

Definitions of Labels

C₂, C₃ = 2nd and 3rd cervical dermatomes
G.1. = Boundary between trigeminal n. distribution and 2nd cervical cermatome ("vertex-ear-chin line")
S.v. = Anterior segment of trigeminal n., related to the cranial part of the spinal nucleus of V
S.m. = Middle segment of trigeminal n., related to the middle part of the spinal nucleus of V
S.h. = Posterior segment of trigeminal n., related to the caudal part of the spinal nucleus of V
V₁, V₂, V₃ = Areas of innervation of the three branches of the trigeminal n.

+₁ = Pressure point for medial br. of supraorbital n.
+₂ = Pressure point for infraorbital n.
+₃ = Pressure point for mental n.
X = Pressure point for greater occipital n.
Au.m. = Great auricular n. field
O.l.,i.,v. = Lesser occipital n. field
O.mj. = Greater occipital n. field
T.c. = Transverse cervical n. field.
The spinal column has long been the primary focus of the chiropractic profession. As patients increasingly use chiropractors as their primary source of health care, the need to address other anatomic areas of dysfunction becomes increasingly important. The evaluation and treatment of disorders affecting the extravertebral articulations have become an integral component of chiropractic practice.

As in the area of conservative spinal health care, the chiropractic approach to dysfunction of the extremities fulfills a void that has not been addressed by allopathic medicine. The area of sports medicine has expanded dramatically in recent years. The chiropractic profession has an important perspective and contribution to make with regard to athletic and recreational injuries.

This chapter is designed to assist the Doctor of Chiropractic in gaining the basic knowledge necessary to clinically address conditions of the upper and lower extremities.

The peripheral joints like those of the spine and pelvis are subject to injury which may result in articular malpositions causing abnormal biomechanical function, as well as potentially altering neural, vascular, and muscular function. It is for this reason that Gonstead (1) conceptualized a philosophical basis for including extraspinal adjusting within the purview of chiropractic care. Furthermore, normal spinal biomechanics not only contribute to, but are dependent on, the integrity of both the upper and lower extremities. To neglect these areas of the body does not provide the patient with optimal care.

The doctor should always consider that many patients presenting with chief complaints which suggest extremity pathology may actually be suffering from symptoms which are secondary to visceral pathology or lesions of the spinal column (e.g., vertebral subluxation complex).

It is the responsibility of the practitioner to arrive at a differential diagnosis through the patient history, physical examination, and special diagnostic procedures: x-ray, MRI, hematologic tests, thermography, etc. As with most diagnostic work-ups, the patient history is generally the most valuable tool.

EXAMINATION

The initial approach to the patient presenting with extremity symptoms as the chief complaint should include a comprehensive spinal evaluation to aid in the detection of the origin of the condition (Table 16.1). If and when vertebral subluxation, as well as visceral pathology, have been eliminated as possible sources of symptomatology, attention should be focused at the peripheral joint in question. Many of the conditions for which the clinician is consulted for are not the result of a macrotraumatic episode and are generally less complicated to properly diagnose. The selective extraction of historical subtleties will ultimately lead to a proper diagnosis. As it is not in the interest of this chapter to instruct on general history-taking procedures, only pertinent questions which supply data helpful in extremity care shall be discussed. Inclusion of such inquiries will be discussed within each portion of the standard health history.

I. Bibliographical Information
II. Chief Complaint
III. Present Illness
IV. Past History
V. Family History
VI. Review of Systems:
   1) Physical
   2) Sociological
   3) Psychological

Table 16.1.
Origin of Pain: Peripheral Joints vs. Vertebral Subluxation Complex (VSC)*

<table>
<thead>
<tr>
<th>Factors</th>
<th>Peripheral Joint</th>
<th>VSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset</td>
<td>General history of specific incident or action</td>
<td>Gradual or insidious</td>
</tr>
<tr>
<td>Provocative</td>
<td>Joint use or load</td>
<td>Spinal postures, stresses, aggravation</td>
</tr>
<tr>
<td>Palliative</td>
<td>Joint rest, support, ice, etc.</td>
<td>Ameliorating factors for spinal conditions</td>
</tr>
<tr>
<td>Quality of pain</td>
<td>Sharp, throbbing</td>
<td>Dull, ache</td>
</tr>
<tr>
<td>Region</td>
<td>Localized, specific, usually unilateral</td>
<td>Diffuse, difficult to isolate, possibly bilateral</td>
</tr>
<tr>
<td>Radiation</td>
<td>Generalized, nonspecific pattern</td>
<td>Dermatomal, sclerotomal, myotomal</td>
</tr>
<tr>
<td>Intensity</td>
<td>Mild to severe</td>
<td>Mild to moderate</td>
</tr>
<tr>
<td>Timing</td>
<td>Generally correlated to joint function</td>
<td>Temporally related to spinal factors</td>
</tr>
</tbody>
</table>

*General information obtained during routine history procedures often leads to the specific site of the lesion.
Biographical Data

After obtaining standard data including name, address, sex, birthdate and marital status, the doctor should inquire about the patient’s occupational and recreational activities. The examiner must retrieve information related to specific physical demands placed on the patient during daily life. Occupational factors include: job duties, postural demands, time commitments for work activities, and exposure to noxious agents. If the patient engages in recreational activities, be it in the form of organized activity or merely sporadic exertion, the patient is susceptible to injury. Helpful information includes all activities inherent to the patient’s leisure schedule, past injuries sustained, recent changes in activity level, awareness of general conditioning techniques, and adherence to warm-up and cool-down practices.

Chief Complaint

The history of the patient’s symptoms begins with the chief complaint (CC) which is a list in the patient’s words of one or more symptoms (2). The duration of the various symptomatology is important as it establishes the chronicity of the condition (3).

The purpose of listing multiple symptoms as chief complaints is two-fold. They serve as meaningful leads that aid in making differential diagnoses, and they also present a prominent list to remind the doctor about what complaints prompted the patient to seek health care.

Present Illness

The present illness section is the heart of the history and frequently leads to the ultimate diagnosis of the patient. The components of the present illness include (4):

1. Onset of symptoms (O)
2. Provoking and palliative factors (P)
3. Quality of pain (Q)
4. Radiation or referral (R)
5. Severity of symptoms (S)
6. Timing and frequency of symptoms (T)

ONSET

The onset of the patient’s symptoms is important diagnostically as the doctor must determine if the injury is a result of an overt macrotrauma, repetitive overuse, microtrauma or misuse (abuse). For example, the patient might state that while jogging one afternoon a sudden step into a hole resulted in a twisted ankle which caused immediate pain and swelling (macrotrauma). Another scenario would be a patient suffering from ankle pain but denying previous injury. A detailed history, in fact, reveals that the patient runs two to five miles daily on the side of a steeply crested road (microtrauma).

| Table 16.2. Generalized Pain Description and Source |
|---------------------------------------------|----------------
| Symptom                                     | Involved Structure |
| Sharp pain with motion                      | Joint            |
| Constant pain                               | Joint or Nerve   |
| Burning/hot pain                            | Nerve            |
| Sharp pain without motion                   | Nerve            |
| Stabbing or shooting pain                   | Nerve            |
| Tingling or numbness                        | Muscle           |
| Crampy, knot or spasm                       | Muscle or Nerve  |
| Dull ache                                   | Vascular         |
| Throbbing                                   |                  |

PROVOKING AND PALLIATIVE FACTORS

Provoking factors are those which the patient can perform and consistently aggravate or reproduce their symptoms. Palliative factors are just the opposite: activities or actions on the patient’s behalf which decrease or alleviate symptoms. For example, a patient presenting with anterior knee pain states that symptoms increase when running down hills but decrease when resting with the knees fully extended.

QUALITY OF PAIN

The patient is asked to describe the pain (Table 16.2). This description is useful in identifying the type of tissue which serves as the source of pain (4).

RADIATION

Radiation refers to pain that has radiated and/or has been referred to another area. Although pain referred by nerve root involvement follows dermatomal patterns, pain originating from muscular pathology refers along specific myotomes. Pain of ligamentous origin will follow a scleratomal pattern. Additionally, myofascial referral patterns have also been demonstrated. The clinician should be familiar with the aforementioned referral patterns to aid in determining the origin of pain.

SEVERITY

The task of assessing a patient’s level of pain can be difficult. Differing thresholds of pain and the willingness or mood of the patient are just a few of the variables to be considered. The patient should be asked to estimate the level of pain on an analog (1–10) pain scale. Grade 0 represents no symptomatology, whereas grade 10 delineates severe, debilitating pain. The grade recorded should correlate with the patient’s overall presentation and behavior.

TIMING/FREQUENCY

The timing or frequency of symptoms should be noted. The doctor should inquire if the symptomatology is inter-
mittent or constant, worse in the morning, daytime or night, or if the symptoms are presently getting better, are worse, or are nonchanging (5). For example, the patient reports suffering occasional pain of the right shoulder which only follows a weekly tennis match and lasts for approximately 1 to 3 hours after cessation of play. This would most likely indicate some type of impingement syndrome of the shoulder which is aggravated by overhead arm motions.

PAST HISTORY

Useful information includes prior injuries to the same area or to the opposite extremity. This becomes important when bilateral comparisons are made. If the doctor discovers a possible laxity of a ligament, it might be desirable to compare it with its contralateral counterpart. The doctor will need to know if there was a previous injury of the opposite joint. If a past history of injury is discovered, the doctor should ascertain if professional care was sought, and if so, what was the type, duration, and results.

FAMILY HISTORY

Historical data pertaining to the family may aid in diagnosis, either directly or indirectly. Hereditary factors can play a direct role in a patient's susceptibility to a particular injury. Indirectly, careful questioning may reveal that patients may be pressured by family members to compete in activities against their wishes, try to perform at a level higher than they are capable of, or continue to participate even when injured.

REVIEW OF SYSTEMS

The review of systems (ROS) portion of the history serves to collect data concerning past and present health and status of the bodily systems. The ROS includes information concerning physical, sociological, and psychological health, which may identify problems not previously uncovered (3). After the history, the clinician should thoroughly examine the patient to obtain additional findings which aid in the quest for an accurate diagnosis. To competently evaluate a patient, the doctor must have a comprehensive knowledge of the structures and functions of the body part or region to be examined.

Upper Extremity Examination

Examination of the upper extremity begins as the patient enters the room and exposes the bare shoulder and arm for examination. Complete exposure is essential for a comprehensive examination. Failure to fully visualize the patient greatly compromises examination efficacy.

The doctor should note the patient's willingness to use the upper extremity (5). The patient is then requested to walk to and from the doctor to demonstrate the freedom of arm swing, the reciprocal movement and posture of the arms, scapular movement, and motion of the trunk. Allowing the patient to be seated once again, the examiner must consider all anatomic structures which in some way may refer symptoms to the upper extremity (Table 16.3).

It should be noted that because the upper extremity and shoulder articulate with the thorax, they form a kinetic chain. An injury or malfunction of any component of the chain may lead to compensatory pathologies elsewhere. It is for this reason that a patient with a complaint of any joint of the upper extremity receive a thorough spinal examination.

Before the initiation of the upper extremity evaluation, unless the symptomatology is directly related to an obvious localized peripheral joint or soft tissue pathology, complete general physical and spinal examination is indicated to accurately evaluate the status of the patient and arrive at the proper diagnosis. The material presented in Chapter 4 serves as a reference for the chiropractic examination of the spine.

PALPATION

Palpation is performed to 1) assess skin temperature, 2) to detect the presence of a sensory deficit, and 3) to locate and identify specific structures which are swollen or painful. A thorough knowledge of surface as well as underlying anatomy is imperative to adequately perform a palpatory examination (Fig. 16.1A-B).

NEUROLOGIC EXAMINATION

The examination of the musculoskeletal system is not adequate without a thorough assessment of the nervous system (6). It is important to keep in mind the segmental nerve supply to both the skin and muscles. Superficial sensation is assessed with a safety pin, whereas deep pain may be tested by squeezing the muscles of the limb.

<table>
<thead>
<tr>
<th>Table 16.3. Sources of Referred Pain to the Shoulder*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical Spine</td>
</tr>
<tr>
<td>Temporomandibular Joint</td>
</tr>
<tr>
<td>Thoracic Outlet Syndrome</td>
</tr>
<tr>
<td>Sternoclavicular Joint</td>
</tr>
<tr>
<td>Acromioclavicular Joint</td>
</tr>
<tr>
<td>Scapulothoracic Joint</td>
</tr>
<tr>
<td>Costalternal Joint</td>
</tr>
<tr>
<td>Costovertebral and Costotransverse Joints</td>
</tr>
<tr>
<td>Thoracic Spine</td>
</tr>
<tr>
<td>Lumbar Spine</td>
</tr>
<tr>
<td>Carpal Tunnel Syndrome</td>
</tr>
<tr>
<td>Visceral Conditions</td>
</tr>
</tbody>
</table>

*Various sources of referral must be considered when examining the patient presenting with shoulder pain.
Table 16.4.
Muscle Strength Grading

<table>
<thead>
<tr>
<th>Grade</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = Zero</td>
<td>No contractile activity</td>
</tr>
<tr>
<td>1 = Trace</td>
<td>Evidence of slight muscular contractibility</td>
</tr>
<tr>
<td>2 = Poor</td>
<td>Complete range of motion with gravity eliminated</td>
</tr>
<tr>
<td>3 = Fair</td>
<td>Complete range of motion against gravity</td>
</tr>
<tr>
<td>4 = Good</td>
<td>Complete range of motion against gravity with some resistance</td>
</tr>
<tr>
<td>5 = Normal</td>
<td>Complete range of motion against gravity with full resistance</td>
</tr>
</tbody>
</table>

*Muscles are graded according to standardized examination findings.

Individual muscles should be tested for strength and graded accordingly. A numerical value of 5 represents normal muscle power, whereas a decreasing grade indicates relative loss of muscular strength (Table 16.4).

Manual muscle testing and strength loss determination are arts that the examiner must learn to master. The doctor must become proficient at isolating individual muscles and muscle groups, and grading them appropriately. Hurried or inappropriate testing methods will likely lead to missed diagnoses (7) (Table 16.5).

It should be noted that a Grade 5 is possible even in the presence of moderate muscle atrophy. If a more objective evaluation is required, an isokinetic muscle testing unit (e.g., Cybex, Merac, etc.) may be used. This evaluation allows the doctor to reliably compare right and left counterparts as well as agonist-antagonist ratios and specific muscle to body weight ratios.

Deep tendon reflexes are assessed to evaluate motor response elicited by a sensory stimulus. As in muscle testing, reflexes are graded. The grading scale most commonly used ranges from 0–4 (Table 16.6). The standard deep tendon reflexes evaluated are:

1. Biceps—C5 and C6 (musculocutaneous nerve)
2. Brachioradialis—C5 and C6 (musculocutaneous nerve)
3. Triceps—C6 to C8 (radial nerve)
4. Wrist extension—C7 and C8 (radial nerve)
5. Wrist flexion—C6 to C8 (median nerve).

RANGE OF MOTION

Active and passive ranges of motion are evaluated bilaterally with the aid of a goniometer or inclinometer. A complete range of motion assessment includes evaluation of the shoulder, elbow and wrist. Although various authors report differing ranges of motion, the more commonly accepted values are listed in Table 16.7 (8).

Active range of motion involves both contractile and noncontractile tissues; therefore, active movements alone are not specific in identifying the involved anatomic structures. It is preferred to perform the active range of motion (AROM) tests before the passive range of motion (PROM). This allows the doctor to get a general idea of the patient’s range of motion while detecting any obviously restricted or painful motions.

