
- Constantly leaning on one's elbow ("student's elbow")
- Repetitive pressure and friction
- Repetitive flexion and extension
- Infection

Acute and Chronic Bursitis

Etiology

A fall on a flexed elbow can lead to an acutely inflamed bursa. Constantly leaning on one's elbow, repetitive pressure, and friction can lead to a chronic inflamed bursa.

Signs and Symptoms

The acutely inflamed bursa presents with an immediate, tender, swollen area of redness in the posterior elbow. The swelling is relatively painless. If the bursa ruptures, a discrete, sharply demarcated goose egg is visible directly over the olecranon process. Approximately half of the patients with olecranon bursitis have a history of an abrupt onset of pain and swelling; the other half have a more insidious onset over several weeks, leading to chronic inflammation. Motion is limited at the extreme of flexion as tension increases over the bursa.

Management

Acute management involves ice, rest, and a compressive wrap applied for the first 24 hours. Significant distention may necessitate aspiration followed by a compressive dressing for several days. Chronic bursitis is managed with cryotherapy, NSAIDs, and use of elbow cushions to protect the area from further insult. In long-term cases of chronic bursitis, the bursa may be aspirated or totally excised, although a risk of poor wound healing over the olecranon process exists. Corticosteroid injections also may be performed.

Septic and Nonseptic Bursitis

Etiology

Occasionally, a bursa can become infected in the absence of trauma to the area. Septic bursitis sometimes is related to seeding from an infection at a distant site, such as **paronychia**, cellulitis of the hand, or forearm infection. Nonseptic bursitis can be caused by crystalline deposition disease or rheumatoid involvement. It has been associated with atopic dermatitis.

Signs and Symptoms

Individuals with septic bursitis are more likely to show traditional signs of infection, including malaise (lethargy), fever, pain, localized heat, restricted motion, tenderness, and swelling at the elbow. These signs and symptoms usually present within 1 week of developing symptoms. Approximately 50% of patients present with a skin lesion overlying the bursa, 92% to 100% have bursal tenderness, and 40% to 100% have peribursal cellulitis. In contrast, nonseptic bursitis is associated with an overlying skin lesion in 5% of the cases, bursal tenderness in 45% of the cases, and cellulitis in 23% to 25%.[19]

Management

An individual with an infected bursa should be referred to a physician. The physician generally aspirates the bursa and takes a sample of the fluid for culture to determine the presence of septic bursitis. Following aspiration, the elbow is immobilized in a sling, and continuous hot packs and appropriate antibiotics typically are prescribed. If an infected bursa is suspected, corticosteroids should not be injected.

The football player has acute olecranon bursitis. Standard acute care should resolve the condition; however, the player should be closely observed for signs and symptoms of infection. Applying a pad to the area can help to prevent recurrence.

SPRAINS

? A gymnast misses the vault, falls to the mat on an outstretched arm, and sustains a visible posterior dislocation of the elbow. The athlete is unwilling to move the elbow and is in extreme pain. Explain the circulatory and neurological assessment for this injury.

Collateral Ligament Sprain

Etiology

Acute tears to ligamentous and joint structures at the elbow are rare, but such injuries may occur during a fall on an outstretched hand (FOOSH), resulting in elbow hyperextension, or through a valgus/varus tensile force. Injuries arising from the application of varus and valgus forces at the elbow occur most often in sports where the hand is in contact with the ground or other players as may happen in wrestling, cheerleading, gymnastics, or rugby.[1] More commonly, however, repetitive tensile forces irritate and tear the ligaments, particularly the ulnar collateral ligament. If the ulnar collateral ligament is damaged, the ulnar nerve also may be affected.

Signs and Symptoms

The patient may describe feelings of instability and/or pain over the ulnar collateral ligament when a valgus force is applied or over the radial collateral ligament when a varus force is applied. For injury to the ulnar collateral ligament, a history of pain localized to the medial aspect of the elbow during the late cocking and acceleration phases of throwing is common. Point tenderness will be elicited over the site of injury.

Management

Treatment involves standard acute care with ice, compression, and protected rest. A brief immobilization may be necessary in acute cases. This is followed by early, protected ROM exercises to stretch the forearm flexor–pronator group and the forearm extensors.

Anterior Capsulitis

Etiology

Anterior joint pain caused by hyperextension usually is attributed to acute anterior capsulitis rather than chronic, repetitive throwing. Microtears in the capsule usually are not sufficient to cause dislocation.

Signs and Symptoms

Diffuse, anterior elbow pain presents after a traumatic episode. It is accompanied by deep tenderness on palpation, particularly on the anteromedial side. A strain to the pronator teres should be ruled out, as should entrapment of the median nerve as it courses through the pronator teres. With nerve entrapment, tingling or numbness of the thumb and index finger usually is noted.

Management

Treatment involves standard acute care with ice, compression, and protected rest. The condition is managed with immobilization for 3 to 5 days, after which active ROM exercises can begin as pain allows. Flexion contracture may result from fibrosis caused by repeated injury to the capsule.

Dislocations

Etiology

In adolescents, the most common traumatic injury to the elbow is subluxation or dislocation of the proximal radial head, often associated with an immature annular ligament. Referred to as "nursemaid's elbow" or "pulled-elbow syndrome," this condition results from longitudinal traction of an extended and pronated upper extremity, such as when a young child is swung by the arms. A small tear in the annular ligament allows the radial head to migrate out from under the annular ligament. If an individual is unable to pronate and supinate the forearm without pain, immediate referral to a physician is warranted.

Most ulnar dislocations occur in individuals younger than 20 years, with a peak incidence during the teenage years. The mechanism of injury usually is hyperextension or a sudden, violent unidirectional valgus force that drives the ulna posteriorly or posterolaterally. Approximately 60% of patients have associated fractures of the medial epicondyle, radial head, coronoid process, or olecranon process.[20] When the dislocation is associated with both radial head and coronoid fractures, it has been termed the "terrible triad of the elbow" because of the difficulties that are inherent in treatment and the consistently poor reported outcomes as compared to a simple elbow dislocation.[21] The injury also may involve disruption of the anterior capsule, tearing of the brachialis muscle, injury to the ulnar collateral ligament, and rarely, brachial artery compromise or nerve injury to the median or ulnar nerves.