After the AROM examination, the doctor should take the patient through the passive ranges of motion. These passive motions stress the noncontractile tissues: ligaments, joint capsule, fascia, nerves, blood vessels, and bone.
Table 16.5.
Standard Manual Muscle Tests for Muscles Acting on the Shoulder and Upper Extremity

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Manual Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezius</td>
<td>The patient shrugs his or her shoulders against resistance offered by the doctor.</td>
</tr>
<tr>
<td>Serratus Anterior</td>
<td>The patient thrusts an outstretched arm against a wall or resistance offered by the examiner.</td>
</tr>
<tr>
<td>Latissimus</td>
<td>The patient attempts downward and backward movement of the arm against examiner resistance.</td>
</tr>
<tr>
<td>Teres Minor</td>
<td>Same as latissimus dorsi. The examiner must differentiate individual muscle function by means of muscle palpation during contraction.</td>
</tr>
<tr>
<td>Rhomboids</td>
<td>The patient holds the hand on the hip with the arm positioned back and medial. The examiner attempts to force the arm (elbow) laterally and forward while palpating the muscle bellies.</td>
</tr>
<tr>
<td>Sternocleidomastoid</td>
<td>The patient rotates the head to one side and then the other against resistance provided by the doctor to the opposite temporal area.</td>
</tr>
<tr>
<td>Deltoid</td>
<td>The patient’s arm is abducted to 90°; the examiner applies downward pressure at the elbow.</td>
</tr>
<tr>
<td>Subscapularis</td>
<td>With the elbow at the patient’s side and flexed at 90°, the patient resists the examiner’s attempt to externally rotate the arm.</td>
</tr>
<tr>
<td>Supraspinatus</td>
<td>The patient is instructed to abduct the shoulder 90° and bring the arm forward 30°. The forearm is pronated until the thumb points directly downward. The patient then resists downward pressure exerted by the doctor.</td>
</tr>
<tr>
<td>Infraspinatus and</td>
<td>With the elbow at the side and flexed to 90°, the patient resists the examiner’s attempt to push the hand medially, thus internally rotating the humerus.</td>
</tr>
<tr>
<td>Teres Minor</td>
<td></td>
</tr>
<tr>
<td>Biceps Brachii</td>
<td>The patient flexes a supinated forearm against resistance offered by the doctor.</td>
</tr>
<tr>
<td>Triceps Brachii</td>
<td>With the forearm in varying positions of flexion, the patient resists efforts of the examiner to flex the elbow.</td>
</tr>
</tbody>
</table>

Passive movements, such as joint play, are also performed to assess “end play” at the end of the patient’s range of motion (9). Cyriax (9) describes the most commonly encountered end-play findings (Table 16.8).

Passive movements should be evaluated in the following joints and directions:

1. Sternoclavicular Joint:
   - Superior Glide
   - Inferior Glide
   - Rotation
2. Acromioclavicular Joint:
   - Anterior Glide
   - Posterior Glide
   - Rotation
3. Glenohumeral Joint:
   - Inferior Glide
   - Anterior Glide
   - Posterior Glide
   - Traction

<table>
<thead>
<tr>
<th>Grade</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Areflexia</td>
</tr>
<tr>
<td>0+</td>
<td>Hyporeflexia</td>
</tr>
<tr>
<td>1-3</td>
<td>Normal</td>
</tr>
<tr>
<td>3+</td>
<td>Hyperreflexia</td>
</tr>
</tbody>
</table>

Table 16.6.
Standard Grading of the Muscle Stretch (DTR) Reflexes

Table 16.7.
Normal Range of Motion Values for the Major Joints of the Upper Extremity

<table>
<thead>
<tr>
<th>Shoulder</th>
<th>Flexion</th>
<th>180°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension</td>
<td></td>
<td>45°</td>
</tr>
<tr>
<td>Abduction</td>
<td></td>
<td>180°</td>
</tr>
<tr>
<td>Internal Rotation</td>
<td>70°</td>
<td></td>
</tr>
<tr>
<td>External Rotation</td>
<td>90°</td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td>Flexion</td>
<td>145°</td>
</tr>
<tr>
<td>Radioulnar Joints</td>
<td>Pronation</td>
<td>90°</td>
</tr>
<tr>
<td>Supination</td>
<td></td>
<td>90°</td>
</tr>
<tr>
<td>Wrist</td>
<td>Flexion</td>
<td>80°</td>
</tr>
<tr>
<td>Extension</td>
<td></td>
<td>70°</td>
</tr>
<tr>
<td>Radial Deviation</td>
<td>20°</td>
<td></td>
</tr>
<tr>
<td>Ulnar Deviation</td>
<td>35°</td>
<td></td>
</tr>
</tbody>
</table>

4. Scapulothoracic Articulation:
   - Elevation
   - Depression
   - Protraction
   - Retraction
   - Downward Rotation
   - Upward Rotation
5. Costovertebral Joints:
   - Anterior Glide
   - Posterior Glide
6. Ulnohumeral Joint:
   - Anterior Glide
   - Posterior Glide
7. Proximal Radioulnar Joint:
   - Anterior Glide
   - Posterior Glide
8. Distal Radioulnar Joint:
   - Anterior Glide
   - Posterior Glide
9. Carpal Joints:
   - Anterior Glide
   - Posterior Glide

ORTHOPAEDIC EVALUATION

The doctor should develop a specific pattern of orthopaedic testing which will ensure a comprehensive evalu-
ation of all structures in question while requiring the least number of postural changes on behalf of the patient.

There exist virtually hundreds of orthopaedic tests from which the doctor must select and design an evaluation program. Only some of the more commonly used tests are discussed here (5,6,10,11).

**Drop Arm Test.** This test evaluates the integrity of the supraspinatus tendon of the rotator cuff. The arm is passively abducted to 90°, and the patient is instructed to maintain this position. The doctor then applies downward pressure to the arm. Injury to the supraspinatus tendon will result in pain and/or weakness in the patient’s inability to hold the arm up (Fig. 16.2).

**Apprehension Test.** The clinician passively moves the shoulder into abduction and external rotation. A history of glenohumeral dislocation or subluxation will likely bring about an apprehensive facial expression by the patient (Fig. 16.3).

**Yergason’s Test.** The patient’s elbow is flexed to 90° with the forearm pronated. The patient then supinates against resistance. Pain localized to the bicipital groove suggests bicipital tendonitis or synovitis of the tendon sheath (Fig. 16.4).

**Ludington’s Sign.** With the patient’s fingers interlocked on top of the head with the elbows back, the biceps are actively contracted. Active pathology within the bicipital groove may cause pain or crepitus (Fig. 16.5).

### Table 16.8
#### Common End-play Findings

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capsular</td>
<td>Hard arrest of movements with some give</td>
</tr>
<tr>
<td>Spasm</td>
<td>Vibrant twang</td>
</tr>
<tr>
<td>Springy Block</td>
<td>A rebound is seen and felt at the extreme of the possible range</td>
</tr>
<tr>
<td>Tissue Approximation</td>
<td>Normal sensation</td>
</tr>
<tr>
<td>Empty</td>
<td>No organic resistance but the patient complains of pain</td>
</tr>
<tr>
<td>Bone-to-Bone</td>
<td>Abrupt halt when two hard surfaces meet</td>
</tr>
</tbody>
</table>

Figure 16.2. Drop arm test.

Figure 16.3. Apprehension test.

Figure 16.4. Yergason’s test.

Figure 16.5. Ludington’s test.
**Adson’s Test.** With the neck extended and rotated to the opposite side of the involved extremity, the patient inhales and holds the breath. The doctor simultaneously takes the patient’s radial pulse. Reduction of the radial pulse and/or reproduction of upper extremity symptoms is considered a positive test. Spasm or hypertrophy of the scalene musculature is implicated (Fig. 16.6).

**Costoclavicular Maneuver.** There exists the possibility that the neurovascular bundle may become compressed between the clavicle and the 1st rib. The patient is instructed to draw the shoulders inferior and posterior. The doctor examines for a reduction in radial pulse, auscultates for a bruit over the mid aspect of the clavicle, and inquires about the reproduction of upper extremity symptoms (Fig. 16.7).

**Hyperabduction Syndrome Test.** The doctor examines the patient for a radial pulse reduction, midclavicular or axillary bruit and reproduction of upper extremity symptoms while the patient’s arm is hyperabducted. Obstruction in this syndrome results from compression of the neurovascular bundle by the pectoralis minor tendon (Fig. 16.8).

**Impingement Test.** The arm is internally rotated and abducted while the scapula is fixed in place. Reproduction of symptoms is indicative of a shoulder impingement syndrome (Fig. 16.9).

**Clunk Test.** With the patient in the supine position, the examiner’s hand is placed posteriorly on the humeral head, and the opposite hand holds the humeral condyles at the elbow to provide rotation motion to the arm. The patient’s arm is brought into full overhead abduction, and the examiner’s hand on the humeral head provides anterior force while the opposite hand rotates the humerus. A “clunk” or grinding can be felt as the humeral head hits or snaps on the labral tear (Fig. 16.10).

**Spring Test.** The doctor applies a slow steady inferiorward pressure to the distal clavicle and follows that action with a rapid release. The doctor observes for an
upward rebound of the distal clavicle, which is indicative of a Grade II or Grade III acromioclavicular sprain (Fig. 16.11A-B).

**Opposition Test.** With the patient seated, the doctor applies a posterior to anterior force to the spine of the scapula and an anterior to posterior force to the distal clavicle, thus creating a shear force within the acromioclavicular joint. Production of pain or crepitus is an indication of acromioclavicular sprain or arthritis (Fig. 16.12).

**Varus/Valgus Stress of the Elbow.** A valgus stress applied to a slightly flexed elbow tests the integrity of the medial collateral ligament, whereas a varus stress challenges the lateral collateral ligament (Fig. 16.13A-B).

**Kaplan’s Test.** With the patient seated, the affected upper limb is held straight out, the wrist is in slight dorsiflexion and grip strength is tested in the normal manner; this maneuver is then repeated, this time with the examiner firmly encircling the patient’s forearm with both hands placed approximately 1 to 2 inches below the elbow joint line. It is a positive sign if the initial grip weakness and lateral elbow pain show a significant increase in grip strength and lessening of the pain in the elbow (6).

**Lower Extremity Examination**

Much like that of the upper extremity, the examination of the lower extremity is initiated as the patient enters the room. The patient’s gait should be observed on entry. The gait test should be observed during a 10-meter level walkway, space permitting (12). Limb deformities or leg length discrepancy can often be detected. A general knowledge of gait is needed to comprehend and identify dysfunction.

Gait of the lower extremity can be divided into two phases: Stance Phase and Swing Phase. The Stance Phase encompasses the time during which the foot is in contact with the ground. The Swing Phase is the span of time when the foot leaves the ground and again returns to the ground. Both the Stance and Swing Phases can further be divided into portions of each phase (Table 16.9). Spinal biomechanics involved in gait are discussed in Chapter 2.

The gait should be scrutinized for deviations which may arise from any anatomic component of the lower extremity:

1. **Ankle and Foot:** Foot slap, toe first, flat foot, hyperpronation, supination, foot varus-valgus, toe drag, etc.
2. **Knee:** Excessive knee flexion, knee hyperextension, limited knee flexion, limited extension, genuvalgum, genuvarum, etc.
3. **Hip:** Excessive flexion, limited flexion, excessive extension, limited extension, circumduction, etc.
4. **Trunk:** Antalgic lean, posterior trunk lean, anterior trunk lean, etc.

![Figure 16.10. Clunk test.](image1)

![Figure 16.11A-B. Spring test.](image2)
The overall function of the lower extremity is strongly related to proper kinesiologic performance of all of its component parts. All too often the doctor focuses on the site of pain, thus limiting the span of examination and often rendering the task of proper diagnosis impossible. It should be considered that local symptomatic treatment will commonly remedy the condition in the present, only for a reagravation later.

PALPATION

Palpation is necessary to locate and identify any painful, tender, or inflamed structure. As with all palpatory examinations, the doctor should also evaluate for skin temperature changes as well as sensory deficits. A comprehensive knowledge of all topical landmarks and underlying anatomy is required for an effective palpatory examination (Fig. 16.14A-B).

NEUROLOGIC EXAMINATION

The standard lower extremity neurologic examination begins with assessment of deep tendon reflexes (DTRs). All DTR findings should be graded and recorded using the customary 0–4 scale. The DTRs most commonly evaluated are the patellar reflex (L2-L4 innervation) and the achilles reflex (S1-S2 innervation).

The superficial nerves are evaluated by using a safety pin to compare bilateral sensation. The evaluation includes the L1 through S2 dermatomes.

STRENGTH EVALUATION

Manual muscle testing is performed bilaterally to assess general muscular strength (7) (Table 16.10).

RANGE OF MOTION

Goniometric measurements, both passive and active, of hip, knee, ankle and subtalar joint should be recorded (8,10,13). Again, authors vary on the normal values of joint ranges of motion (Table 16.11).

Passive movements or joint play should be evaluated in the following joints and directions:

1. Hip Joint:
   - Anterior Glide
   - Posterior Glide

2. Knee Joint (femorotibial):
   - Posterior Glide
   - Medial Glide
   - Lateral Glide
   - Anteromedial Rotational Glide
   - Anterolateral Rotational Glide
   - Posteromedial Rotational Glide
   - Posterolateral Rotational Glide

Figure 16.12. Opposition test.

Figure 16.13. A, Varus test for the elbow. B, Valgus test for the elbow.
Table 16.9.
The Components of the Normal Gait Cycle

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stance Phase:</td>
<td>1. Heel Strike: The initiation of the stance phase when the heel first contacts the ground.</td>
</tr>
<tr>
<td></td>
<td>2. Foot Flat: Following heel strike as the sole of the foot contacts the floor.</td>
</tr>
<tr>
<td></td>
<td>3. Midstance: The point at which the body travels directly over the planted foot.</td>
</tr>
<tr>
<td></td>
<td>4. Heel-Off: The point at which the heel of the planted foot lifts off the ground.</td>
</tr>
<tr>
<td></td>
<td>5. Toe-Off: The point at which the toe of the planted foot leaves the ground.</td>
</tr>
<tr>
<td>Swing Phase:</td>
<td>1. Acceleration: The portion of the arc traveled by the swinging extremity initiated by toe-off and completed as the swinging extremity is underneath the body.</td>
</tr>
<tr>
<td></td>
<td>2. Midswing: The portion of the swing when the extremity passes directly below the body.</td>
</tr>
<tr>
<td></td>
<td>3. Deceleration: The portion of the swing which the extremity is decelerating in preparation for heel strike.</td>
</tr>
</tbody>
</table>

3. Superior Tibiofibular Articulation:
   - Anterior Glide
   - Posterior Glide
   - Superior Glide (with dorsiflexion of the foot)

4. Inferior Tibiofibular Articulation:
   - Anterior Glide
   - Posterior Glide

5. Mortise Joint:
   - Anterior Glide
   - Posterior Glide

6. Subtalar Joint:
   - Medial Glide
   - Lateral Glide
   - Posterior Glide

7. Intertarsal Joints:
   - Superior Glide
   - Inferior Glide

**ORTHOPAEDIC EVALUATION**

As with the evaluation of the upper extremity, there exists far too many individual orthopaedic tests to expect the clinician to perform all of them. Again, the doctor must select a variety of appropriate tests to provide a comprehensive orthopaedic evaluation of the lower extremity. The following selected orthopaedic tests are used during routine examinations:

**Ober's Test.** The patient is positioned in the lateral decubitus position with the lower leg slightly flexed at the hip and knee. The upper limb, the limb being tested, is abducted and extended. The knee is then flexed to 90° and the limb is allowed to drop to the table. If the limb does not drop, there might be a tight or shortened iliotibial band (10) (Fig. 16.15).

**Trendelenburg Test.** The patient stands on one leg. The test is positive if the hip on the non-weight-bearing side does not rise as the patient stands on one lower extremity. The indications of a positive test include hip dislocation, weakness of the hip abductors, or coxa vara (Fig. 16.16).

**Abduction Test.** The doctor applies a valgus stress to the knee while the ankle is stabilized in slight external rotation. The test is performed with the knee in full extension and also with the knee flexed at 20°. Excessive movement of the tibia away from the femur is indicative of damage to the medial collateral ligament (Fig. 16.17).

**Adduction Test.** The doctor applies a varus stress to the patient's knee while the ankle is stabilized. The test is performed with the knee in full extension and flexed to 20° to 30°. Excessive movement of the tibia away from the femur is indicative of damage to the lateral collateral ligament (Fig. 16.18).

**Anterior Drawer Sign.** The patient lies in the supine position with the involved knee flexed to 90°. The doctor sits atop the forefoot of the flexed limb to anchor the lower leg. With the patient's foot positioned in neutral rotation, the doctor pulls forward on the proximal portion of the posterior tibia. The test is positive if there is excessive anterior movement of the tibia with respect to the femur. A positive test is indicative of instability of the anterior cruciate ligament (Fig. 16.19).

**Apley's Grinding Test.** The patient is in the prone position with the knees flexed to 90°. The doctor applies a compressive force through the foot down into the knee while internally and externally rotating the tibia. A sensation of pain and/or the presence of joint crepitation is indicative of a meniscal injury (Fig. 16.20A-B). The test continues by applying a distracting force to the leg. Pain elicited by distraction implies ligamentous rather than meniscal injury.