Signs and Symptoms

A snapping or cracking sensation is experienced on impact, followed by severe pain, rapid swelling, total loss of function, and an obvious deformity (**Fig. 18.16**). The anterior capsule, brachialis muscle, and flexor and extensor muscle masses also may be disrupted. The arm is frequently held in flexion, with the forearm appearing shortened. The olecranon and radial head are palpable posteriorly, and a slight indentation in the triceps is visible just proximal to the olecranon. Signs and symptoms of a posterior elbow dislocation are listed in **Box 18.2**.

Figure 18.16. Elbow dislocation. A, Clinical view of a posterior dislocation. B, Radiograph of a typical posterior dislocation. Note that the coronoid process is adjacent to the olecranon fossa.

BOX 18.2 Signs and Symptoms of a Posterior Elbow Dislocation

- Snapping or cracking sensation
- Obvious deformity as the olecranon is pushed posteriorly
- Immediate, severe pain with rapid swelling, primarily on the medial aspect of the elbow
- A slightly flexed elbow is supported, if possible, by the uninjured arm.
- Pain is predominantly localized over the medial aspect of the elbow.
- Total loss of function
- Crepitation may be palpated if an associated fracture is present.

Nerve palsies are common, making prereduction and postreduction neurovascular examination critical. Ulnar nerve dysfunction usually is transient. If damaged, numbness will extend into the little finger. The median nerve, however, may become trapped within the joint, trapped within a healing medial epicondylar fracture, or looped anteriorly into the joint. Persistent, unexplained pain and median nerve dysfunction (e.g., finger flexor weakness or numbness in the palm of the hand) necessitate immediate reevaluation by a physician.

Activation of the emergency action plan, including summoning EMS, is warranted. Because of the risk of neurovascular injury, on-site reduction is not indicated. Additional guidelines for management of an elbow dislocation are discussed in Application Strategy 18.2.

APPLICATION STRATEGY 18.2

Management Algorithm for Posterior Elbow Dislocation

1. Apply ice to reduce swelling and inflammation.
2. To rule out circulatory impairment, assess the following:
   - Radial pulse
   - Skin color
   - Blanching of the nails
3. To rule out nerve impairment, assess motor and sensory function:
   - Have the patient (if able) flex, extend, abduct, and adduct the fingers with the person looking away.
   - Stroke the palm and dorsum of the hand in several different locations with a blunt and sharp object.
   - Ask the individual to identify where you are touching and whether the object is sharp or dull.
4. Immobilize the area with a vacuum splint or other appropriate splint.
5. Take vital signs, recheck pulse and sensory functions, and treat for shock.

Management

Reduction usually is performed under general or regional anesthesia. Early reduction minimizes the amount of muscle spasm. For cases in which the forearm flexors, extensors, and annular ligament have maintained their integrity with no associated fracture, limited immobilization, early ROM exercises, and proprioceptive neuromuscular facilitation exercises have proved to be quite successful. Although rare, recurrent dislocations are often related to laxity in the lateral ulnar collateral ligament of the elbow, leading to posterolateral rotary subluxation. A recurrent dislocation in the first 6 months after initial injury is more often attributed to a missed osteochondral fracture. Elbow dislocations involving fractures of the radial head and capitellar fracture dislocations are more complex and require internal fixation.

This injury should be considered a medical emergency. The emergency action plan, including summoning EMS, should be activated.

In assessing the dislocation sustained by the gymnast, circulatory assessment should include checking for a distal pulse, assessing skin color and temperature, and aassessing capillary refill. Neurological assessment includes checking for sensation distal to the injury.

STRAINS

After receiving a severe blow to the right forearm, an offensive lineman is having problems flexing his wrist and fingers. The lineman has rapid swelling, discoloration, and diminished pulse. Passive stretching of the wrist flexors increases pain. What condition should be suspected, what structures are involved, and how should this injury be managed?

Muscular strains commonly result from inadequate warm-up, excessive training past the point of fatigue, and inadequate rehabilitation of previous muscular injuries. A less common cause of strains in this area is a single, massive contraction or sudden overstretching. Application Strategy 18.3 summarizes the management of isolated muscular strains.

APPLICATION STRATEGY 18.3

Management Algorithm for Muscular Strains

1. Control inflammation, swelling, and pain. Use ice, compression, elevation, NSAIDs, and rest if necessary.
2. Use ice, ultrasound, electrical muscle stimulation, interferential current,

or thermotherapy to precede therapeutic exercise.

3. Restore ROM. (Assess flexibility at the shoulder region, because limitations may increase stress at the elbow.)
4. Perform isometric exercises throughout a pain-free ROM.
5. Progress to isotonic exercises with light resistance, building from 1 to 5 lb, throughout a pain-free range.
6. Improve neuromuscular control with closed kinetic chain exercises, such as shifting a weighted ball in the hand, press-ups, or walking on the hands in a push-up position between boxes of varying heights.
7. Add surgical tubing exercises as tolerated.
8. When pain-free, ensure adequate warm-up and gradual return to functional exercises.
9. Recommend activity modification, biomechanical analysis of skill performance, or equipment modifications.

If involved in a throwing activity, do the following:

1. Begin functional throwing with a light toss over a distance of 20–30 ft for 5 minutes and then progressing to between 15 and 20 minutes.
2. When the individual can throw for 15–20 minutes, gradually increase the distance to 150 ft.
3. When proper throwing mechanics are present, gradually increase velocity.
4. Continue a strengthening and stretching program as return to activity is initiated.

Flexor and Extensor Strains

Etiology

Repetitive tensile stresses to the elbow flexors (i.e., brachialis, biceps brachii, and brachioradialis) and pronator teres can lead to a self-limiting muscle strain, especially after an inadequate warm-up or fatigue. In rowing, excessive wrist motion during the feathering action can lead to chronic forearm tendinitis and tenosynovitis.[22] In a triceps strain, the mechanism generally is a decelerating-type injury. It has been reported in tennis and baseball players as well as in weight lifters with a history of anabolic steroid use or local steroid injections.[23]

Signs and Symptoms

Palpable pain can be elicited over the involved muscle mass. Pain increases with active and resisted motion.

Management

Treatment involves standard acute care with ice, compression, and protected rest; brief immobilization may be necessary in acute cases. Activity modification, NSAIDs, and a program of gradual active ROM and strengthening exercises should be initiated as tolerated. In rowing, special attention should be paid to improper technique, wrong-sized grips, poor rigging, and limiting rowing during wet or rough conditions, which can cause the rower to use excessive wrist motion.[21]

Rupture of the Biceps Brachii

Etiology

Approximately 97% of all biceps brachii ruptures are proximal; only 3% involve the distal attachment.[20,24] In many cases, preexisting degenerative changes in the distal tendon make it vulnerable to rupture following a sudden eccentric load (e.g., during weight lifting or trying to catch oneself during a fall). Individuals at increased risk for this injury tend to be men younger than 30 years of age with a history of using steroid medication.[21]

Signs and Symptoms

The patient may describe hearing or feeling a pop in the shoulder, upper arm, or elbow. Tenderness, swelling, and ecchymosis are visible in the antecubital fossa. The biceps tendon is not palpable, because the belly muscle retracts proximally. The individual is still able to flex the elbow and supinate the forearm, but these movements are weak when resisted. Ludington test is positive in the presence of a complete rupture.

Management

Acute treatment involves managing the patient's pain and swelling with ice, compression, and rest. Treatment for a rupture may involve a nonoperative approach or surgical repair. Some studies have found a significant loss of elbow flexion (30%) and supination (40%) strength with a nonoperative approach.[25] Although this decreased level of function may suffice for daily activities, the distal biceps tends to scar to the brachialis muscle, illuminating the normal contour of the muscle.

Surgical repair to reattach the avulsed distal biceps tendon to the radial tuberosity provides the greatest likelihood of maximal functional results and return to physical activity. Following repair, the elbow is immobilized at 90° of flexion with moderate forearm supination for 8 weeks, followed by gradual active ROM and strengthening.[20,24]

Rupture of the Triceps Brachii

Etiology

Occasionally, a direct blow to the posterior elbow or an uncoordinated triceps contraction during a fall results in an acute rupture of the tendon. In addition to the tendon rupture, 80% of all injuries involve an olecranon avulsion fracture.[12] Spontaneous ruptures of the tendon can occur, but these are rare and usually associated with systemic diseases or steroid use.

Signs and Symptoms

Pain and swelling are present over the distal attachment of the extensor mechanism on the olecranon process. A palpable defect in the triceps tendon or a step-off deformity of the olecranon may also be present. Active extension of the elbow may be weak (if a partial tear is present) or nonexistent (with a total rupture).

Management

Treatment involves standard acute care with ice, compression, and immobilization in a sling followed by immediate referral to a physician. Partial tears are treated conservatively. Surgical reattachment of the tendon onto the olecranon process is necessary in a total rupture. If an avulsion fracture of the olecranon is present, open reduction and internal fixation of the fragment are necessary. Subsequently, the elbow is immobilized in 45° of flexion for 4 weeks, followed by allowing 0° to 45° of flexion for 4 weeks and then gradual incorporation of active ROM and strengthening exercises.

Compartment Syndrome

Etiology

The deep fascia of the forearm encloses the wrist and finger flexor and extensor muscle groups in a common sheath. The two groups are separated into compartments by an interosseous membrane between the radius and ulna. The wrist and finger flexors are in the anterior compartment; the wrist and finger extensors are in the posterior compartment.

Compartment syndrome is often secondary to an elbow fracture or dislocation, crushing injury, forearm fracture, postischemic edema, or excessive muscular exertion, as in weight lifting. Hemorrhage or edema causes increased pressure within the compartment, leading to excessive pressure on neurovascular structures and tissues within the space.

Signs and Symptoms

Onset of symptoms is rapid and includes swelling, discoloration, absent or diminished distal pulse, and subsequent onset of sensory changes and paralysis. Severe pain at rest, aggravated by passive stretching of the muscles in the compartment, signals a potential problem.

Management

Treatment involves immobilization of the forearm and wrist as well as application of ice and elevation above the heart to limit pain and swelling. External compression should not be applied to the area, because the neurovascular structures already are compressed by the swelling. Immediate referral to a physician is necessary, because a fasciotomy may be needed to decompress the area.

> The football player most likely has compartment syndrome. Injury usually involves the wrist flexors, finger flexors, and median nerve. The condition warrants immediate referral to a physician.

OVERUSE CONDITIONS

> ? The athletic trainer for a summer tennis camp has been asked to provide suggestions to decrease the risk of lateral epicondylitis. What recommendations should be made?

The throwing mechanism discussed in Chapter 17 also can lead to overuse injuries at the elbow. During the initial acceleration phase, the body is brought forward rapidly, but the elbow and hand lag behind the upper arm. This results in a tremendous tensile valgus stress being placed on the medial aspect of the elbow, particularly the ulnar collateral ligament and adjacent tissues. As acceleration continues, the elbow extensors and wrist flexors contract to add velocity to the throw. This whipping action produces significant valgus stress on the medial elbow and concomitant lateral compressive stress in the radiocapitellar joint (**Fig. 18.17**). Before release of the ball, the elbow is almost fully extended and is positioned slightly anterior to the trunk. During release, the elbow is flexed approximately 20° to 30°. As these forces decrease, however, the extreme pronation of the forearm places the lateral ligaments under tension. During the deceleration phase, eccentric contractions of the long head of the biceps brachii, supinator, and extensor muscles decelerate the forearm in pronation. Additional stress occurs on structures around the olecranon as pronation and extension jam the olecranon into its fossa. Impingement can occur during this jamming.

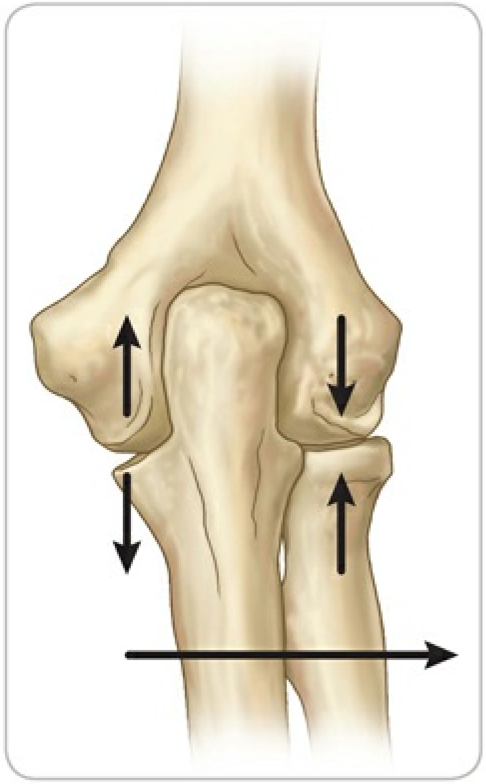


Figure 18.17. Traction–compression mechanism. An excessive valgus force can lead to both medial tensile stress and lateral compression stress, causing injury to both sides of the joint.