**Apprehension Test.** The patient is placed in the supine position with the knees flexed to 30°. The examiner slowly displaces the patella laterally. The test is positive if the
Table 16.10.
Manual Muscle Tests for the Lower Extremities

| Muscles: | Psosas Major and Iliacus (Hip Flexion) |
| Test: | The patient lies or is seated with legs over the edge of the table. The patient flexes the hip through the last portion of the range of motion as the doctor offers resistance at the distal femur. |

| Muscle: | Sartorius (Hip Flexion, Abduction and Lateral Rotation with Knee Flexion) |
| Test: | From a seated position, the patient flexes, abducts and laterally rotates the hip and flexes the knee. Resistance to hip flexion and abduction is provided with one hand above the joint; resistance to hip lateral rotation and knee flexion is offered by the other hand above the ankle joint. |

| Muscles: | Gluteus Maximus, Semitendinosus, Semimembranosus, and the Long Head of the Biceps Femoris (Hip Extension) |
| Test: | With the patient in the prone position, the hip is extended as the doctor offers resistance proximal to the knee joint. |

| Muscle: | Gluteus Medius (Hip Abduction) |
| Test: | The patient lies in the lateral decubitus position with the hip slightly extended beyond midline. The patient abducts the hip against resistance offered by the doctor proximal to the knee joint. |

| Muscles: | Adductor Magnus, Adductor Brevis, Adductor Longus, Pectineus and Gracilis (Hip Adduction) |
| Test: | The patient lies in the lateral decubitus position with the leg to be tested resting on the table. The doctor supports the upper leg in approximately 25° of abduction. The patient adducts the lower leg as the doctor offers resistance proximal to the knee joint. |

| Muscles: | Obturator Externus, Obturator Internus, Quadratus Femoris, Piriformis, Gemellus Superior and Gemellus Inferior (Hip Lateral Rotation) |
| Test: | The patient is seated with knee flexed to 90°. The patient laterally rotates the hip as the doctor stabilizes the lateral aspect of the knee and resists the patient’s attempt to rotate the hip by applying pressure to the medial aspect of the ankle. |

| Muscles: | Gluteus Minimus and Tensor Fasciae Latae (Hip Medial Rotation) |
| Test: | Same as the lateral hip rotation test except the patient attempts to medially rotate the hip against resistance offered by the doctor to the lateral ankle. |

| Muscles: | Biceps Femoris, Semitendinosus, and Semimembranosus (Knee Flexion) |
| Test: | With the patient in the prone position, the doctor stabilizes the pelvis with one hand and offers resistance to active knee flexion with the other hand just proximal to the ankle. |

| Muscle: | Quadriceps Femoris (Knee Extension) |
| Test: | The patient sits on the table with knees flexed at 90°. The patient attempts to extend the knee while the doctor offers resistance proximal to the ankle joint. |

| Muscles: | Gastrocnemius and Soleus (Ankle Plantarflexion) |
| Test: | The patient stands on the limb to be tested and raises the heel off the floor 5 to 10 times. |

| Muscle: | Tibialis Anterior (Ankle Dorsiflexion and Foot Inversion) |
| Test: | The seated patient dorsiflexes and inverts the foot against resistance offered by the doctor. The patient should be instructed to keep the toes relaxed to avoid involvement of the extensor digitorum and hallucis longus. |

| Muscle: | Tibialis Posterior (Foot Inversion) |
| Test: | The patient lies in the lateral decubitus position with the upper ankle positioned midway between plantarflexion and dorsiflexion. The patient then inverts the ankle as the doctor stabilizes the lower leg with one hand, while providing resistance to the patient’s efforts with the other. |

| Muscles: | Peroneus Longus and Peroneus Brevis (Foot Eversion) |
| Test: | The seated patient inverts the foot. The patient attempts to evert the foot as the doctor resists the motion. |

| Muscles: | Flexor Digitorum Longus, Flexor Digitorum Brevis, and Flexor Hallucis Longus (Flexion of Toes) |
| Test: | The patient flexes the proximal phalanges of the 2nd through 5th digits against resistance offered by the doctor. This test assesses the flexor digitorum brevis. Flexion of the distal phalanges with stabilization provided to the middle row of phalanges and resistance offered to the distal phalanges evaluates the strength of the flexor digitorum longus. Flexion of the 1st toe against resistance assesses the flexor hallucis longus. |

| Muscles: | Extensor Digitorum Longus and Extensor Digitorum Brevis |
| Test: | The seated patient extends the toes as the doctor stabilizes the metatarsals with one hand and offers resistance to the distal phalanges of all the toes. |

The patient looks apprehensive or contracts the quadriceps. A positive test is suggestive of a history of patella dislocation (Fig. 16.21).

**Clarke's Sign** The patient is in the supine position with the knees extended. The doctor lightly compresses the patella with the web of the hand. The patient is instructed to slowly contract the quadriceps. Inability to complete a full contraction without pain is suggestive of chondromalacia of the patella (Fig. 16.22).

**Hughston Plica Test.** This test is intended to identify an abnormal suprapatellar plica. The patient is in the supine position, and the doctor flexes the knee and medi ally rotates the tibia with one hand, while displacing the patella medially with the opposite hand. The test is positive if a "pop" is elicited at the plica while the knee is flexed and extended by the doctor (Fig. 16.23).

**Lateral Pivot Shift Test.** The doctor holds the lower leg with one hand and places the other hand on the lateral proximal aspect of the leg. With the knee in full extension, a valgus stress is applied followed by internal rotation of
Table 16.11. Commonly Accepted Joint Ranges of Motion for the Major Joints of the Lower Extremity

<table>
<thead>
<tr>
<th>Joint</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip</td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>125°</td>
</tr>
<tr>
<td>Extension</td>
<td>10°</td>
</tr>
<tr>
<td>Abduction</td>
<td>45°</td>
</tr>
<tr>
<td>Adduction</td>
<td>10°</td>
</tr>
<tr>
<td>Internal Rotation</td>
<td>45°</td>
</tr>
<tr>
<td>External Rotation</td>
<td>45°</td>
</tr>
<tr>
<td>Knee</td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>140°</td>
</tr>
<tr>
<td>Ankle</td>
<td></td>
</tr>
<tr>
<td>Plantarflexion</td>
<td>45°</td>
</tr>
<tr>
<td>Dorsiflexion</td>
<td>20°</td>
</tr>
<tr>
<td>Subtalar Joint</td>
<td></td>
</tr>
<tr>
<td>Inversion</td>
<td>35°</td>
</tr>
<tr>
<td>Eversion</td>
<td>20°</td>
</tr>
</tbody>
</table>

Figure 16.17. Abduction test for the knee.

Figure 16.15. Ober's test.

Figure 16.16. Trendelenburg's test.

Figure 16.18. Adduction test for the knee.

Figure 16.19. Anterior drawer test for the knee.

the leg and flexion of the knee. At approximately 30° flexion, an anterior jump of the lateral tibial plateau is suggestive of anterolateral rotatory instability (Fig. 16.24).

Reverse Pivot Shift Test. This test is intended to demonstrate posterolateral rotatory instability of the knee. With the patient in the supine position and the knee in full extension, the doctor supports the patient's knee posteriorly with one hand and the heel of the foot with the other hand. The foot is then laterally rotated. The test is positive if there is a jerk in the knee, or the tibia shifts posteriorly and the knee gives way (Fig. 16.25).
Figure 16.20. A, Apley’s compression test. B, Apley’s distraction test.

Figure 16.21. Patellar apprehension test.

Figure 16.22. Clarke’s sign.

Figure 16.23. Hughston test.

Figure 16.24. Lateral pivot shift test.
**Lachman’s Test.** With the patient in the supine position, the doctor stabilizes the distal anterior femur with one hand and holds the proximal tibia with the other hand. The knee is held in slight flexion as the tibia is drawn forward on the femur. Excessive anterior movement of the tibia is indicative of injury to the anterior cruciate ligament (Fig. 16.26).

**McMurry Test.** The patient is in the supine position while the examiner holds the foot with one hand and palpates the joint line of the knee with the other. The knee is then flexed and the tibia is rotated internally and externally and then alternately positioned in internal and external rotation as the knee is fully extended. Crepitus or popping felt over the joint line may indicate a meniscal tear (Fig. 16.27).

**Posterior Drawer Test.** The patient is positioned as in the anterior drawer test. The doctor attempts to move the tibia posteriorly on the femur. Excessive posterior slippage is suggestive of posterior cruciate ligament damage (Fig. 16.28).

**Anterior Drawer Test of the Ankle.** As the anterior distal tibiofibular articulation is stabilized, the doctor holds the foot in 20° of plantarflexion and draws forward. Anterior slippage which exceeds that of the uninjured side is indicative of anterior ankle instability (Fig. 16.29).

**Homan’s Sign.** If, during passive dorsiflexion of the foot, deep pain is felt in the lower leg, deep vein thrombosis should be suspected.

**Thompson Test.** With the patient in the prone position, the doctor squeezes the middle third of the gastrocnemius. The normal result is mild plantarflexion of the foot. Absence of this is indicative of a rupture of the Achilles tendon.

**Quadriceps-angle (Q-angle).** An indirect method of assessment of patellar tracking is the measurement of the Q-angle. The Q-angle is the measured angle formed by the line connecting the anterior superior iliac spine and the center of the patella and the line connecting the tibial tuberosity and the center of the patella (14). The measurement is made with the knees fully extended and the hips in the neutral position.

The normal values of the Q-angle are 14° for men and
17° for women. Although increased Q-angles have been associated with recurrent patellar dislocation, chondromalacia, and patellar arthralgia, objective documentation of the association is limited. Fox (15) claims that the Q-angle itself is not indicative of pathology.

Also, variations in the Q-angle do not significantly alter peak torque values of knee extension when tested at 30°, 60°, and 90°/sec (15) (Fig. 16.30).

SHOULDER GIRDLE

The shoulder girdle consists of four independent linkages: the sternoclavicular joint, the acromioclavicular joint, the glenohumeral joint, and the scapulothoracic articulation.

Sternoclavicular Joint

The sternoclavicular joint is a synovial joint which allows for three planes of motion: elevation-depression, protraction-retraction, and rotation. The joint is comprised of the medial end of the clavicle, the articular surface of the manubrium, and the interposed sternoclavicular disc. Ligamentous support is provided by the costoclavicular ligament and the sternoclavicular ligament (Fig. 16.31).

KINESIOLOGY

Elevation-depression occurs around an anterior posterior axis; protraction-retraction occurs around a vertical axis; and rotation occurs around an axis running longitudinally through the clavicle. Interposed between the osseous components of the sternoclavicular joint is a fibrocartilage disc or meniscus. The disc is attached superiorly to the clavicle and inferiorly to the manubrium. It acts as a hinge during joint motion and further serves as a shock absorber when forces are transmitted along the clavicle from its lateral end. Misalignment of the sternoclavicular joint commonly results when a force is applied to the lateral aspect of the shoulder which exceeds the shock-absorbing capacities of the meniscus and the tensile strength of the supporting ligaments and joint capsule.

RADIOGRAPHIC ANALYSIS

The standard radiographic analysis of the sternoclavicular joint requires a P-A view of the involved joint. The P-A projection is often insufficient to accurately assess the status of the joint. It is occasionally necessary to obtain a tomogram of the joint.

The most common injury to the sternoclavicular joint is a sprain which occurs when the patient falls directly on the shoulder. If the force is great enough, the proximal end of the clavicle may subluxate or dislocate. With subluxation, the direction of misalignment is usually superior. Complete dislocation produces a malalignment of the proximal clavicle in a superior and medial direction.

Acromioclavicular Joint

The acromioclavicular joint is composed of the distal end of the clavicle and the acromion process of the scapula. Ligamentous support is supplied by the conoid ligament, trapezoid ligament, acromioclavicular ligament, and the coracoacromial ligament.
KINESIOLOGY

The acromioclavicular joint is a synovial, hinge-type joint which permits three definable motions to occur (8,13,16). The primary movement at the acromioclavicular joint involves rotation of the scapula around an anterior-posterior axis as noted during abduction of the shoulder. A description of shoulder abduction is required.

During abduction, the glenohumeral joint and the scapulothoracic articulation move in a 2:1 ratio, that is to say, for every 3° of abduction, 2° occur at the glenohumeral joint and one degree occurs at the scapulothoracic articulation. The scapula does not move until the shoulder has been abducted approximately 20°. From this point the glenohumeral and scapulothoracic articulation move in the 2:1 ratio. This ratio of movement continues until 120°. At this point the surgical neck of the humerus contacts the acromion and full abduction to 180° can only be completed if the humerus is externally rotated (13) (Fig. 16.32). If fixation occurs at any of the articulations of the shoulder girdle, this scapulothoracic rhythm will likely be altered, which may result in dysfunction of another joint in the region. During abduction the acromion slides on the distal clavicle in the same direction as the movement of the scapula (8,13).

There are two remaining motions allowed by the acromioclavicular joint. One movement is described as "winging," in which the scapula slides laterally around the rib cage. This motion is around the vertical axis. The final motion is referred to as "tipping" of the inferior angle of the scapula around a coronal axis. Motions at the acromioclavicular joint are very small and not clinically
measurable, yet the few degrees of motion allowed are nonetheless fundamental for normal shoulder function.

RADIOGRAPHIC ANALYSIS

To evaluate the acromioclavicular joint, an anteroposterior radiograph of both shoulders is exposed on one film while the patient stands. Downward traction is then applied to both arms by securing 10-pound weights to the patient’s wrists, and the exposure repeated. The central ray should be directed cephalically 15°. In normal studies, the acromioclavicular joint should measure 11 to 13 mm (16). A Grade II injury is noted when the acromioclavicular interval is greater than 13 mm. A Grade III separation demonstrates a large widening of the acromioclavicular interval (13mm), upward displacement of the clavicle, and widening of the coracoclavicular space.

Glenohumeral Joint

The glenohumeral joint is a synovial ball and socket, or spheroid joint which allows three degrees of motion: flexion-extension, abduction-adduction, and internal-external rotation. It is composed of the glenoid fossa of the scapula, the head of the humerus, a joint capsule, the glenoid labrum, the rotator cuff and a myriad of other structures (Fig. 16.33A-B).

KINESIOLOGY

The range of motion for each of the three axes of movement varies greatly. The range of flexion through extension varies from 190° to 240° with 120° to 180° devoted to flexion. The range of abduction varies depending on whether the humerus is internally or externally rotated. Abduction of an internally rotated humerus is measured
up to 60°, whereas in full external rotation, it will abduct further to 120° to 135°. As discussed earlier, the scapulothoracic articulation is responsible for an additional 50° to 60° total shoulder abduction.

Abduction of the shoulder occurs through a combination of rolling and sliding of the humeral head on the glenoid fossa. As the humeral head rolls through abduction, it simultaneously slides inferiorly to prevent impaction of the humeral head into the acromion process (Fig. 16.34). This pattern of motion should be kept in mind as the doctor palpates the glenohumeral joint. The humerus can internally rotate 70° to 90°. External rotation ranges from 80° to 90°.

**Radiographic Analysis**

To analyze the glenohumeral joint, anteroposterior radiographs are obtained with the humerus positioned first in internal rotation and then in external rotation. The glenohumeral joint normally widens during external humeral rotation. This widening should be symmetrical with that of the opposite shoulder. Excessive widening is suggestive of glenohumeral joint instability. A lateral scapular radiograph should also be performed. The lateral scapular view is beneficial in assessing the position of the humeral head. In this view, the acromion, coracoid process, and the body of the scapula form a “Y” which serves as a reference point from which the position of the humeral head can be assessed.

Normally, the humeral head lies at the junction of the three structures. If the humeral head lies either anterior, posterior, superior or inferior to this junction, then glenohumeral misalignment in that specific direction should be considered. Approximately 85% of all shoulder misalignments are anteroinferior in direction, 10 to 13% are primarily anterior in direction, and perhaps only 2% are posterior.

**Scapulothoracic Articulation**

Although the scapulothoracic articulation is not a true joint, it does consist of a relationship between the scapula and posterior thoracic wall. The scapula is normally positioned approximately two inches from midline, between the second and seventh ribs. It is from this position that the normal motions of the scapula are described. These motions consist of elevation-depression and abduction-adduction, which are translatory movements, and upward and downward rotation of the inferior tip of the scapula. It is the latter which allows for complete abduction of the shoulder. Positional stability of the scapula is provided osseously by a competent sternoclavicular-acromioclavicular kinetic chain as well as the muscular elements (10,13) (Table 16.12).

**Common Disorders of the Shoulder**

**Shoulder Girdle**

**Anterior Dislocation of the Glenohumeral Joint**

**Definition.** The anterior-inferior dislocation of the glenohumeral joint is the most common type of shoulder dislocation. The injury typically occurs when the humeral head is forced anteriorly beyond the edge of the glenoid rim without spontaneous reduction.

**Etiology.** The displacement of the humeral head occurs when the arm is hyperabducted and externally

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**Table 16.12.**

**Muscles that Move or Stabilize the Scapula**

<table>
<thead>
<tr>
<th></th>
<th>Adduction</th>
<th>Abduction</th>
<th>Upward Rotation</th>
<th>Downward Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezius</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serratus anterior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper trapezius,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>serratus anterior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower trapezius,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rhomboid major,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rhomboid minor,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>levator scapulae,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pectoralis minor</td>
<td></td>
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</table>
rotated. The acromion acts as a fulcrum at which time the head is levered out of the glenoid fossa. As this occurs, there is tearing of the inferior glenohumeral ligament, anterior capsule and possibly the glenoid labrum.

Damage to the axillary or musculocutaneous nerve may complicate this injury. If the axillary nerve is involved, the resultant disability may demonstrate slight weakness or hypesthesia over the deltoid region of the arm. If the musculocutaneous nerve is involved, it may demonstrate weakness of the biceps brachii, brachialis, and the coracobrachialis muscles. Both of these conditions usually resolve spontaneously in a matter of a few weeks to several months. Other complications may include fractures of the humerus and/or glenoid process. The most commonly associated fracture of the humerus is avulsion of the greater tuberosity.

**Signs and Symptoms.** The athlete-individual suffering an anterior dislocation of the shoulder usually experiences a feeling of uselessness and pain in the shoulder region with muscle tightness and tenderness about the shoulder and anterior chest region. Tingling and numbness may also be present in the arm and hand region. Further, on reduction the patient usually experiences an increase in general symptomatology.

**Diagnostic Work-Up.** On disrobing the patient for examination, a noticeable loss of rounding of the shoulder with a prominent acromion process will be viewed. The humeral head may be noticed inferior to the coracoid process. The patient generally presents with the affected arm held across the chest. Infrequently, the arm may hang away from the body in an externally rotated posture. Any attempt to abduct or internally rotate the arm will be resisted by the patient. Neurologic sensation can be demonstrated with a safety pin over the lateral arm (axillary nerve) and radial aspect of the forearm (musculocutaneous nerve). The remainder of the arm should be tested for other brachial plexus nerve lesions. Further testing of the brachial plexus may be aided by evaluating muscle strength in the upper extremity. Distal pulses should be evaluated for compromise of the vascular supply into the extremity. On completion of the physical examination, adequate plain film x-rays should be taken. An anterior-inferior dislocation of the shoulder will demonstrate the humeral head in the subcoracoid potential space. Complications with this type of injury may include impaction of the humeral head (Hill-Sachs's defect), fracture of the greater tuberosity, and avulsion of the inferior aspect of the glenoid rim (Bankart lesion).

Depending on where the humeral head comes to rest, positional terms should be applied (e.g., subglenoid, subcoracoid and sublascicular dislocation).

**Treatment.** Shoulder dislocation is an acute emergency. The shoulder should be reduced to normal anatomic posture. There are a number of methods used to reduce this injury. Turek discusses the Kocher maneuver as a technique in the reduction of anterior shoulder dislocations. It basically consists of flexing the abducted arm at the elbow while maintaining slow distal inferior traction of the affected arm. While maintaining this traction, the arm should be slowly externally rotated to approximately 80°, at which time the elbow is then placed in front of the chest. The arm is then rotated internally, placing the affected hand on the opposite shoulder. Once the shoulder has been reduced, the arm should be immobilized across the chest in a sling and swathe.

An alternative method which is very effective also exists. The elbow of the affected extremity is flexed to 90° while an inferior tractional force is applied to the humerus. The shoulder is then slowly abducted and externally rotated. Reduction of the dislocation may occur during any of these steps (Fig. 16.35A,B-C,D). As with the Kocher maneuver, the arm is then placed across the body and immobilized. The period of immobilization is very controversial, ranging from 1 to 2 days (as pain subsides) up to 6 weeks. The above maneuvers required to reduce the shoulder should not be performed by the uninstructed.

The patient may be placed on electrical muscle stimulation of the pectoralis major as it inserts into the humerus within 48 hours of injury. Soft tissue manipulation including transverse frictional massage and trigger point therapy should also be applied to the muscles about the shoulder. After the immobilization phase of recovery, the shoulder should be evaluated to detect the presence of an antero-inferior humeral subluxation. If present, manual correction as discussed earlier should follow. Also, once immobilization has ceased, the glenohumeral joint should be maintained with a supportive taping procedure (Fig. 16.36).

**RECURRENT TRANSIENT SUBLUXATION OF THE SHOULDER**

**Definition.** Transient subluxation of the shoulder may cause the so called dead-arm syndrome, which is characterized by a sudden sharp or paralyzing pain when the shoulder moves forcibly into a position of maximal external rotation in elevation or is subjected to a direct blow.

**Etiology.** Many of the recurrent subluxations of the shoulder are subjected to forceful external rotation in positions of abduction and varying amounts of hyperextension. Other forms of recurrent subluxation occur by direct trauma (17) or repetitive inferior tractional loads. This syndrome may also occur during throwing, repetitive forceful serving in tennis, or working with the arm in a strained position above the shoulder level.

**Anatomic Considerations.** Most frequently, the anterior capsule is stretched or detached, allowing the humeral head to slip forward when a certain point of abduction and external rotation is reached (18).

**Symptoms.** It is imperative to obtain a good history of the injury. Many times the patient will complain of inter-
mittent shoulder pain and/or weakness, crepitus, and loss of various ranges of motion.

**Diagnostic Work-Up.** Passive and active ranges of motion of the shoulder demonstrate normal range without pain. Orthopaedic examination should include the apprehension test. Muscle testing should be performed for the deltoid, supraspinatus, teres minor and major, infraspinatus, subscapularis, and pectoral muscles.

Radiographically, Hill-Sach's lesions of the humeral head may be found. This deformity occurs with impaction of the humeral head on the inferior glenoid rim. A true axillary radiograph (Fig. 16.37) will show changes along the anterior rim of the glenoid.

Magnetic resonance imaging of the shoulder may aid in demonstrating anterior instability. Signs specifically related to the disruption of the anterior capsule are very commonly identified in patients with instability. One of the results of capsular stripping or detachment that occurs in these patients after the first and subsequent dislocations is a large anterior pouch, usually in association with a large subscapularis bursa. This then forms a potential space into which the humeral head can dislocate or subluxate (19).

**Treatment.** Initial chiropractic treatment of recurrent subluxation of the shoulder should include restoring normal position of the humeral head in the glenoid rim. Because the majority of these conditions are anterior and inferior, the humerus should be set inferior to superior and anterior to posterior. This should then be followed up with electrical muscle stimulation to the pectoralis clavicular division with a 15-second contraction time and a 45-second release time over a period of 15 minutes. This
should be performed at intervals of three times per week for 2 to 6 weeks. Supportive taping may also prove beneficial.

As with rehabilitation of any joint, full range of motion with progressive resistance is indicated within pain limits. Surgical tubing exercises may be included to improve strength and stability of the internal and external rotators of the shoulder. Soft tissue work such as transverse friction massage and trigger point therapy may also be applied to the internal and external rotators of the shoulder.

If after 4 to 8 weeks of conservative care, the shoulder remains unstable, further chiropractic or orthopaedic consultation should be obtained.

**Impingement Syndrome**

**Definition.** This disorder is a painful condition that most commonly results from entrapment of the supraspinatus tendon between the humeral head of the acromion, the coracoacromial ligament, or acromioclavicular clavicular joint (20–22).

**Etiology.** The impingement occurs between the anterior edge and undersurface of the anterior third of the acromion, the coracoacromial ligament, and at times, the acromioclavicular joint, rather than against the lateral acromion (22). When the arm is raised forward, the supraspinatus passes under the anterior edge of the acromion and the acromioclavicular joint. Further, any disorder that results in an increase volume of the rotator cuff tendons, such as hypertrophy, and arthritic degeneration, may predispose the patient to this disorder (23). Shoulder impingement syndrome has been divided into three stages:

1. **Stage 1 Edema and Hemorrhage:** This phase is characterized by edema and hemorrhage which may result from excessive overhead use in sports or work (23). Individuals usually suffering from this particular phase are 25 years of age or younger.

2. **Stage 2 Fibrosis and Tendonitis:** This phase is less common than Stage 1. It occurs with repeated episodes of overuse. The shoulder function is satisfactory for light activity but becomes symptomatic after vigorous overhead use. Commonly, individuals with this particular lesion are in the age range of 25 to 40 years (23).

3. **Stage 3 Tears of the Rotator Cuff, Biceps Ruptures and Bone Changes:** During this phase of injury, the patient is usually greater than 40 years of age. With chronic impingement and wear, tears of the rotator cuff, biceps lesions, and bone alterations may be seen at the anterior acromion and greater tuberosity (23). The earliest bone changes evidenced radiographically include a slight prominence on the greater tuberosity at the point of insertion of the supraspinatus tendon, and a traction spur at the anterior acromion which is inside the coracoacromial ligament (22).

**Signs and Symptoms.** Initially, the patient presents with a dull ache over the anterior, posterior, and lateral aspects of the shoulder. This is usually brought on by strenuous activity as occurs with competitive swimmers and pitchers.

The patient suffering from Stage 2 impingement syndrome will present with a persistent dull ache in the shoulder which often interferes with sleep and work. Because of the chronic inflammation in the region, there may be
restrictions with shoulder movements during activities of
daily living.

The Stage 3 patient demonstrates a symptomatic pre-
sentation of prolonged periods of pain, especially at night.
Weakness of the shoulder may also be present.

Clinical Findings. Stage 1 impingement syndrome
demonstrates: (a) palpable tenderness over the greater
tuberosity at the supraspinatus insertion; (b) palpable ten-
derness along the anterior edge of the acromion; (c) a
painful arc of abduction between 60° and 120° (24).

Stage 2 impingement syndrome demonstrates palpa-
table tenderness over the greater tuberosity at the supraspi-
natus insertion with associated palpable tenderness along
the anterior edge of the acromion. Additionally, there is:
(a) a greater degree of soft tissue crepitus, due to scarring
in the subacromial space; (b) a catching sensation with
reversal of elevation at approximately 100°, thought to
represent scar tissue entrapment beneath the acromion;
and (c) mild limitation to both passive and active range of
motion (24).

Stage 3 impingement syndrome includes all of the
findings found in Stage 1 and Stage 2 as well as: (a) limi-
tation to shoulder motion, active being more limited than
passive; (b) infraspinatus atrophy; (c) weakness of shoul-
der abduction and external rotation; (d) biceps tendon
involvement with rupture or degenerative changes, which
occurs in a high percentage of patients with rotator cuff
tears; and (e) acromioclavicular joint tenderness, espe-
cially if degenerative changes are present (24).

Diagnosis. The diagnosis of impingement syndrome
can be made on the basis of a good clinical examination
(25). The “impingement sign” is elicited with the patient
seated and the examiner standing. Scapular rotation is
prevented with one hand while the other hand raises the
arm in forced forward elevation, thereby causing the
greater tuberosity to impinge against the acromion (23).
Another evaluation can be performed by forcibly inter-
nally rotating the forward flexed proximal humerus,
which forces the greater tuberosity against the leading
edge of the coracoacromial ligament, producing an
impingement sign (24). Manual muscle testing may
reveal weakness of the supraspinatus muscle.

Plain film radiographic alterations may include bone
proliferation, eburnation, and cystic change in the greater
tuberosity (26). A well-defined osseous excrescence,
termed a subacromial spur, is present in some patients
with this syndrome. It extends from the anterior inferior
aspect of the acromion and is best visualized on an antero-
posterior radiograph with 30° of caudal angulation of the
x-ray beam (27). The subacromial spur appears to be a
traction phenomenon created by the repetitive impinge-
ment of the greater tuberosity on the coracoacromial lig-
ament (26).

Magnetic resonance imaging of the shoulder can play
an important part in making the diagnosis of impinge-
ment syndrome. The distal supraspinatus tendon will
demonstrate an increased signal intensity. This increase is
probably related to a number of factors including edema
and inflammatory changes, as well as mucoid degenera-
tive changes (28). It may also be noted that the anterior
acromion is at a distinctly lower positional level than the
distal clavicle. Neer (22) felt that an abnormal size or pos-
tion of the anterior aspect of the acromion can predispose
a patient to impingement syndrome.

Treatment. Impingement syndrome should be
treated conservatively in Stage I. This should include
decreased activity (limited external rotation and abduc-
tion). Applications of ice should be recommended to mit-
gate the acute severity. During the acute phase, stretching
of the external rotators of the arm can be performed. This
is a combined movement of horizontal abduction and
internal rotation while blocking the scapula from move-
ment. Further, exercises within pain-free range of motion
to enhance glenohumeral range of motion, such as Cod-
man’s pendulum exercises, should be incorporated. Also,
exercises to help decompress the supraspinatus should be
performed. This may include strengthening the pectoralis
major (sternal division), latissimus dorsi, serratus ante-
rior, rhomboid major and minor, trapezius, and levator
scapulae.

The doctor should also evaluate the painful shoulder
with regard to joint fixation. This should include exami-
nation of the A-C joint, the scapulothoracic articulation,
and the glenohumeral joint. If an area of fixation dys-
function is identified, the structures involved should be
adjusted accordingly. Areas of fixation in the spine (cervi-
cal and thoracic) should be evaluated as well. Restora-
tion of function in the cervical and thoracic spine will
enhance neurologic function at the affected extremity.

Rotator Cuff Lesions

Definition. Lesions of the rotator cuff are common in
the adult. The most common site of injury is the supraspi-
natus tendon. In the young athlete, such lesions are
probably due mainly to wear and tear of the supraspinatus
tendon as it passes under the acromion process (29). The
rotator cuff is made up of the following muscles: supraspi-
natus, infraspinatus, teres minor, and subscapularis
(30).

Tears of the rotator cuff may be considered partial or
complete. Partial tears are of two types: 1) the intraten-
dinous tear and 2) deep surface tear (3). Complete tears
involve the entire thickness of the tendons thus causing
exposure of the humeral head. The tendon most com-
monly involved is the supraspinatus. Less frequently, the
infraspinatus and teres minor are torn.

Etiology. The supraspinatus muscle is located
between the humeral head and acromion. This “sand-
wich” phenomenon, with its unyielding boundaries, may
result in chronic bursal inflammation and tendinitis
which eventually leads to significant tendon degeneration
and tearing (31). It must be noted that the coracoclavicular ligament contributes to the anterior one-third of the acromial arch which also introduces compressive forces on the rotator cuff.

The supraspinatus tendon has been studied by Rathbun and McNab (32) who demonstrated a hypovascularity in the area of the supraspinatus insertion. This may help explain why tears in the rotator cuff take time to heal.

Historically, there are five mechanisms through which a rotator cuff tear can occur: an injury without fracture or dislocation of the shoulder; anterior dislocation of the shoulder; dislocation with a fracture of the greater tuberosity; chronically with or without a history of injury; and avulsion fracture of the greater tuberosity (33).

**Signs and Symptoms.** Patients may be of any age when they present with a cuff tear, but clearly, the majority of symptomatic rotator cuff tears occur in patients over the age of 40 (31). Commonly, the patient may present with pain in the area of the rotator cuff which is most noticeable at night. Pain may be experienced in the area of the biceps tendon which radiates cephalically towards the neck. Activities that involve raising the arm above the level of the shoulder in internal or external rotation may become awkward and painful.

**Clinical Findings.** Examination should include bony and soft tissue comparison of the involved shoulder with the uninjured extremity. Active and passive range of motion should be noted with particular attention to abduction and internal and external rotation. Isolated strength examination should be performed on the supraspinatus, infraspinatus, teres minor, deltoid, and the subscapularis muscles. Weakness of the supraspinatus muscle is common, as is weakness of any of the rotator cuff muscles if they are involved.

**Diagnosis.** Injuries to the rotator cuff have been categorized into four stages: In Stage 1, the rotator cuff becomes inflamed and contracted with concurrent muscle atrophy (34). Stage 2 lesions involve fibrous disruption without an actual tear in the muscle. Stage 3 demonstrates permanent thickening of the bursa accompanied by a 1 cm or less defect in the tissue. Stage 4 demonstrates permanent thickening of the bursa along with a tear greater than 1 cm.

Plain film examination of a shoulder with a suspected tear should aid the examiner in evaluating alignment, bony structures, and soft tissue changes. Further examination of the shoulder with a suspected tear in the rotator cuff should include magnetic resonance imaging which will help demonstrate a tear in the tissues. If a tear is identified, this examination should be followed up with arthrography to better determine the extent of the tear.