Epicondylitis is a common, chronic condition seen in activities involving pronation and supination, such as in tennis, javelin throwing, pitching, volleyball, and golf. This condition is usually referred to as a **tendinosis**, because degeneration rather than an inflammatory condition exists. A pattern of poor technique, fatigue, and overuse often is associated with this condition.

Medial Epicondylitis

Etiology

Medial epicondylitis is caused by repeated, medial tension/lateral compression (valgus) forces placed on the arm during the acceleration phase of the throwing motion.[26] The medial humeral apophyseal growth plate in the pediatric athlete is particularly vulnerable to injury and, if affected, is called Little League elbow. In a recent study of 9- to 12-year-old pitchers, medial elbow pain was found in 26%.[27] Efforts have been imposed in leagues and recreational programs to limit the number of innings pitched per game and/or the number of pitches per week and pitches per season in an attempt to decrease the incidence of medial epicondylitis in adolescents.[13]

Injury occurs when valgus forces produce a combined flexor muscle strain, ulnar collateral ligament sprain, and ulnar neuritis. The two most commonly involved tendons are the pronator teres and the flexor carpi radialis. Simultaneously, lateral compressive and shearing forces generated in the olecranon fossa can damage the lateral condyle of the humerus and radial head, leading to capitellar osteochondral injuries. Posterior stresses may lead to triceps strain, synovial impingement, olecranon fractures, or loose bodies and degenerative joint changes.

Signs and Symptoms

Assessment reveals swelling, ecchymosis, and point tenderness over the humeroulnar joint or the flexor/pronator origin, slightly distal and lateral to the medial epicondyle. Pain usually is severe over the medial epicondyle, extending distally 1 to 2 cm along the track of the flexor carpi radialis and pronator teres. Pain is aggravated by resisted wrist flexion and pronation and by a valgus stress applied at 20° to 30° of elbow flexion. There will be a negative Tinel sign at the cubital tunnel for ulnar neuritis. If the ulnar nerve is involved, tingling and numbness may radiate into the forearm and hand, particularly the fourth and fifth fingers.

Management

Most conditions can be managed with ice, NSAIDs, and immobilization in a sling, with the wrist in slight flexion, for 2 to 3 weeks. In cases involving apophysitis, the resting period may extend from 4 to 6 weeks with limitation or elimination of throwing.[28] Transcutaneous electric nerve stimulation (TENS), high-voltage galvanic stimulation, ultrasound, and interferential current are used to decrease pain and inflammation. Early ROM exercises and gentle, resisted isometric exercises should progress to isotonic strengthening and use of surgical tubing. Activity should not resume until the individual can complete all functional tests without pain. A functional brace may limit valgus stress and allow early resumption of strenuous activities. In moderate injuries, throwing or overhead motions should be avoided for up to 6 to 12 weeks.[20]

> In the adolescent, if an apophyseal fracture or an avulsion fracture of the medial epicondyle is suspected, immediate referral to a physician is warranted. In some settings, this may require activation of the emergency action plan.

With intra-articular injuries, ulnar nerve problems, or moderate to severe cases of pain or instability, referral to a physician is indicated. Application Strategy 18.4 describes management of medial epicondylitis.

APPLICATION STRATEGY 18.4

Management Algorithm for Medial Epicondylitis

1. Limit pain and inflammation with ice, compression, NSAIDs, and rest.
2. Avoid all activities that lead to pain; immobilization may be necessary if simple daily activities cause pain.
3. Other therapies also may supplement the treatment plan, such as ice massage, contrast baths, ultrasound therapy, electrical muscle stimulation, interferential current, and friction massage over the flexor tendons.
4. Maintain ROM and strength at the wrist and shoulder.
5. Stretching exercises, within pain-free motions, should include wrist flexion–extension, forearm pronation–supination, and radial and ulnar deviation.
6. Begin with fast contractions using light resistance:
   - Perform tennis ball squeezes and other strengthening exercises within pain-free ranges.
   - Add surgical tubing as tolerated.
   - Work up to three to five sets of 10 repetitions per session before moving on to heavier resistance.
7. Incorporate early, closed chain exercises, such as press-ups, wall push-ups, or walking on the hands.

8. Add strengthening exercises for all shoulder, elbow, and wrist motions.
9. Perform a biomechanical analysis of the throwing motion to determine proper technique and make adjustments as necessary.

After return to protected activity, do the following:

1. Continue stretching exercises before and after practice.
2. Continue ice after practice to control any inflammation.
3. Return to full activity as tolerated.

Common Extensor Tendinitis (Lateral Epicondylitis)

Etiology

Pain over the lateral epicondyle denotes extensor tendon overload and is the most common overuse injury in the adult elbow. The condition is typically caused by eccentric loading of the extensor muscles, predominantly the extensor carpi radialis brevis, during the deceleration phase of the throwing motion or tennis stroke. Faulty mechanics (e.g., "leading" with the elbow and off-center hits in racquet sports), poorly fitted equipment (e.g., improper grip size and improper racquet string tension), and age (i.e., 30 to 50 years of age) contribute to this condition.[20]

Signs and Symptoms

Pain is anterior or just distal to the lateral epicondyle and may radiate into the forearm extensors during and after activity. Pain initially subsides but then becomes more severe with repetition and increases with resisted wrist extension, the "coffee cup" test (i.e., pain increases while picking up a full coffee cup), and the tennis elbow test.

Management

Initial treatment should include ice, compression, NSAIDs, and rest. Grasping an object with the forearm pronated is highly discouraged until acute symptoms resolve. Rehabilitation should focus on increasing the strength, endurance, and flexibility of the extensor muscle group. If appropriate, evaluation of mechanics and equipment should be conducted. A counterforce strap placed 2 to 3 in distal to the elbow joint can limit excessive muscular tension placed on the epicondyle and usually is sufficient to eliminate symptoms. Application Strategy 18.5 describes management of common extensor tendinitis.

APPLICATION STRATEGY 18.5

Management of Common Extensor Tendinitis

1. Use ice, compression, elevation, NSAIDs, and rest to limit pain and inflammation.
2. Immobilize the wrist in slight extension to allow functional use of the hand.
3. Use cryotherapy, ultrasound, thermotherapy, electrical muscle stimulation, interferential current, and/or friction massage over the extensor tendons to reduce pain and inflammation.
4. Avoid strong gripping activities and any activities that aggravate symptoms.
5. Perform stretching exercises within pain-free motion, including wrist flexion–extension, forearm pronation–supination, and radial and ulnar deviation.
6. Perform isotonic strengthening exercises and add surgical tubing exercises as tolerated. Begin with fast contractions using light resistance.
7. Work up to three to five sets of 10 repetitions per session before moving on to heavier resistance.
8. Continue active ROM and strengthening exercises for all shoulder, elbow, and wrist motions.
9. Incorporate closed chain exercises, such as press-ups, wall push-ups, or walking on the hands.
10. Perform a biomechanical analysis of the skills to determine if improper technique may have contributed to the problem and make appropriate

changes.