**Treatment.** Rotator cuff tears in Stage 1 or Stage 2 should be treated conservatively. Early management of this lesion should include passive range of motion, soft tissue mobilization, trigger point therapy as needed, and shoulder manipulation when indicated. Cryotherapy can be applied over the involved area. Stretching exercises should be performed with the arm in 90° of shoulder abduction, 90° of elbow flexion, and as much external rotation as can be achieved at the glenohumeral joint (34). A second stretching exercise will require the patient to lie diagonally on the table to allow head support while the shoulder hangs over the edge. The arm is put as far over head as possible, with the palm towards the ceiling, weight in hand, and the elbow extended (34). As pain-free range of motion increases, the patient should begin active strengthening of the damaged muscles. In terms of recovery of musculature strength and power, evidence is beginning to accumulate that isokinetic training is the most effective means of rehabilitation after injury (35–37).

If isokinetic equipment is not available, strengthening exercises can be performed using rubber tubing. In using rubber tubing, the examiner must keep in mind that early strengthening programs should be initiated during mid-range excursion of the muscle, performed rapidly and pain free. As strength increases, the arc of motion performed with the tubing increases until full pain-free motion is possible. These larger arcs are performed slowly to reduce the likelihood of “pushing” the joint through a painful range of motion.

If the shoulder arthrogram demonstrates extravasation of contrast material from the joint into the adjoining soft tissues, surgical consultation is recommended.

**ADHESIVE CAPSULITIS (FROZEN SHOULDER)**

**Definition.** Adhesive capsulitis is a condition that begins with insidious onset of pain and gradual restriction of movement in the shoulder region (38). Often, the pain associated with this condition radiates medially and cephalically into the upper back and neck. The pain is exacerbated with even minimal shoulder movement.

**Etiology.** The etiology of this condition remains unknown. Typically, there is an insidious onset of gradually progressive shoulder pain with marked limitation of movement. Features of this pathologic condition include microscopic evidence of chronic capsular inflammation with fibrosis and perivascular infiltration (38–40). Immunologic studies in individuals with this condition reveal that a certain percentage of patients have HLA B27 antigen (41).

Chronic cases of adhesive capsulitis are characterized by adhesions of the synovial folds, obliteration of the joint cavity, and a thickened, contracted capsule that eventually becomes fixed to the bone (39,42,43). Other factors that have been implicated include recurrent trauma to the shoulder, manual work, thyroid disease, ischemic heart disease, repeated injection of phenobarbital and isoniazid, and diabetes.

**Anatomic Considerations.** Current doctrine supports Neviser’s theory that the capsule is the sight of the lesion and lends credence to the synonymous use of the terms
adhesive capsulitis and frozen shoulder (44). The antero-inferior aspect of the dependent fold between the long head of the biceps and the subscapularis tendon is the region where adhesions develop within the fold itself and also at the glenoid fossa and humerus (45,46).

Signs and Symptoms. With many patients, there is a description of an onset of acute pain that progresses during the first few weeks and months. Individuals frequently complain of night pain that is manifested on awakening when rolling over on the affected side. The pain is distributed vaguely in the deltoid muscle area (44). The pain is present at rest and during activity. With time, the pain abates spontaneously; however, motion restriction persists. Some patients also complain of proximal soreness of the upper back and neck, a symptom probably attributable to the compensatory overuse of shoulder girdle muscles, such as the trapezius, rather than to referred pain from the shoulder (44). The pain associated with this condition is often described as a mild to severe ache.

Clinical Findings. Most patients are between the ages of 40 and 50 years (39). The magnitude of pain ranges from mild to severe and is characterized as a dull ache which is poorly localized. The pain is generally noted to be more intense at the posterior and superior aspects of the shoulder. Women frequently complain of inability to hook a bra or comb hair, whereas men experience difficulty in reaching for a wallet or the back of a shirt collar (39). Restriction of movement at first seems secondary to pain, but subsequently, measurable limitation of both active and passive range of motion in different planes is noted (38).

The syndrome usually progresses through four stages:

1. Stage 1: The patient usually presents with signs and symptoms of the impingement syndrome. Motion usually is restricted very little, if at all. Stage 1 is commonly misdiagnosed as rotator cuff tendinitis (47).
2. Stage 2: Arthroscopy demonstrates the synovium is red and thickened with adhesions visualized growing across the dependent fold of the capsule onto the humeral head. There are decreased joint spaces between the humeral head and glenoid, as well as the space between the humeral head and biceps tendon (47). Physical exam during this stage will demonstrate marked loss of motion throughout all planes with associated pain in all ranges of motion.
3. Stage 3: Arthroscopy demonstrates a pink synovitis that is not as marked as in Stage 2; however, the dependent fold of the capsule is noted to be half its original size. The humeral head is still positioned against the glenoid and bicapital tendon.
4. Stage 4: Arthroscopy demonstrates no synovitis. The dependent fold of the capsule is markedly contracted and motion is essentially lost. The humeral head continues to be pressed against the glenoid and biceps tendon.

Diagnosis. Depending on the stage, the patient will demonstrate decreased ranges of motion with associated pain. Plain film radiography in the early stages may not show any bony or soft tissue abnormalities. In long-standing cases, the most common radiographic finding is localized osteoporosis of the humeral head (48). Arthrography is the most reliable method to make the diagnosis. The arthrographic evidence of adhesive capsulitis is loss of the normally loose dependent fold of the joint and a dramatic decrease in the volume of contrast material that can be injected (47).

Clinical examination of the cervical spine should be performed. This should include, range of motion, orthopaedic, and neurologic examination. Pain sometimes radiates distally along the C5 dermatome.

Treatment. Early treatment of adhesive capsulitis should be initially conservative, with the emphasis on controlling inflammation and passive stretching of the capsular structures (47). This should be followed up with passive joint mobilization. Joint mobilization should occur in the direction of the joints accessory motion. The accessory motions are described as small spinning, gliding, rolling or distractive movements that occur between joint surfaces and are essential for normal mobility (49). As the range of motion increases in the affected shoulder, active exercises can be performed by the patient at home. Early home exercises should include pendulum and finger climbing up a wall.

Rizk et al. (38) developed a unique approach for the treatment of this condition in the acute phase. Their study reported 28 cases treated with range of motion exercises as well as pulley traction and the use of transcutaneous nerve stimulation (38). At the end of the study, the patients had 90% of full range of motion and pain-free sleep by 8 months.

Patients suffering from this condition should have the cervical spine examined. This examination should determine areas of hypomobility or fixation. Specific gentle cervical adjustments should be performed to help restore normal function.

The patient should respond to conservative treatment within 3 to 6 months. If desired clinical results are not forthcoming, an outside chiropractic or orthopaedic consultation is advised. If, however, conservative treatment continues to fail in delivering the desired results, the patient should be advised about manipulation under anesthesia. The procedure is as follows: an assistant stabilizes the scapula, the shoulder is then gently manipulated into abduction, then into flexion, and then combined with internal and external rotation (50). On completion of this maneuver, the arm is placed into 90° abduction with the use of a swathe tied to the head of the bed. Twenty-four hours postmanipulation under anesthesia, range of motion is maintained by instituting an active exercise program. This is monitored at intervals of five times a week for 2 weeks and then three times a week for the next 2 weeks (50). Manipulation under anesthesia is not without risk, because tissues are grossly torn and may develop further scarring (44). Further, manipulation also
increases the possibility of fractures, dislocation, and brachial plexus injuries (40,51).

**ACROMIOCLAVICULAR SEPARATION**

**Definition.** The acromioclavicular separation is defined as partial or complete tearing of the coracoacromial ligament, acromioclavicular ligament, and coracoclavicular ligaments (trapezoid ligament, conoid ligament).

**Etiology.** The acromioclavicular (A-C) joint is the most commonly sprained joint in the shoulder complex. Injuries to the A-C joint occur mainly by a direct fall on the shoulder or falling on the hand of an outstretched arm. The degree of disruption of the acromioclavicular and coracoclavicular ligaments varies. The initial injury is to the acromioclavicular ligaments followed by damage to the coracoclavicular ligament.

**Signs and Symptoms.** Acromioclavicular joint separations have been classified into three categories: A Grade 1 (first degree) demonstrates pain and discomfort directly over the joint. The differentiation between a mild sprain and a contusion is extremely difficult, because a mild sprain does not demonstrate hypermobility, and indeed, normal motions of the shoulder girdle will elicit no pain (29). A Grade 2 (second degree) will elicit pain on forced motion of the shoulder. Pain, tenderness, and swelling will also be localized to the acromioclavicular joint. Palpatory tenderness may be noted over the coracoclavicular ligaments. Range of motion of the shoulder will be limited due to pain. A slight elevation of the acromioclavicular joint may be present. A Grade 3 (third degree) demonstrates marked swelling, and point tenderness about the joint. Point tenderness will also be noted about the coracoclavicular ligaments. There is marked elevation of the distal end of the clavicle. The patient often holds the arm, because any downward pull or motion increases the pain and discomfort from the joint.

**Clinical Findings.** Allman's classification of injuries to the acromioclavicular joint into Grades 1, 2, and 3 has been widely accepted (52).

Grade 1 injuries to the acromioclavicular joint demonstrate minimal tearing of the joint capsule and ligaments. The A-C articulation appears normal on visual inspection. Grade 2 A-C separation demonstrates tearing of the capsule and A-C ligament along with some tearing of the coracoclavicular ligament. The distal portion of the clavicle may demonstrate slight elevation with associated swelling and point tenderness. Point tenderness will also be noted over the coracoclavicular ligaments. Further, pain is exacerbated with abduction of the arm. Grade 3 injuries demonstrate marked elevation of the distal clavicle. This injury demonstrates complete tearing of the capsule, A-C ligaments, and coracoclavicular ligaments. There is often damage to the deltoid and trapezius muscles (53). A Grade 4 type separation has been defined although it is very rare. This is a true posterior dislocation with tearing of all ligaments and buttonhole placement of the clavicle through the fibers of the trapezius muscle.

**Diagnosis.** The clinical presentation and plain film radiographs assist with the diagnosis. With Grade 1 type injuries, the plain film will be essentially normal. In Grade 2 separation, the stress radiograph will demonstrate elevation of the distal clavicle. In normal studies, the acromioclavicular articulations should measure 11 to 13 mm in width (16). A Grade 2 injury will have an A-C interval greater than 13 mm. A Grade 3 acromioclavicular separation will demonstrate a marked increase in the A-C interval. There will also be an increase in the coracoclavicular space. This is due to the disruption of the conoid and trapezoid ligaments.

**Treatment.** With Grade 1 A-C sprains, treatment should be focused on reducing the inflammatory response to the joint. Cryotherapy should be used on and about the injured joint. Further, stabilization of the joint can be enhanced by strengthening the anterior deltoid. Soft tissue mobilization, pain-free range of motion below 90° of shoulder abduction, trigger point therapy, and transverse frictional massage should be performed around the injured joint to minimize local adhesions.

Grade 2 separations can also be treated conservatively. The distal acromioclavicular joint will demonstrate subluxation in the superior direction. Applications of ice should be placed over the affected joint. After 20 minutes of cryotherapy, the distal clavicle can be adjusted in a superior to inferior direction. Once this procedure has been completed, the arm should be placed across the body and a Kenny/Howard splint applied. This splint provides vertical control of both the acromion and clavicle in achieving and maintaining reduction. If bracing is not available or desired the distal clavicle may be secured by use of athletic tape (Fig. 16.38A-B). The splint or tape should be worn for 2 to 4 weeks. The patient can be seen on a daily basis for 5 days to ensure proper alignment of the joint. Soft tissue mobilization, trigger point therapy and transverse frictional massage can also be applied to the affected area. Applications of electrical muscle stimulation can be performed on the anterior deltoit in a strengthening mode to help assist the clavicle in maintaining its proper position. Applications of ice should be used after each treatment program. During the second through fourth week of treatment, the patient may be given home exercises to further enhance strengthening of the anterior deltoit.

Taft et al. (52) found that most patients who have a Grade 3 injury can be treated nonoperatively, using a Kenny/Howard splint. The goal is to maintain the position of the distal part of the clavicle so that its distal edge is separated from the proximal part of the acromion by only 2 to 3 mm to minimize cosmetic deformity. The
splint is worn for 5 to 6 weeks to allow for sufficient maturation of the collagenous scar. This will prevent a latent increase in the deformity due to the weight of the arm (52). Surgical consultation should be considered if conservative measures fail.

Elbow

The humeroulnar and humeroradial joints, which are comprised osseously of the humerus, ulna and radius, make up two functional units: a uniaxial hinge (ginglymus) joint which permits flexion and extension and a trochoid joint which allows pronation and supination of the forearm and wrist. The trochlea of the humerus articulates with the trochlear notch of the ulna, while the capitulum of the humerus opposes the head of the radius (8,13) (Fig. 16.39A-C).

The elbow is enveloped in a fibrous capsule that attaches proximally to the humerus just above the olecranon and the coronoid fossa, distally to the ulna just behind the greater sigmoid notch, and to the neck of the radius and the lesser sigmoid notch. The capsule is thin, pliable, and redundant anteriorly and posteriorly to permit freedom during flexion and extension (8). The collateral ligaments are found on the inner and outer aspects of the capsule and provide stability by checking mediolateral motion. The collateral ligaments are divided into: 1) medial collateral (internal); 2) lateral collateral (external); and 3) annular ligaments (orbicular). The medial collateral ligament extends from the lower edge of the medial epicondyle and fans out to attach to the margin of the greater sigmoid fossa. The lateral collateral ligament extends from the lower edge of the lateral epicondyle and passes distally to blend with the annular ligament. The annular ligament is composed of transversely oriented fibers that encircle the radial head and attach to the radial notch anteriorly and posteriorly (8,13,16).

KINESIOLOGY

The axis of motion around which the elbow flexes and extends is represented by a line through the centers of the capitulum and the trochlea. With the forearm held in full supination, active flexion of the elbow is approximately 135° to 145°, whereas the range for passive flexion is 150° to 160°. Extension, both passive and active, is 0° (8,13).

Because the trochlea extends further distally than does the capitulum, the axis for flexion and extension of the elbow is not fully perpendicular to the shaft of the humerus. When the elbow is positioned in full extension, the forearm deviates laterally from the humerus. This angle of deflection is known as the Carry Angle. The average angle for the male elbow is 5° and for the female, 10° to 5° (10,11) (Fig. 16.40). Significant deviations of the angle are usually the result of epiphyseal injury or fracture malunion during bone maturation. Such deviations rarely result in functional abnormalities (26).

SUPERIOR AND INFERIOR RADIOULNAR JOINTS

The superior (proximal) radioulnar joint is contained within the capsule of the elbow joint and is described as a pivot (trochoid) joint. The circular head of the radius articulates with the radial notch of the ulna. Both the inner surface of the annular ligament and the head of the radius are lined with articular cartilage. The joint allows for supination and pronation of the forearm. Pronation of the forearm is 70° to 80°. Supination of the forearm ranges from 80° to 90° (8,13). The inferior radioulnar joint is composed of the ulnar notch of the distal radius, an articular disc, and the head of the ulna (Fig. 16.41). The disc is triangular in shape with its base at the ulnar notch and its apex attached to the styloid process of the ulna. The articular surface of the radius is concave. The radius, along with the wrist and hand, rotate around the head of the ulna.

RADIOGRAPHIC ANALYSIS

The standard radiographic series for the elbow is composed of three views: anteroposterior, lateral, and a tangential (Jones) projection (54). The anteroposterior view demonstrates the distal humerus, the proximal ulna, the proximal radius, as well as the elbow joint space. This view is used to rule out osseous fracture or dislocation and joint space abnormalities. The lateral projection is useful in the detection of fractures of the olecranon process, the
radial head, and the coronoid process. The Jones view is important in the detection of intraarticular loose bodies.

**Common Disorders of the Elbow**

**EPICONDYLITIS (MEDIAL AND LATERAL)**

**Definition.** Epicondyliotis designates a pattern of pain at the origins of either the extensors of the fingers and wrist on the lateral epicondyle of the humerus (tennis elbow), or the flexors on the medial epicondyle (little leaguer’s or golfer’s elbow) (55). The lateral epicondyle is said to be seven times more involved than the medial.

**Etiology.** Activities which require repetitive pronation and supination movements with the elbow almost fully extended are commonly present in the development of epicondylitis. Such activities include performing work with a screwdriver, hammer, lifting or ironing, or playing tennis or the violin (56).

Several pathologies have also been named with this condition: traumatic periostitis, arthritis, synovitis, sprain, adhesions of the radiohumeral joint, adhesions of the radioulnar joint, frayed or torn orbicular ligament, bursitis, tears of the extensor tendons and infection (56).

The various conditions on the lateral side which may
be labeled tennis elbow are: 1) true epicondylitis of the extensor supinator aponeurotic attachment to the lateral epicondy 1e; 2) radioulnar synovitis marked by development of a pannus of synovium between the radius and ulna; 3) strain in the aponeurosis itself, often directly over the radial head; and 4) radioulnar bursitis (29). Attending injuries to the lateral aspect of the elbow may also produce avascular necrosis and osteochondral fractures. Medial lesions may develop from strains from the origin of the wrist flexors, ulnar neuritis, or ulnar nerve entrapment.

Anatomic Considerations. Lateral lesions of the elbow are commonly related to macroscopic or microscopic tears in the extensor carpi radialis brevis or the common extensor origin (55). The medial lesions primarily involve the flexor carpi radialis, pronator teres and less commonly, the palmaris longus, flexor carpi ulnaris and flexor sublimis (29). In the young athlete, problems in this region may be related to an ununited epiphysis.

Symptoms. With lateral epicondylitis, pain is noted on palpation about the radiohumeral articulation and the lateral epicondy 1e. A persistent ache may also be noted throughout the joint. With medial epicondylitis, pain is noted primarily at the medial epicondy 1e and the origin of the wrist flexors. Activities which require grasping objects with the hand and pronating and supinating movements reproduce the symptoms.

Clinical Findings. The onset of symptoms is usually gradual. A persistent dull ache appears over the lateral or medial aspect of the elbow and may be referred into the forearm. The condition is exacerbated with movements requiring grasping and twisting motions of the hand and wrist. A well-localized point of tenderness exists at one of the following sites: the epicondylar ridge, the lateral epicondyle, the lower edge of the capitulum, the lateral radiohumeral interval, or the area overlying the radial head during rotation of the forearm (16). Digital palpation may reveal articular swelling and protrusion. The shoulder complex should also be evaluated because of its possible kinetic chain effect on the elbow.

Diagnosis. Motion of the elbow should be performed for all planes. In most instances, range of motion will be complete. Point tenderness may be noted with digital palpation over the radiohumeral articulation, the lateral epicondy 1e or the medial epicondy 1e. Hypomobility may be noted with compression, distraction and medial to lateral glide of this articulation. Grip strength should be noted bilaterally. Often, the affected limb will demonstrate weakness. Orthopaedic testing includes Cozen's, Mill's, and Kaplan's tests.

The cervical spine should also be evaluated for range of motion, fixation dysfunction, muscle tightness and tenderness, and nerve root irritation.

Plain film radiography of the elbow is usually normal; however, osteochondral fragments may be found. If the condition has been long standing, a periostis may be seen. As a rule, periostis is seen only after months or years of disability (56). With acute elbow conditions, especially after trauma, the radiograph should be inspected for a Fat

![Figure 16.40](image1) Carry angle and axis of rotation of the elbow joint. Modified from Lehmkuhl LD, Smith LK. Brunstrom's clinical kinesiology. Philadelphia: FA Davis, 1983:149.

![Figure 16.41](image2) Superior and inferior radioulnar joints. Modified from Warwick R, Williams P. Gray's anatomy. 35th British ed. Philadelphia: WB Saunders, 1980:465.
Pad sign. If present, either advanced soft tissue injury or fracture is present.

TREATMENT. It should be emphasized that tennis elbow is a common lesion which usually responds to conservative treatment (57). Initial management should include isolation of the joint fixation followed with manipulation. Before manipulative treatment it is often necessary to mildly mobilize or “pump” the articulation to increase joint mobility. Soft tissue mobilization and trigger point therapy should be performed over the medial and lateral epicondyles, the triceps, the biceps brachii, the brachialis, the brachioradialis, the wrist flexors, and the wrist extensors. Ice massage may be performed over the involved structures.

Rehabilitative exercises for the elbow include the following:

1. Wrist flexion, extension, supination, and pronation range of motion stretches.
2. Elbow flexion, extension, supination, and pronation range of motion stretches.
3. Wrist curls and reverse curls with wrist weights.
4. Elbow curls, reverse curls, thumb up and thumb down curls with wrist weights.
5. Squeezing a rubber ball.

Supporting the elbow with a neoprene sleeve is helpful and allows for rest of the joint. The condition should resolve within 4 to 6 weeks.

WRIST AND HAND

The wrist is composed of: (a) the distal ulna, (b) the proximal row of carpals consisting of the scaphoid (navicular), the lunate, the triquetrum, the pisiform, and (c) the distal carpal row comprised of the trapezium, the trapezoid, the capitate, and the hamate (Fig. 16.42). Discussions in this text, in regards to the wrist and hand, shall be limited to the radiocarpal joint, the midcarpal joint (the articulation between the proximal and distal rows of carpal bones), the carpometacarpal joints of digits II through V, and the carpometacarpal joint of the thumb.

RADIOCARPAL JOINT

The radiocarpal joint is classified as condyloid. The distal end of the radius is concave, and this surface articulates with a disc. Opposing the radius are the convex surfaces of the proximal scaphoid and lunate. Please note that neither the distal ulna nor the triquetrum possesses articular surfaces and is anatomically separated from the radiocarpal joint by the articular disc. Clinically, the lunate is found to be the most commonly dislocated or subluxated carpal bone while the scaphoid is the most frequently fractured carpal bone.


KINESIOLOGY

During flexion, the scaphoid and lunate glide posteriorly while in extension they slide anteriorly. Radial deviation primarily occurs as the distal carpals move on the proximal carpals. Ulnar deviation occurs predominantly as radiocarpal motion (8,13,58).

The normal ranges of motion for the wrist are as follows:

Flexion: 75° to 90°
Extension: 65° to 75°
Radial Deviation: 15° to 25°
Ulnar Deviation: 25° to 40°

MIDCARPAL JOINT

The midcarpal joint is the series of articulations located between the proximal and distal rows of carpal bones. It is not a true joint in terms of opposing uninterrupted articular surfaces and a joint capsule but rather a functional unit. Although small amounts of motion take place between the individual carpal bones, the majority of motion occurs at the midcarpal joint and consists primarily of flexion and extension.

CARPOMETACARPAL JOINTS OF DIGITS II AND V

The trapezoid, capitate, and hamate bones articulate with the proximal ends of the second through fifth metacarpals. Motion at these joints consists primarily of very limited amounts of flexion and extension as well as minimal amounts of rotation.
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CARPOMETACARPAL JOINT OF THE FIRST DIGIT

The trapezium articulates with the proximal end of the first metacarpal. The joint is classified as saddle type. The capsule is thick and strong yet loose, which permits a great deal of motion. Flexion ranges from 40° to 90°. The joint also allows a minimal amount of abduction and adduction.

RADIOGRAPHIC ANALYSIS

The standard radiographic series for the wrist and hand includes six views: posteroanterior wrist, posteroanterior wrist with ulnar deviation, medial oblique wrist, lateral wrist, posteroanterior hand, and the oblique hand. If it is desirable to evaluate the wrist or hand independently, only the pertinent views need be obtained.

Although all of the aforementioned radiographs are useful in fracture and dislocation detection, the posteroanterior ulnar deviation projection and the lateral wrist projection are especially helpful. The posteroanterior ulnar deviation projection can be used to better visualize scaphoid fractures by distracting the fragments and widening the fracture line (59). The lateral wrist projection aids in the visualization of the carpal bones and their positional relationship to the distal radius.

Common Disorders of the Wrist

CARPAL TUNNEL SYNDROME

Definition. Carpal tunnel syndrome (CTS) is a compressive neuropathy of the median nerve. The compression occurs over the volar aspect of the wrist.

Etiology. There are many causes of carpal tunnel syndrome. The most common though is a thickening of the flexor synovialis in the carpal tunnel as a result of nonspecific inflammation of the tendons (60). Current theory cites carpal bone fixation dysfunction (subluxation) as a possible cause of local nonspecific inflammation. Numerous other causes have been linked to carpal tunnel syndrome and include gout, calcium pyrophosphate dehydrate crystal deposition disease, hydroxyapatitite crystal deposition disease, acromegaly, hypothyroidism, amyloidosis, rheumatoid arthritis, ganglion cysts, neumomas and other tumors, infection, thrombosis of the median artery, fibrosis of the tendon sheaths, muscle and bone anomalies, hemorrhage, and fractures or dislocations of the wrist (26).

Carpal tunnel syndrome occurs more often in women, in a ratio of 5 to 1. The average age of onset is between 30 to 50 years. CTS can be aggravated by activities such as sewing, peeling potatoes, using wrenches or vibratory tools, performing repetitive wrist movements, and heavy manual labor (16, 61–64).

In most instances, the onset of CTS is insidious, spontaneous, and nocturnal (16).

Anatomic Considerations. The carpal groove is converted into an osseous fibrous carpal tunnel by a strong fibrous retinaculum attached to the bony margins (19). The tunnel transmits the flexor tendons and median nerve to the hand. Just proximal to the flexor retinaculum, the nerve is lateral to the tendons of the flexor digitorum superficialis but dorsal to the retinaculum. It is bound by the space in front of the retinaculum and behind the anterior surfaces of the carpal bones.

It is important to remember that the median nerve is responsible for most of the sympathetic nerve supply to the hand. This may explain the frequency of trophic disturbances associated with median nerve injury (16).

Clinical Findings. The initial onset may be a slight paresthesia which precedes the onset of the acute symptoms by several months. The paroxysms of pain, paresthesia, and numbness occur in the thumb, index, middle finger, and one-half of the ring finger (15). Atrophy and weakness may be seen in the thenar muscles.

The patient is commonly awakened after a few hours of sleep complaining of burning, aching, pricking, or pins and needles, and numbness in one or both hands (16). A deep aching sensation may be noted in the forearm, shoulder, and neck region. Difficulty may be noted with opposition of the thumb and fingers.

CTS usually develops in the dominant limb. Bilateral afflictions can occur and when this happens; it is usually first observed in the dominant limb.

Diagnosis. Physical examination will demonstrate a positive Tinel's sign (paresthesia noted over the distribution of the median nerve after percussion over the volar aspect of the wrist) and reproduction of pain and paresthesia with the Phalen maneuver (flexion of the patient's hand at the wrist for greater than one minute) (26). The flick sign has also been noted to be beneficial in the diagnosis of this condition. The flick sign is characterized by a flicking movement of the wrist and hand, similar to that used when shaking down a thermometer. In one study, the presence of a positive flick sign accompanied electrodiagnostic abnormality in 93% of the subjects (65). A nerve conduction study should be considered to aid in obtaining the definitive diagnosis. A pneumatic-tourniquet test can be performed by inflating a tourniquet about the upper arm to exacerbate the symptoms of carpal tunnel syndrome. The cuff is placed about the upper arm and inflated above the patient's normal systolic pressure. In normal patients, a tingling sensation develops in the entire hand and fingers over the ulnar aspect of the hand approximately 2 to 3 minutes after initiation; in patient's with carpal tunnel syndrome, tingling in the thumb, index middle and ring fingers develops within 30 to 60 seconds (66). This test is based on a transient ischemia to an already compromised median nerve. Sensory and motor
deficits can be determined by electromyelographic diagnostic studies.

Plain film radiographic evaluation will help rule out fractures, tumors, and arthritic changes. A carpal tunnel view will demonstrate the greater multangular, hook of the hamate, capitate and pisiform. The examiner should look for proper alignment of the tunnel as well as soft tissue or bony changes within the tunnel.

The role of MRI in the evaluation of CTS remains unclear at this time (67).

**Treatment.** Initially, all tasks requiring repetitive hand and wrist motion (especially extension) and equipment which causes excessive vibration to the hand and wrist should be modified or discontinued. If the offensive mechanisms are not modified, the condition could relapse or even progress into a reflex sympathetic dystrophy.

Fixation dysfunction of the radiocarpal, carpal, and carpometacarpal joints should be adjusted. Commonly present is anterior misalignment of the lunate, which approximates the tunnel, or separation of the distal radioulnar articulation, which subsequently stretches the transverse ligament thus compromising the carpal tunnel. The distal forearm, wrist, and hand may be supported in a cock-up splint. Rehabilitative exercises should include:

1. Active pain-free wrist range of motion stretches;
2. Grip strength increase with use of sorbothane hand exerciser performed with the hand positioned palm up, palm down, and thumb up;
3. Wrist curls, reverse curls, radial deviation, ulnar deviation, supination, and pronation with hand weights for 3 to 4 sets of 10 repetitions;

The patient should also be evaluated with regards to sleeping posture. It should be noted if the patient sleeps on the side with the arms above the head or on the stomach with the head turned sideways and the arms above the head. If either one of these sleeping postures is discovered, the patient must be instructed in proper resting posture.

Fixation dysfunction of the elbow should be adjusted. The cervical spine should also be examined for fixation-subluxations to help restore neural integrity to the upper extremity. It is commonplace to successfully treat CTS by means of conservative chiropractic cervical care.

Using an underwater technique, ultrasound may be applied to the volar surface of the wrist. Also, cryotherapy over the involved structures may be helpful.

**Hip Joint**

The hip joint is best described as a ball and socket joint. Unlike the glenohumeral joint, the hip offers a deep bony socket which encompasses the ball (head of the femur) constituting a very stable yet highly mobile articulation.

The bony components of the hip joint (articulatio coxae) include the spheroid-shaped head of the femur and the concave cup-like acetabulum which is formed by the union of three bones: the ilium, ischium and pubis. A horseshoe-shaped articular cartilage lines the roof of the acetabulum. The entire head of the femur is covered with articular cartilage.

The head of the femur projects from the femoral neck which angles anteriorly, superiorly, and medially, from its origin between the greater and lesser trochanters on the femoral shaft (8,13) (Fig. 16.43).

Three ligaments offer the majority of support to the hip joint: (a) iliofemoral ligament (Y-ligaments); (b) pubofemoral ligament; and (c) transverse ligament.

The iliofemoral ligament (IFL) is an inverted Y-shaped structure. It is the thickest and strongest part of the capsule. The IFL acts as the main stabilizer of the hip in the upright posture (Fig. 16.44). The blood vessels and nerves of the hip pass into the joint through the foramen inferior to the transverse ligament.

**KINESIOLOGY**

The hip joint offers three degrees of freedom: 1) flexion-extension, 2) abduction-adduction, and 3) internal-external rotation.

Flexion of the hip with the knee flexed may be continued until the thigh contacts the abdominal wall. When the knee is fully extended, tension produced by taut posterior thigh musculature limits hip flexion to approximately 75° to 90°. Extension of the hip is 0° to 10°.

Hip abduction is approximately 40° to 55° and adduction is 30° to 40°. External rotation is estimated to be 40° to 50° and internal rotation is 30° to 45° (8,13).

![Figure 16.43. Hip joint with the joint capsule. Modified from Warwick R, Williams P. Gray’s anatomy. 35th British ed. Philadelphia: WB Saunders, 1980:481.](image-url)
The osseous components provide very little in terms of stability of the knee joint. Strength and stability depends on the integrity of local muscles and ligaments.

The anterior cruciate ligament proceeds superiorly and posteriorly from its anterior medial tibial attachment and inserts on the medial side of the lateral femoral condyle. It stabilizes the knee in extension and prevents hyperextension, as well as limiting external rotation of the tibia on the femur, and anterior displacement of the tibia relative to the femur.

The posterior cruciate ligament originates from the posterior tibia and travels anteriorly, superiorly and medially to attach on the lateral surface of the medial femoral condyle. The posterior cruciate ligament restricts posterior displacement of the tibia on the femur as well as excessive tibial internal rotation (68).

Mediolateral stability of the knee is primarily offered by the medial (tibial) collateral ligament and the lateral (fibular) collateral ligament. The medial collateral ligament attaches to the medial aspect of the medial femoral epicondyle and inserts into the medial aspect of the proximal tibia. The lateral collateral ligament spans from the lateral epicondyle to the head of the fibula. The lateral collateral ligament has no attachment to the lateral meniscus and is separate from the joint capsule proper. Additionally, medial support is offered by the tendons of the semitendinous gracilis and sartorius. Lateral support is provided by the iliotibial band and the biceps femoris (8). The proximal tibia-fibular joint is an arthrodiad joint. The tendon of the biceps femoris attaches to the head of the fibula and is instrumental in providing lateral support to the knee (Fig. 16.45A-C).

KINESIOLOGY

Flexion of the knee ranges from 120° to 140°. During flexion, the femoral condyles roll and spin as well as slide
anteriorly. During extension from full flexion, the femoral condyles roll in an anterior direction while sliding posteriorly (8, 13) (Fig. 16.46).

Pure rolling and spinning are impossible because the femoral articulating surfaces are much longer in the sagittal plane than are those of the tibia. Further, because the medial femoral condyle is longer than the lateral femoral condyle, the knee externally rotates approximately 5° to 10° during full extension.