11. Return to full activity, as tolerated, but continue stretching exercises before and after practice. Apply ice after practice to control any inflammation.

Neural Entrapment Injuries

The ulnar nerve passes behind the medial epicondyle of the humerus through the cubital tunnel to rest against the posterior portion of the ulnar collateral ligament (**Fig. 18.18**). The nerve is vulnerable to compression and tensile stress, which may be caused by trauma (i.e., acute or chronic), cubital valgus deformity, irregularities within the ulnar groove, or subluxation as a result of a lax ulnar collateral ligament. The condition often is referred to as **cubital tunnel syndrome**. The individual complains of a shocking sensation along the medial aspect of the elbow, radiating as if "hitting the crazy bone." Palpation or percussion in the ulnar groove generally produces tingling and numbness down the medial aspect of the forearm into the ring and little finger (Tinel sign). Observation may reveal the disappearance of the concavity of the ulnar nerve sulcus. Because the ulnar nerve innervates several intrinsic muscles of the hand, the patient may develop gradual hand weakness, hypotrophy of the first dorsal interosseous muscle, and reduced strength of the deep 5th digit flexor and flexor carpi ulnaris, all of which result in grip and pinch weakness.[29]

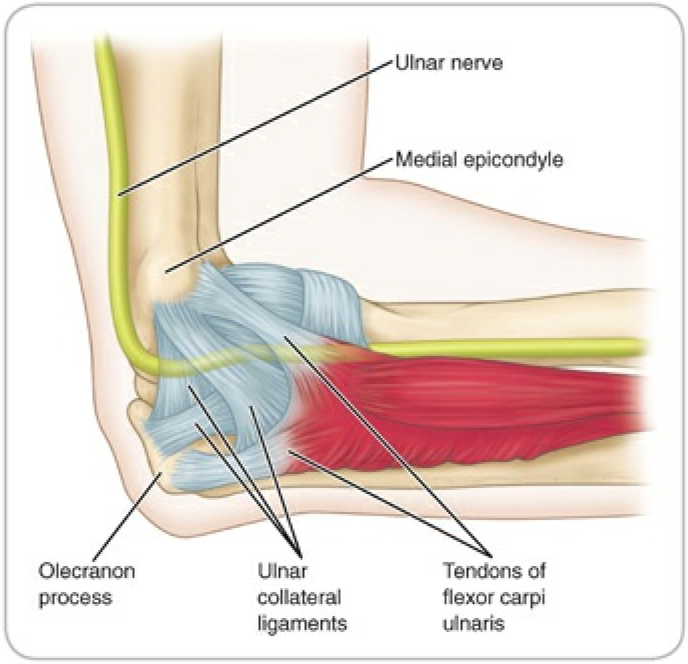


Figure 18.18. Ulnar nerve. As the ulnar nerve passes through the cubital tunnel between the ulnar collateral ligament and the olecranon fossa, it passes under the two heads of the flexor carpi ulnaris. This tendon is slack during extension, but it becomes taut during flexion, contributing to ulnar nerve compression.

The median nerve travels across the cubital fossa, passing between the two heads of the pronator teres and the two heads of the flexor digitorum superficialis, to give off its largest branch, the anterior interosseous nerve. Compression may be caused by hypertrophied muscles, particularly the pronator teres, or by compression from fibrous arches near the flexor digitorum superficialis muscle, bicipital aponeurosis, or supracondylar process. It can lead to a condition called **pronator syndrome**, in which pain is felt in the anterior proximal forearm and is aggravated with pronation activities. Numbness may occur in the anterior forearm or in the middle and index fingers and thumb.

The radial nerve may be damaged during a midshaft humeral fracture. Less frequently, direct trauma or entrapment occurs at the elbow as the nerve passes anterior to the cubital fossa, pierces the supinator muscle, and runs posterior, again, into the forearm. The condition is referred to as **radial tunnel syndrome**. The terminal branch, the posterior interosseous nerve, supplies the deeper lying extensor muscles of the forearm. Symptoms of injury often mimic those of lateral epicondylitis. An aching lateral elbow pain may radiate down the posterior forearm. Significant point tenderness can be elicited over the supinator muscle, and resisted supination generally is more painful than wrist extension. Extensor weakness of the wrist, called **wrist drop**, is seen in extreme cases, but no sensory loss tends to be present.

Management

The individual should be referred to a physician immediately. Treatment for neural entrapment depends on the frequency, duration, intensity, magnitude, and cause of the problem. If recognized early, complete rest and NSAIDs can help in acute cases. If the injury is secondary to direct blows, a pad can protect the area. Occasionally, chronic nerve damage may require surgery to release any pressure or constriction on the nerve.

> The following recommendations may help to decrease the risk of lateral epicondylitis: use of a well-fitted racquet with appropriate grip size and string tension, limiting the number of single backhand strokes, increasing the strength of the wrist extensors and supinators, and performing wrist flexibility exercises.

FRACTURES

> ? A forearm fracture is suspected in a hockey player who was hit by an opposing player's stick. What tests can be used to determine whether a fracture is, in fact, present?

Displaced and undisplaced fractures to the humerus, radius, and ulna usually result from violent compressive forces caused by direct trauma, such as an impact with a helmet or implement, a fall on a flexed elbow or outstretched hand with or without a valgus/varus stress, or tensile forces associated with throwing. Because major nerves and vessels run along the bones, serious neurovascular injury can result from the jagged bone fragments. Fractures to the growth plates also are common in javelin throwers, gymnasts, water polo and tennis players, and adolescent baseball and softball pitchers, whereas stress fractures have been reported in gymnasts, volleyball players, and weight lifters.

Epiphyseal and Avulsion Fractures

Etiology

Because the closing growth plate of the medial epicondyle in adolescents is sensitive to tension stress, a repetitive or sudden contraction of the flexor–pronator muscle group may result in a partial or complete avulsion fracture of the medial epicondyle of the humerus. Referred to as Little League elbow, the tension stress is related to throwing curve balls and other breaking pitches that require forceful pronation. Use of this term, however, negates the fact that other individuals, such as golfers, gymnasts, javelin throwers, tennis players, bowlers, squash and racquetball players, wrestlers, and weight lifters, also are susceptible to the condition. Fracture to the secondary growth center of the lateral epicondyle is similar to a medial epicondyle fracture and is treated in a similar manner.