With the foot planted (closed kinematic chain), the spin of the femur on the tibia during the late stages of extension causes the femur to rotate medially on the tibia. This medial rotation brings the knee into a close-packed position and is appropriately termed the "Screw Home Mechanism." To unlock the knee, the femur must rotate laterally on the tibia.

In an open kinematic chain (foot not planted), the tibia rotates laterally on the femur to produce locking (close-packed) of the knee. Unlocking of the knee is brought about by medial rotation of the tibia on the femur.

The patellofemoral joint is comprised of the triangular patella and the central groove of the femur located anteriorly between the medial and lateral condyles. During flexion and extension the central ridge of the patella slides along the central groove. Both the posterior patella and the central groove of the femur are lined with articular cartilage. The posterior surface of the patella is divided into five regions or facets: superior, inferior, medial, lateral, and odd (8, 13).

During flexion, the patella slides approximately 7 to 8 mm inferiorly until it comes to rest on the inferior facet. In a closed kinematic chain, active flexion of the knee from 60° to 120° rotates the patella laterally and the lateral patellar facet is engaged. In active extension the patella slides superiority along the central groove until it assumes a position either laterally or incongruently in contact with the lateral aspect of the central groove, or centered in the patellar groove. The patella may come to rest in either place because of the considerable variation among individuals in the configuration of the patellofemoral joint.

During active rotation at the tibiofemoral joint in the opened kinematic chain, with the knee flexed to 90°, the patella rotates in the opposite direction to the femur. For example, when lateral rotation of the femur on the tibia occurs at the tibiofemoral joint, it is accompanied by medial rotation of the patella. That is to say that the apex of the patella moves toward the medial aspect of the tibia (8, 13).

The PTF joint is responsible for diminishing torsional stresses at the ankle, to decrease lateral bending of the tibia and to decrease weight-bearing torsion (69). The

**Figure 16.45A-C.** AP, PA, and superior to inferior views of the osseous and soft tissue components of the knee. Modified from

**Figure 16.46.** Movement of the knee during flexion and extension. Modified from Norkin CC, Levangie PK. Joint structure and function: a comprehensive analysis. Philadelphia: WB Saunders, 1983:299.

PTF joint moves superiorly and medially during ankle dorsiflexion; it moves inferiorly and laterally on ankle plantarflexion.

**RADIOGRAPHIC ANALYSIS**

The standard radiographic series for the knees requires two views: the weight-bearing anteroposterior bilateral knee projection and the lateral view (of the involved knee). The anteroposterior projection should be taken with the feet of the patient parallel and spaced approximately 6 to 8 inches apart.

A radiographic marking system is used to establish the relative alignment of the tibiofemoral joint. A line is drawn from a point in the center of the tibia approximately midshaft to a point in the center of the tibial plateaus. Another line is drawn from a point in the center of the femoral shaft to the center of the patella. Two additional lines are drawn on the inferior aspect of the femoral condyles (FCL) and the superior aspect of the tibial plateaus (TPL), respectively. These two lines should appear parallel. The femoral shaft line (FSL) and the tibial shaft line (TSL) should intersect one another at the joint line.

A wedging of the FCL and the TPL indicates a misalignment of the tibiofemoral joint. If the wedge is wider on the medial aspect of the joint, the medial side of the tibiofemoral joint is listed and denotes medial (M or internal-In) misalignment of the involved structure. If the wedge is wider on the lateral aspect of the tibiofemoral joint, the lateral side of the tibiofemoral joint is listed and denotes lateral (L or external-Ex) misalignment of the involved structure. The determination of whether to list the femur or the tibia is based on comparison of the involved structures and their contralateral counterparts. For example, if both tibiae appear symmetrical radio-

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graphically, whereas the femurs do not, the femur would be listed. If, however, the femurs are commensurable and the tibiae are not, the tibia would be listed.

The determination if rotational misalignment has occurred at the tibiofemoral joint requires comparisons of the FSL and the TSL. If when listing the femur, the FSL is positioned lateral to the TSL, the femur has rotated anteriorly on the medial aspect and the femur is listed anteromedial (AM or Aln). If the FSL is positioned medial to the TSL, the femur has rotated posteriorly on the medial aspect and is listed posteromedial (PM or Pln). If when listing the tibia, the TSL is positioned lateral to the FSL, the tibia has rotated posteriorly on the lateral aspect and is listed posterolateral (PL or PEx). Finally, if the TSL is positioned medial to the FSL, the tibia has rotated anteriorly on the lateral aspect and is listed anterolateral (AL or AEx) (Fig. 16.47A-B). The Gonstead listing protocol uses the In and Ex terminology to delineate the medial or lateral component of the misalignment. The authors have introduced the M and L terminology to more clearly depict the actual misalignment and to better correlate with recognized rotatory instability patterns of the knee.

Common Disorders of the Knee

ANTERIOR KNEE PAIN

**Definition.** In the past, anyone who came into the doctor’s office complaining of anterior knee pain and crepituation was diagnosed with chondromalacia patella. Although this type of differential diagnosis was fairly simple, it is obvious that such generalization does not allow for successful management. Patellar tracking disorders, patellar malalignment, patellalgia, patellofemoral arthralgia, chondromalacia patella, and runner’s knee are just a few of the terms used to describe a patient with anterior knee pain. More important in the diagnosis and treatment of a patient with anterior knee pain is the localization of the tissues or structures involved in the pathology. Basically, there are four general categories that encompass the many conditions that present with anterior knee pain (70). Patellar tracking and/or instability problems involve some sort of aberrant tracking or disrelationship of the patellofemoral joint. The second category is chondral and osteochondral disorders which include such conditions as osteochondritis dessicans or osteochondral fractures of the knee. The third category is soft tissue inflammatory disorders. These injuries involve pathologic soft tissue changes, specifically bursitis and tendinitis around the anterior knee. The last general category is traction apophysitis. This includes Osgood Schlatter’s disease, Larsen-Johansson disease, and bipartite patella. These are inflammatory conditions of tendons or fibrocartilage at their insertions into the bone.

**Etiology.** Patellofemoral tracking and instability-patellofemoral malalignment is a condition caused by excessive horizontal movement of the patella during knee flexion and extension due to an increased Q angle. With a Q angle greater than 15°, the excessive patellar motion begins to wear the undersurface of the patella (70). This condition, as well as other patellar tracking problems, is more common in females because of a wider pelvis causing an increased Q angle. It is also important to consider other structural variants that may affect the Q angle, such as foot pronation, femoral anteversion, In and/or Ex ilium, and coxa vara.

Lateral patellofemoral compression syndrome is caused by a tight lateral patellar retinaculum and a weak vastus medialis muscle which creates abnormal pressure on the patellofemoral joint (70). A tight iliobibial band (ITB) or tensor fascia lata may also contribute to patellofemoral compression syndrome. Femoral anteversion and hyperpronation are other structural abnormalities that may also contribute to patellofemoral compression syndrome (71).

Some tracking disorders can be the result of patellar instability. Subluxation or dislocation of the patella occurs with an acute twisting, jumping, or deceleration injury (70). Instability of the patella, as in patellar dislocation, has been associated with patella alta (72).

**Chondral and Osteochondral Disorders:** Chondromalacia patella, osteochondritis dessicans, and osteochondral fractures are the result of cartilage and subchondral bone destruction due to trauma or aberrant patellar tracking. Chondromalacia patella is the result of abnormal patellar tracking and is characterized by cartilaginous destruction and bone softening.

Osteochondral fractures usually arise from a fall on or blow to the knee. They often occur in motor vehicle accidents when the knee hits the dashboard (70).
Osteochondritis dessicans of the patella is a less common osteochondral disorder. It may be initiated by trauma, has an element of avascular necrosis, and is often associated with osteochondritis dessicans in other areas.

**Soft Tissue Inflammatory Disorders:** The main cause of inflammatory disorders to the soft tissue of the knee is overuse injury, but acute trauma is also possible. The primary conditions are quadriceps and patellar tendonitis, prepatellar bursitis (Housemaid’s knee), and pes anserine bursitis. Synovitis or an inflamed plica may also cause anterior knee pain.

Traction apophysitis disorders include Osgood-Schlatter’s disease, Larsen-Johansson disease, and bipartite patella. They usually occur in adolescents from overuse or direct trauma, which in an adult would ordinarily cause only tendonitis (70).

**Anatomic Considerations.** The clinical picture of anterior knee pain may involve chondral and osteochondral surfaces of the patellofemoral articulation, the patellar tendon, the suprapatellar, and prepatellar bursa, pes anserine bursa, or the osseous and muscular structures involved in the patellar tracking mechanism. Chondral and osteochondral surfaces of the patellofemoral joint are damaged by trauma or aberrant tracking of the patellar facets over the adjacent femoral joint surfaces. The most commonly injured tendons associated with anterior knee pain are the patellar and quadriceps tendons which endure much of the stress of the quadriceps mechanism.

The pes anserine and prepatellar bursas are most commonly implicated in anterior knee pain that involves micro or macro trauma. Occasionally, the ITB bursa may cause anterior knee pain, but more commonly the ITB is involved with muscular imbalance resulting in anterior knee pain. In adolescents, the site of the proximal and distal patellar tendon insertion to the bone can be susceptible to traction apophysitis. Similarly, the fibrocartilage that connects the area of incomplete fusion in bipartite patella may become inflamed. Abnormal patellar tracking or instability may be the result of several structural abnormalities. Aberrant tracking is the result of an increased Q angle. A wide pelvis (more common in females), femoral anteversion, coxa vara, genu valgum, and hyperpronation are some of the structural abnormalities that increase the Q angle. Another major factor in abnormal patellar tracking is muscular imbalance. Most often a weak vastus medialis muscle or hypertonic quadriceps, hamstrings, or lateral structures (e.g., tensor fascia lata, ITB, extensor retinaculum) increase stress on the patellofemoral joint (71). Also, gastrocnemius muscle tightness may affect the Q angle by increasing pronation of the foot (71). It is also important to consider the effect of functional limb length differences and pelvic obliquity on the Q angle and the musculature of the lower extremity.

**Symptoms.** The patient may report a traumatic event but often cannot relate the onset of symptoms to a specific incident. In cases of a traumatic event, severe pain, hemarthrosis, and inability to move the knee indicate possible osteochondral fracture. In cases of subluxation, giving way with pain, and effusion of the joint are common (70). Pain may be located behind or around the patella and inferior to the patella in conditions such as infrapatellar tendonitis and Osgood-Schlatter’s disease. Pain may also be referred to the posterior or medial aspect of the knee.

Soft tissue inflammatory conditions are usually the result of running, jumping, or some sort of overuse activity. Kneeling tends to increase anterior knee pain. The patient may also complain of pain while ascending and descending stairs, as well as with long periods of sitting, due to the increased tension on the patella. Crepitation or clicking sounds, especially when flexing the knee are a common complaint. Intermittent swelling (associated with bursa, tendon, or synovial irritation), muscular weakness (especially vastus medialis), and burning pain in the knee may also be present. It is very important to inquire about any trauma or associated symptoms of the lumbar spine and feet.

**Physical Examination.** The physical examination of the patient with anterior knee pain must include complete lumbopelvic, knee, and foot evaluation. The lumbosacral area is evaluated for evidence of local joint irritation and dysfunction (especially the upper lumbar) causing referred or radicular knee pain. In addition, the low back and hip area should be inspected for anatomic or functional abnormalities (e.g., pelvic obliquity, coxa vara, and femoral anteversion) which biomechanically increase stress at the patellofemoral joint due to muscular imbalance or an increased Q angle. The foot should be examined weight-bearing and nonweight-bearing to assess for hyperpronation. This exam should include at a minimum, static weight-bearing arch analysis, gait analysis, and subtalar joint function.

The knee examination must evaluate all of the tissues represented by the four general categories associated with anterior knee pain:

1. **Patellar Tracking Disorders:** Visual inspection of the knee may reveal structural abnormalities such as an increased Q angle, genu valgum, patella alta or baja, femoral anteversion or external tibial rotation associated with a "squinting" or medially rotated patella (73). Varying degrees of swelling are associated with tracking disorders but more commonly with tendonitis and bursitis. Palpation may reveal tenderness around the patella or a tight lateral retinaculum and iliotibial band (ITB). Ober's test is used to identify a hypertonic ITB associated with tracking disorders. Straight leg raising test may be decreased due to hamstring tightness. Passive knee flexion to 30° and lateral pressure on the patella may cause pain or apprehension (patellar apprehension test) (73). Pain with patellar compression, or apprehension with Clarke's test is indicative of a patellar tracking disorder; however, Clarke's test has a high false positive rate in asymptomatic individuals.

2. **Chondral and Osteochondral Disorders:** In osteochondral fractures, the patient has difficulty moving the knee. Swell-
ing, hemarthrosis, locking or catching may be visible (70). A positive Waldron's test demonstrates palpable clicking and pain during active squatting by the patient and is an indication of chondromalacia patella. Quadriceps atrophy, especially of the vastus medialis oblique muscle, is a common finding in tracking and osteochondral disorders.

3. Soft Tissue Inflammatory Disorders: Localized tenderness and swelling over inflamed bursae or tendons may help identify involved tissues. Swelling over the anterior patella indicates prepatellar bursitis (Housemaid's knee). Effusion may be present in cases involving synovitis (74). The pes anserine bursa and infrapatellar tendon are also commonly inflamed. Active and active resisted knee extension should produce pain due to the tension placed on an inflamed patellar tendon. Passive extreme flexion will also stress an inflamed patellar tendon as well as some of the bursae in the area.

4. Traction Apophysitis: Tenderness at the superior or inferior aspect of the patellar ligament where it inserts into the patella, or pain at the tibial tuberosity is an indication of Larsen-Johansson disease or Osgood Schlatter's disease, respectively. Palpable thickening of the inferior pole of the patella or the tibial tuberosity is also a sign of traction apophysitis. In cases of a symptomatic bipartite patella, tenderness and or swelling may be present directly over the patella.

**Diagnosis.** The differential diagnosis of a patient with anterior knee pain involves many conditions and requires a complete history and physical examination of the knee as well as the lumbar spine and foot. Plain film knee and patellofemoral views are important in ruling out fracture, arthritides, and in diagnosing chondromalacia patella. Also of use are bone scans which show increased uptake with chondromalacia patella. Osteochondral fractures may or may not be visualized radiographically, but osteochondritis dissecans is usually visualized as a loose fragment, which may not be displaced. The traction apophysitis may be visualized as a fragmentation at the tibial tuberosity in Osgood Schlatter's disease or an elongation of the inferior pole of the patella in Larsen-Johansson disease. Radiographically, bipartite patella demonstrates a lucent line dividing the patella into two pieces. The radiographs can also be used to determine a superior or inferior patella, as well as the patellofemoral index (74). Scout views of the lumbar spine and pelvis may be indicated to aid in the discovery of pelvic obliquity or other structural abnormalities.

**Treatment.** The initial goal of the treatment plan is to restore normal biomechanics to both the tibiofemoral and patellofemoral joints. Rotational misalignments of the femur or tibia may underlie symptomatology. Such dysfunctional conditions must be identified and remedied. A common finding with anterior knee pain is patella alta. Patella alta is accompanied by shortening of the rectus femoris muscle. Treatment should be tailored to lengthen the muscle. The application of hydrocollator packs directly over the rectus femoris while exerting a superior to inferior pressure to the patella initiates this lengthening process. After this procedure, ice is applied to the same region. This procedure should be repeated 3 to 4 times per day for 2 to 4 weeks. This procedure effectively alters the muscular length by means of plastic deformation. A neoprene knee sleeve with an inverted horseshoe pad may be worn to stabilize the patella.

Atrophy of the vastus medialis oblique may be present. If so, restoration of normal muscular girth is indicated. If there is limitation of knee extension, the patient should be instructed to perform quadriceps sets and straight leg raises to maintain and possibly increase quadriceps strength. As normal ROM is acquired, terminal knee extensions should be incorporated. This exercise consists of knee extension exercises on a knee extension weight bench. These extensions are limited to the final 30° of extension which is effective in strengthening the vastus medialis oblique. Any rehabilitative exercise program should be immediately followed by cryotherapy for a duration of 15 to 20 minutes. The avoidance of knee flexion beyond 30° is emphasized to avoid potential aggragation of the anterior knee by placing too much tensile and compressive load on the anterior knee as seen with increased knee flexion. Along this same line of thought, the patient should be instructed not to sit with the knee flexed beyond 30° for prolonged periods of time.

With Osgood Schlatter's disease, as with other anterior knee pain conditions, the patient should lessen the load or demand they place on the knees. Activities such as bicycling, stair climbing, and hiking should be avoided. With Osgood Schlatter's disease the use of a neoprene knee sleeve with a horseshoe pad placed at the inferior pole of the patella is suggested during symptomatic periods and during challenging activities.