Signs and Symptoms

In the initial phase of the injury, the individual complains of aching during performance, but no limitations in performance and no residual pain are present. As the condition progresses, however, an aching pain during activity limits performance, and a mild postexercise ache is present. Some localized tenderness can be elicited directly over the epicondyle. In severe cases, pain can be intense, with point tenderness, swelling, and ecchymosis directly on the epicondyle.

Management

Standard acute protocol, with activity modification, is followed during the initial stages of injury. If performance is limited because of pain and if postexercise pain is present, the individual should be referred to a physician.

The fracture is managed conservatively, with rest and immobilization in a sling for as little as 2 to 3 weeks. Usually, throwing is not allowed for 6 to 12 weeks. Surgery is necessary only if a valgus instability is present, the medial epicondyle is incarcerated within the elbow joint, or ulnar nerve symptoms are present.

Stress Fractures

Stress fractures to the diaphysis of the ulna can occur during intensive weight lifting. Bilateral distal radial and ulnar fractures have been found in young individuals who lift heavy weights or lose control of the barbells, resulting in added shear stress. For this reason, adolescents in a weight-lifting program should be properly instructed and supervised.

Osteochondritis Dissecans

Etiology

An unusual complication of repetitive stress to the skeletally immature elbow is osteochondritis dissecans. The mechanism is attributed to lateral compressive forces exerted during the throwing motion, which can damage the radial head, capitellum, or both. It is the leading cause of permanent elbow disability in adolescent athletes.[28] In adolescents with open growth plates (12 to 15 years of age), a focal lesion can lead to destruction of the overlying articular cartilage, with fragmentation and softening of the underlying subchondral bone. A microfracture (i.e., loose bodies) and eventual avascular necrosis lead to further joint degeneration.

An associated osteochondrosis condition, called **Panner disease**, is the most common cause of chronic lateral elbow pain, encompassing the entire capitellum in athletes younger than 10 years of age.[27] Pain is present over the lateral and anterior elbow. The pain increases with deep palpation or pronation–supination, but it quickly resolves with decreased activity. Elbow extension may be limited by 20° or more secondary to synovitis and a deformed capitellar congruity. Loose body formation is much less likely to occur in Panner disease.

Signs and Symptoms

Signs and symptoms of osteochondritis dissecans mirror Little League elbow. An insidious onset of dull, activity-related, and poorly localized pain may precede other, more severe symptoms, such as locking, decreased motion, and flexion contractures of more than 15°.[24] Swelling and tenderness are centralized over the radiocapitellar joint, and grating may be present during passive pronation and supination. The ability to fully extend the elbow may be limited.

Management

Management involves referral to a physician. Treatment is conservative with rest for 6 to 18 months. If no loose body is present, no further treatment may be needed. If a fragment is displaced, surgery may be necessary to reattach a large articular fragment or to excise a small fragment.

Displaced and Undisplaced Fractures

Supracondylar fractures, which are caused by falling on an outstretched hand, occur largely in children, with the peak incidence occurring between 4 and 8 years of age.[30] A catastrophic complication from this fracture is ischemic necrosis of the forearm muscles, known as **Volkmann contracture**. The brachial artery or median nerve can be damaged by the fractured bone ends, leading to major circulatory or neural impairment of the forearm and hand. As a result, the hand is cold, white, and numb. The presence of a radial or ulnar pulse does not automatically indicate adequate circulation to the forearm muscles. Severe pain in the forearm is aggravated by passive extension of the fingers. These symptoms indicate a serious problem.

> The arm should be immobilized in a vacuum splint. The emergency action plan should be activated to ensure immediate transport of the patient to the nearest medical facility.

Fracture of the olecranon process of the ulna results from direct trauma, such as being struck with an implement or falling on a flexed elbow. The tension of the triceps pulls the bone fragment superiorly. Because this fracture is intra-articular, it does not respond to conservative treatment and requires surgical intervention.

The head of the radius may be fractured as a result of a valgus stress that tears the ulnar collateral ligament, leading to traumatic compressive and shearing stress on the radial head. The fracture may be nondisplaced (type I), displaced (type II), or comminuted (type III). Tenderness can be elicited on palpation of the radial head, and swelling can be seen lateral to the olecranon. Flexion and extension may or may not be limited. In contrast, passive pronation and supination are both painful and restricted. There also may be an associated valgus instability of the elbow or axial instability of the forearm. A nondisplaced fracture is treated nonoperatively, with early ROM exercises to prevent joint stiffness. With more than one-third of the articular surface involved, more than 30° of angulation, or more than 3 mm of fracture gap, open reduction is recommended.[20]

The **nightstick fracture**, which is seen in football and hockey players, is caused by a direct blow to the forearm that fractures the ulna. Following closed reduction, splinting or casting for 7 to 10 days is needed to allow the initial swelling and discomfort to subside. If a radial head dislocation or a distal radial ulnar joint subluxation is present, open reduction and internal fixation are necessary.

In gymnastics, a unique forearm fracture occurs as a result of wearing leather grips with enclosed dowels. The dowels help to grip the horizontal bar. Problems arise, however, when the leather grip “catches” or grabs onto the bar and holds the hand in position, preventing the individual from continuing during a giant swing maneuver. This action causes the forearm to “wrap around” and sustain multiple fractures. Severe pain and disability with this fracture require immediate immobilization in a vacuum splint and transport to the nearest medical facility.

Fracture Management

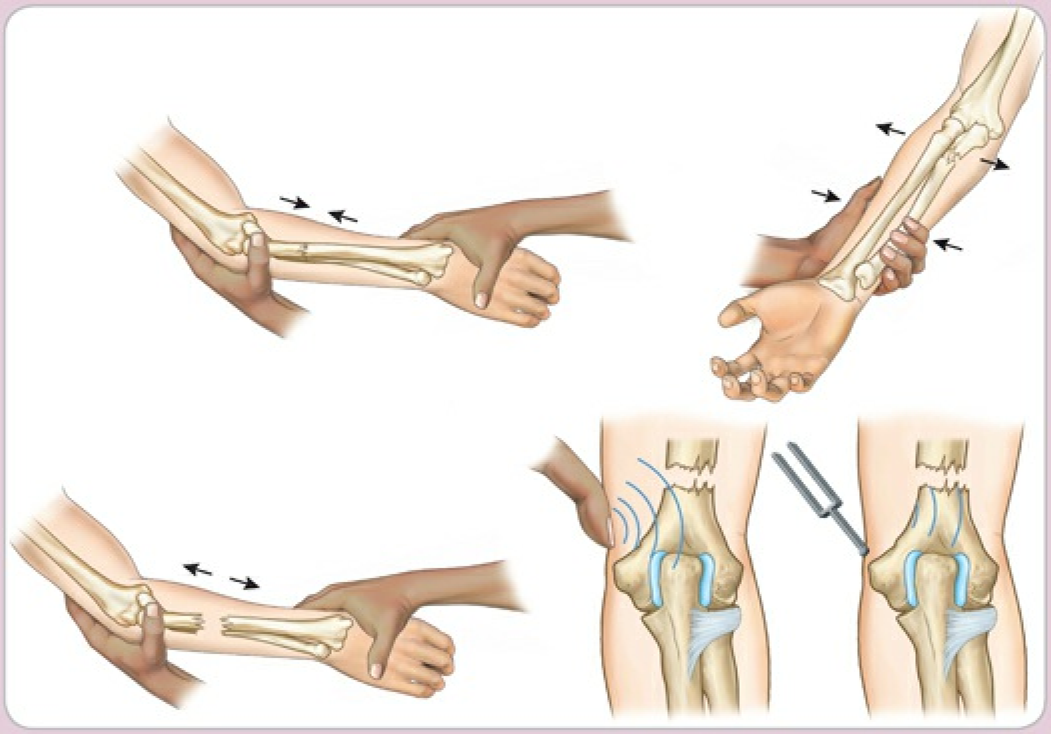
Fractures should be suspected in all elbow and forearm injuries. In the absence of visible deformity, palpation should be used to detect the presence of deformity. If no visible or palpable deformity is present, compression, traction, and percussion can assist in determining possible fractures and are explained in **Application Strategy 18.6**. In addition, a neurological and circulatory assessment should be conducted. If the radial nerve is damaged, forearm supination and extension at the elbow, wrist, or fingers will be weak, and sensory changes may occur on the dorsum of the hand. If the median nerve is damaged, active wrist and finger flexion will be weak, and sensory changes may occur on the palm of the hand.

APPLICATION STRATEGY 18.6

Determining a Possible Fracture in the Upper Arm and Forearm in the Absence of Deformity

1. **Compression.** Palpate the region for any pain, deformity, crepitus, or loose bodies. Ask if the individual heard any cracking sounds that might indicate a possible fracture. Apply gentle compression along the long axis of the bone. Then, encircle the distal ulna and radius with your hand and give mild compression. This will produce some distraction at the proximal end of the ulna and radius. Increased pain in either position indicates a possible fracture.
2. **Distraction.** Slowly distract the bones. If pain eases, this may indicate a possible fracture. If pain increases, it indicates soft-tissue damage.
3. **Percussion.** Gently tap the superficial bony landmarks. Vibrations travel along the bone and cause increased pain at the fracture site. For example, tap the following sites:
   - **Humerus**—medial and lateral epicondyles
   - **Ulna**—olecranon process and distal styloid process
   - **Radius**—distal styloid process
4. **Tuning fork.** Tap a tuning fork and place the base on the superficial bone sites mentioned in the preceding. Increased pain indicates a possible fracture.

Any positive signs indicate a possible fracture. Immobilize the limb in a vacuum splint or other appropriate splint or sling and transport the individual to the nearest medical facility.



If the ulnar nerve is damaged, ulnar deviation and finger abduction and adduction will be weak, and sensory changes may occur on the ulnar border of the hand. The clinician should take a pulse at the wrist or the ulnar and radial arteries, or the clinician should blanch the fingernails and note capillary refill. A vacuum splint should be applied and the individual transported immediately to the nearest medical facility.

The tests to determine a possible forearm fracture include applying gentle compression along the long axis of the bone and noting any pain; encircling the distal ulna and radius with the hand, applying mild compression, and noting any pain; and performing percussion over superficial bony landmarks or using a tuning fork over the bony prominences and noting any increase in pain at the fracture site.

REHABILITATION

> ? The Little League Baseball player is diagnosed with Little League elbow. The fracture was managed conservatively with a sling for 3 weeks. When the patient begins rehabilitation, what exercises should be included in the general program?

Rehabilitation of the upper arm, elbow, and forearm must involve exercises for the entire kinetic chain, because muscles in the upper arm cross the shoulder and elbow and muscles in the forearm cross the elbow and wrist. Traumatic injuries to the elbow often require immobilization. Although the elbow is immobilized, early ROM and strengthening exercises can be conducted at the wrist, hand, and shoulder.

The management of some injuries will not require immobilization, but pain may be exacerbated by certain motions. The exercise program should focus on early mobilization in the available pain-free motions and expand to the other motions once the pain has subsided. Individuals who are involved in throwing-type activities also should include scapular stabilization exercises along with strengthening exercises for the shoulder.

The reader should refer to Chapter 17 for appropriate shoulder exercises. This section focuses only on those exercises specific to the upper arm, elbow, and forearm.

Restoration of Motion

ROM exercises should focus on elbow flexion and extension, forearm pronation and supination, wrist flexion and extension, and wrist radial and ulnar deviation. The individual can use the opposite hand to apply a low-load, prolonged stretch in the various motions to minimize joint trauma and increase flexibility (**Fig. 18.19**). The upper body ergometer also is an effective ROM tool.

Figure 18.19. Range of motion exercises can be facilitated by using the opposite hand to apply sustained a sustained stretch.

Restoration of Proprioception and Balance

Closed chain exercises may be performed immediately after the acute phase of injury. Shifting body weight from one hand to the other may be performed on a wall, tabletop, or unstable surface, such as a foam mat or a biomechanical ankle platform system board. Push-ups and exercises in a frontal and sagittal plane can be performed on a Pro Fitter or slide board, if available. Step-ups can be completed on a box, stool, or StairMaster. This activity can progress to stepping up and down on boxes of differing heights, arranged so that the exercise is performed in diagonal patterns, circles, or figure eights.

As with the shoulder injury, the throwing motion should be rehearsed using mirrors or videotape. As the motion is performed, biomechanical errors at the elbow are corrected. When motion is perfected, speed of movement and distance of throw are increased gradually.

Muscular Strength, Endurance, and Power

Gentle, resisted isometric exercises can begin immediately after injury or after surgery while the arm is still immobilized. As the individual improves, more overload is applied. When normal ROM is achieved, open kinetic chain exercises can be performed in the various motions using lightweight dumbbells; many of these exercises were demonstrated in **Application Strategy 18.1**. The individual should complete 30 to 50 repetitions using a 1-lb weight and should not progress in resistance until 50 repetitions are achieved. Wrist curls, reverse wrist curls, pronation, and supination should be performed with the forearm supported on a table. A weighted bar or hammer can be used for both radial and ulnar deviation and for pronation and supination. Another common exercise is the wrist curl-up. Using a broomstick with a light weight suspended on a 3- to 4-ft rope, the individual slowly winds the rope up around the stick and then slowly unwinds the rope. Proprioceptive neuromuscular facilitation, resisted exercises, and surgical tubing are used for concentric and eccentric loading.

Plyometric exercises may involve catching a weighted ball and using a quick, eccentric stretch of the muscle to facilitate a concentric contraction in throwing the ball. The exercise can progress through various one- and two-arm chest passes and overhead passes. A minitramp can also be used to perform plyometric bounding push-ups.

Cardiovascular Fitness

Cardiovascular conditioning should be maintained throughout the rehabilitation program. Several examples of such programs are provided in *Application Strategy: Cardiovascular-Conditioning Exercises* located on thePoint Web site.

> The Little League Baseball player should focus on restoring ROM in elbow flexion–extension, forearm pronation–supination, wrist flexion–extension, and radial and ulnar deviation. Isometric strengthening exercises should begin immediately in pain-free motions, with active exercises beginning as soon as normal ROM is achieved. The program also should include general body conditioning and strengthening exercises for the shoulder, elbow, and wrist.

SUMMARY

1. The elbow encompasses three articulations: the humeroulnar, humeroradial, and proximal radioulnar joints.
2. The medial collateral ligament is the most important ligament for stability of the elbow joint. It is divided into the anterior, transverse, and posterior oblique bands.
3. The major nerves of the elbow and forearm include the musculocutaneous, median, ulnar, and radial nerves.
4. Chronic blows to the arm can result in the development of ectopic bone, either in the belly of the muscle (myositis ossificans) or as an outgrowth (exostosis) of the underlying bone.
5. The subcutaneous olecranon bursa is the largest bursa in the elbow region. Bursitis may be acute or chronic, aseptic or septic.
6. In adolescents, the most common traumatic injury to the elbow is subluxation or dislocation of the radial head, referred to as "nursemaid's elbow" or "pulled-elbow syndrome."
7. Most ulnar dislocations occur in individuals younger than 20 years, with a peak incidence during early adolescence. The mechanism usually is hyperextension or a sudden, violent, unidirectional valgus force that drives the ulna posterior or posterolateral. Because 60% of elbow dislocations have an associated fracture, the limb should be immobilized in a vacuum splint and the individual transported immediately to the nearest medical facility.
8. Chronic injuries can result from inadequate warm-up, excessive training past the point of fatigue, inadequate rehabilitation of previous injuries, or neglect of seemingly minor conditions that progress to major complications.
9. Repetitive throwing motions place a tremendous tensile stress on the medial joint structures (i.e., medial collateral ligament, ulnar nerve, and

common flexor tendons) and concomitant lateral compressive stress in the radiocapitellar joint.

10. Medial epicondylitis produces severe pain on resisted wrist flexion and pronation and with a valgus stress applied at 15° to 20° of elbow flexion.
11. Common extensor tendinitis produces severe pain on resisted wrist extension and supination and with a varus stress applied at 15° to 20° of elbow flexion.
12. Lateral compressive forces on the radiocapitellar joint can lead to osteochondritis dissecans of the skeletally immature elbow.
13. If a decision is made to refer an individual to a physician for care, the limb should be appropriately immobilized to protect the area.
14. Subsequent to the history, observation, and palpation components of an assessment, the clinician should have established a strong suspicion of the structures that may be damaged. As such, during the physical examination component, some tests will be compulsory, whereas others are used to confirm or exclude suspected injury or pathology. Only those tests that are absolutely necessary should be performed.
15. A rehabilitation program should focus on the following: reduction of pain and spasm; restoration of motion and balance; development of strength, endurance, and power; and maintenance of cardiovascular fitness. The individual should have bilateral strength, flexibility, and muscular endurance as well as an appropriate cardiovascular level before returning to participation in sport and physical activity. Whenever possible, protective equipment or padding should be used to prevent reinjury.

APPLICATION QUESTIONS

1. A high school baseball pitcher reports to the athletic training room complaining of pain on the medial elbow that began approximately 2 weeks earlier. What questions should be asked as part of an injury

assessment for this individual?

2. During basketball practice, a 16-year-old male inadvertently falls and lands on a flexed elbow. What questions should be asked as part of the history component of an assessment of this injury? What factors should be addressed in the inspection/observation component of the assessment?
3. A football player is complaining of pain in his right arm during blocking drills. Palpation reveals a hardened mass within the soft tissue over the distal anterior arm. The mass is very tender and sore. Bilateral strength of the involved musculature is normal, but the pain has progressively gotten worse over the last week. What potentially serious condition might develop? How might this condition be managed?
4. A collegiate women's tennis player complains of right elbow pain that is present during and after activity, which increases during her backhand stroke. It is midseason and the condition has become worse over the past 2 weeks. How would you differentiate whether this athlete's injury is lateral epicondylitis or a chronic wrist extensor muscle strain?
5. A volleyball player is complaining of vague forearm pain aggravated during overhead spiking drills. Palpation elicits point tenderness on the proximal anterior arm. Pain increases with resisted elbow flexion and wrist ulnar deviation. What muscles are most likely involved with this condition? What additional signs or symptoms would warrant immediate physician referral?
6. A 22-year-old wrestler lands on his elbow during a match. A day later, he complains of elbow pain and tingling sensations into his forearm and hand. How would you differentiate whether this condition is cubital tunnel syndrome or radial tunnel syndrome?
7. A pole vaulter lost his grip on the pole and fell to the ground on a flexed elbow. Immediate pain and deformity is evident just proximal to the elbow. What is the probable injury? What actions are necessary to assess possible damage to the neurovascular structures of the arm?

8. What recommendations would you, as the athletic trainer for a summer tennis camp for participants in an elite youth tennis league, provide to decrease the risk of lateral epicondylitis?
9. You suspect that a high school athlete has pronator teres syndrome. How would you explain the condition and its development to the athlete and his parents?

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