The pedal foundation should be evaluated for, among other things, pes planus and hyperpronation. If such conditions exist, appropriate osseous adjunctive procedures should be incorporated. Occasionally the patient may require an orthotic appliance to normalize foot function.

**COLLATERAL LIGAMENT INJURIES**

**Definition.** The collateral ligaments of the knee act as prime stabilizers of the medial and lateral knee. Injury to the medial collateral ligament is the most common knee injury (75,76). Medial or lateral collateral ligament injury is usually associated with large amounts of valgus or varus force, resulting in partial or complete tearing and often involves injury to associated structures.

**Etiology.** Collateral ligament injuries most often occur in sports like football, hockey, or skiing, but minor sprains can occur from stepping into a hole, stumbling, or landing with the knee in a varus/valgus position.

Medial collateral ligament tears result from varus force to the knee. With the knee in slight flexion and the foot planted, isolated tears are more apt to occur.

Traumatic valgus force with the knee in full extension also results in capsular tears. If any knee rotation is pres-
ent, cruciate and meniscus injury is also possible (77). Lateral collateral ligament injury is far less common and results from a varus or abduction force to the knee joint. In addition, muscular imbalance may contribute to injury.

**Anatomic Considerations.** The medial collateral ligament is located superficially to the middle fibers of the medial joint capsule and attaches superiorly to the adductor tubercle on the femur and inferiorly to the medial tibia deep to the pes anserine bursa. The lateral collateral ligament runs from the lateral femoral condyle to the proximal fibula and is intertwined with the arcuate ligament complex. The proximity of the collasars to capsular ligaments and musculotendinous structures makes isolated injury uncommon.

**Symptoms.** Clinically, the patient reports traumatic varus or valgus injury to the knee. Inability to bear weight due to medial knee instability often indicates a Grade III tear (78). Initial ability to bear weight which later becomes impossible due to pain may indicate a Grade II tear (78). Medial or lateral knee pain and muscle spasm of varying degrees with little improvement after several weeks are the most prevalent symptoms. Mild swelling or synovial effusion is also possible. Early effusion or hemorrhosis is suggestive of cruciate or meniscal injury. Other clinical signs and symptoms often exist due to concurrent injury to the cruciates, menisci, or capsular ligaments.

**Clinical Findings.** Visual inspection of the knee may reveal swelling or effusion. Massive effusion or hemorrhosis indicates possible injury to associated structures. Tenderness to palpation over the medial or lateral collateral ligament helps to locate the injury. Palpation of the lateral collateral ligament is most easily performed with the knee in the Hardy position (79). In lateral collateral ligament tears, peroneal nerve dysfunction is possible (80). Therefore, foot drop and/or weak dorsiflexion or eversion may be present, indicating associated peroneal nerve damage. Active or passive knee flexion with rotation is painful. Also, the patient’s ability to actively flex the knee is decreased. The most clinically relevant orthopaedic tests are varus and valgus stress testing with the knee in varying degrees of flexion.

In full extension (0° of flexion), a valgus force that produces mild laxity indicates a complete medial collateral ligament tear as well as capsular sprain. A large degree of laxity with the knee in extension indicates medial collateral, capsular, and possible cruciate ligament injury (77,78). Valgus force with the knee in 15° of flexion indicates an isolated medial collateral ligament tear, Grade I, II, or III, depending on the extent of the laxity and the end-feel. A hard end-feel is indicative of ligament integrity, while an absent or mushy end-feel indicates anatomic or functional incompetence.

Lateral collateral ligament injury is detected with the varus or abduction stress test. A positive test is characterized by laxity with the knee in zero or 30° of flexion. The degree of knee flexion and the amount of laxity determines how the sprain is graded and is similar to the grading of medial ligament injuries. Manual muscle testing of the medial (vastus medialis, gracilis, sartorius, semimemembranosus) and lateral (iliotibial band, tensor fascia lata, biceps femoris, vastus lateralis) muscles may reveal weakness or pain. Because of the large percentage of concurrent injuries associated with collateral ligament tears, a complete orthopaedic examination of the knee with careful investigation of the cruciates, menisci, and associated capsular structures should always be performed. In cases of severe pain, effusion, or muscle spasm, stress testing under anesthesia may be necessary to evaluate true ligamentous injury.

**Diagnosis.** A diagnosis of collateral ligament injury is made with a complete history, including mechanism of injury, positive ab/adduction stress tests and possibly other positive orthopaedic tests in the presence of concurrent ligamentous injury. Plain film radiography should be performed to rule out fracture or other bony pathology (78). Plain film ab/adduction stress radiographs or arthrography are also helpful in making the diagnosis. A stress radiograph that demonstrates a 5-mm opening is indicative of a Grade I sprain, an opening between 5 and 8 mm classifies as Grade II, and greater than 8 mm a Grade III. The most important aspect in diagnosis and subsequent treatment of collateral ligament injuries is ruling out concomitant knee injury.

**Treatment.** Initial treatment should consist of bracing the injured knee to provide support and avoid any potential further injury. The biomechanics of the knee should be assessed and any detected dysfunctions should be corrected. The application of ice over the involved structures helps control inflammation. The application of microcurrent may help speed the recovery rate.

The patient should be instructed on isometric contractions of the quadriceps, hamstrings, hip adductors, and abductors. Passive and active range of motion exercises should be performed to pain tolerance. As ROM normalizes, the implementation of surgical tubing and isotonic weight exercises may be included. Optimally, the patient should be evaluated isokinetically to accurately assess the level of strength loss as compared with the uninvolved extremity. An appropriate exercise regime with realistic goals can then be prescribed.

As the patient approaches a return of complete strength, balance boards may be initiated to help restore normal proprioceptive response to the knee. Further, the patient may be instructed to run in large figure-of-eight patterns. These exercises should be performed slowly initially, with increasing intensity as the patient improves.

**CRUCIATE INJURIES**

**Definition.** An estimated 50,000 anterior cruciate ligament injuries occur during the winter ski season (81).
Although cruciate ligament injuries represent one of the most common traumatic injuries to the knee, their clinical diagnosis and treatment remain extremely difficult. Injury to the cruciate ligaments are classified as partial tears, complete midsubstance tears, or avulsion of the distal end of the ligament with an osseous fragment.

In chronic anterior cruciate laxity, the ligament may be completely intact but functionally incompetent resulting in an unstable knee. Midsubstance tears appear to be more common in adults whereas avulsion injury has a higher incidence in adolescents. (82)

**Etiology.** Cruciate ligament injuries are common in contact as well as noncontact sports. Downhill skiing and football seem to account for the most numerous occurrences of this injury.

Injuries to the anterior cruciate ligament (ACL) most commonly occur from a blow to the anterior knee causing forceful hyperextension, noncontact deceleration with internal tibial rotation, noncontact hyperextension, or a rapid change in direction (e.g., cutting). Injury to the ACL is the third most common of knee injuries.

The posterior cruciate ligament (PCL) may also be injured from a forceful hyperextension blow to the anterior knee. A fall on a flexed knee with a plantar flexed foot or blows to the tibial tubercle also damage the PCL. The speed of the incident and whether or not the foot was planted are essential in determining the degree of injury to the cruciates and supporting structures. When considering the mechanism of injury, it is important to remember that the ACL is susceptible to injury in both internal and external tibial rotation.

**Anatomic Considerations.** The ACL runs from the posterior medial side of the lateral femoral condyle inferiorly, anteriorly, and medially to attach to the tibia. The PCL travels from the medial femoral condyle anteriorly in an inferior, posterior and lateral direction to insert on the posterior tibia. The cruciates are surrounded by synovial tissue containing numerous blood vessels that branch off and supply the ligament. Interruption of this blood supply during injury greatly delays healing and is of importance during surgical repair. (83) The cruciates prevent translation of the femur and tibia on each other, as well as controlling the amount of rolling and gliding of the femur during flexion of the knee. During knee extension, the ACL prevents meniscal trapping by the femoral condyles and anterior translation of the tibia induced by quadriceps muscle pull. (84) Also of anatomic importance are the properly balanced cocontractile forces of the hamstrings and quadriceps muscle groups in reducing stress on the ACL and secondary joint restraints by drawing the tibia superior towards the femur. (84)

**Signs and Symptoms.** The patient suffering from an ACL injury may describe hearing a pop during the traumatic blow to the anterior knee or perhaps a sudden giving way or buckling after a jump, pivot, or quick change in direction. (82). If the ligament-damaging incident occurred a prolonged time before the patient reports for evaluation, they might complain of recurrent buckling, especially during athletics. Pain and swelling may or may not be present. The presence of pain with subluxation often indicates damage to the secondary restraints of the knee.

The most common complaint of a patient with PCL tear is pain with walking or ascending/descending stairs. Swelling, hemorrhrosis, effusion, and muscle spasm may also be present. The patient may also describe or demonstrate with the hands a sense of buckling or giving way.

**Clinical Findings.** With ACL injuries, effusion or hemorrhrosis of the knee joint may be visualized within 2 to 3 hours after injury. The most clinically relevant orthopaedic tests include the anterior drawer, Lachman’s, and pivot shift tests. A positive Lachman’s test produces anterior subluxation of the tibia on the femur with or without pain and is the most clinically useful test. The anterior drawer test may be falsely negative due to hamstring spasm or hemorrhrosis, which increases the stability of the joint with the knee in 90° of flexion. The pivot shift test is said to be positive when a palpable shift in the tibia is felt when internal tibial rotation, valgus stress and flexion movements are simultaneously created by the examiner. This test may also be falsely negative due to spasm or hemorrhrosis. It is important to examine the entire knee joint including the collaterals, menisci, and patellofemoral joint, as concomitant injury to these structures is not only possible but likely. Some have reported a 62% chance of meniscal damage with an ACL tear (85,86).

With the PCL patient supine and the knees flexed to 90°, the tibia on one side may appear to sag posteriorly (sag sign). In the same position, palpation of the joint line may reveal a less prominent tibial plateau medially and laterally which is analogous to the visual sag sign. The posterior drawer test may now be performed from this same position. With the foot in neutral or external rotation, a positive test is indicated by pain and laxity.

Posterior drawer testing with internal rotation of the foot is often falsely negative due to blocking by the posterior horn of the lateral meniscus and tightening of the ligament of Wrisberg. (87) Isolated PCL tears are rare and are most commonly associated with posteromedial instability (associated medial collateral ligament damage) and posterolateral instability (associated arcuate ligament complex damage) (88). Anterior drawer testing may reveal a “pseudo” laxity due to posterior subluxation of the tibia with an insufficient PCL. Abduction/adduction stress tests with the knee in full extension may demonstrate laxity indicating associated collateral ligament injury. With associated arcuate ligament complex injury, the external rotation recurvatum test demonstrates relative hyperextension and varus motion of the lateral aspect of the tibia with external tibial rotation.
Diagnosis. Early detection of ACL tears is crucial because chronic laxity predisposes the menisci, collateral ligaments, articular cartilage, and patellofemoral joint to damage (89). The most accurate objective test in the diagnosis of ACL tear is MRI. Plain film radiographs of the knee are important in ruling out tibial spine and osteochondral fractures, as well as growth plate injuries in adolescents. In cases of chronic instability, signs of degenerative joint disease (e.g., joint space narrowing, osteophytes, and subchondral sclerosis) may be present. Although MRI is a good objective test, a thorough history and physical exam coupled with clinical judgment are the most important factors in diagnosing ACL tears. If confusion still exists after examination and MRI, arthroscopy can be the most definitive means of determining the extent of injury and allows for immediate surgical correction (85). Nevertheless, because of the invasiveness of the procedure and its high cost, it should be recommended cautiously.

With PCL injuries, plain film radiographs may demonstrate posterior tibial translation, avulsion of the medial adductor tubercle, or normal findings (87). Medial joint degeneration is also a possibility. As with ACL injuries, a thorough history, examination, and plain film radiographs should be performed before resorting to more expensive tests such as MRI and arthroscopy.

Treatment. In general, as with other acute injuries, cruciate injuries are managed with the application of cryotherapy and other acute-phase therapeutic modalities. Immobilization of the knee should be instituted from 3 days to 2 weeks, depending on continued pain and inflammation (90). As with other injuries of the knee, biomechanical dysfunction should be assessed and corrected. Straight leg raises and hamstring sets should be implemented the first day after injury. The patient should be instructed to avoid weight-bearing activities until pain and inflammation subside.

Range of motion exercises such as swimming and bicycling should be incorporated 2 to 4 weeks post injury. As ROM improves the patient may begin strengthening the muscles of the involved extremity. ACL patients are required to strengthen knee flexors and hip extensors, whereas PCL patients should focus on increasing the strength of the knee extensors and hip flexors.

If a conservative treatment fails to provide adequate results in terms of knee strength, stability, or level of pain, an orthopaedic consultation is indicated for the purpose of possible surgical intervention.

MENISCAL INJURIES

Definition. The menisci of the knee joint act as shock absorbers, aid in nutrition, and help to lubricate or decrease friction in the knee joint. Injury to the menisci of the knee joint occurs as a tear in the cartilage.

The medial meniscus is injured three times more often than its lateral counterpart (68). A longitudinal or bucket handle tear in the medial meniscus and a transverse tear in the lateral meniscus are the most common types. Tears toward the ends of the menisci are called horn tears.

Etiology. The meniscus may be injured by noncontact compression and forceful rotation with the knee in flexion or extension (e.g., cutting on a planted foot), and/or a traumatic blow to the knee with the foot rotated. Injury of the medial meniscus is the most common knee injury. Anatomic Considerations. The medial meniscus is a “C” shaped fibrocartilaginous structure firmly attached at the circumference to the medial tibial plateau. It is comprised of a superior meniscofemoral portion and a lower meniscotibial portion. It is attached to the semimembranosus muscle, the medial collateral ligament, and the medial joint capsule by the coronary ligament (68).

The lateral meniscus is closer to an “O” shape, and its horns are firmly attached near the tibial spines. It also has attachments to the posterior cruciate ligament, popliteus muscle, and joint capsule, but is more loosely attached laterally than its medial counterpart. The loose attachment peripherally allows for a more mobile lateral meniscus which is the reason it is injured less often than the firmly attached medial meniscus.

Functionally, the menisci move anterior during knee extension and posterior during knee flexion, avoiding pinching of the femoral condyles. Rotation with sudden flexion or extension of the knee may pinch the menisci between the femoral condyles causing a tear. Also of anatomic importance is the relative avascularity of the menisci. The horns, central zone, and outer portions are the most vascular areas (91).

Symptoms. Because of the relative avascularity of the menisci, the severity of injury cannot be graded by the degree of pain. Most of the symptoms of meniscal injury are actually caused by a synovial reaction rather than the tear itself (68). The patient may experience severe pain immediately and be forced to stop the activity. A feeling of tightness in the joint due to effusion without any pain may be the only complaint. Immediate hemarthrosis is possible and suggests injury to the surrounding capsule or the cruciates. Clicking, buckling, and intermittent joint locking may also be involved in the symptom picture. It is important not to rule out meniscal tear in the absence of locking because many knees never lock (63).

Clinical Findings. Visual inspection findings vary from mild or no swelling to massive effusion or hemarthrosis. In the latter, it is important to include capsular and cruciate ligament tests as these structures are likely to be injured with this clinical finding. The knee may demonstrate a midflexed position due to reflex inhibition of the quadriceps mechanism or to facilitate maximal capsular effusion. Depending on the chronicity of the injury,
atrophy of the quadriceps will be measurable and probably visible.

It follows that active or passive extension in this individual will increase pain. Passive extension is equivalent to a bounce home test, and a springy block indicates possible meniscal tear.

Lateral meniscus injuries show lesser degrees of effusion because of their decreased peripheral attachments. Joint line tenderness is often present in meniscal injury. Important orthopaedic tests in the diagnosis of meniscal injury are McMurray’s, Apley’s, and Steinman’s. Steinman’s tenderness displacement test is positive for meniscal injury when anterior joint line tenderness with the knee extended moves posteriorly when the knee is flexed and is a good differential test for degenerative joint disease of the knee (78). Apley’s test with compression and rotation will produce pain and possibly clicking with a meniscal tear, whereas pain with distraction is indicative of capsular or ligamentous injury. McMurray’s test is probably the most widely used test in detecting meniscal injury; however, it is not sensitive enough to detect tears of the anterior one-third of the meniscus (68). A positive test is indicated by clicking/snapping and possibly pain when the examiner takes the knee from flexion towards extension and applies varying amounts of varus/valgus and internal/external rotation forces. O’Donoghue’s test and the modified Helfet test may also be positive as well as capsular and cruciate tests with concomitant injury. In addition, supporting knee musculature may be weak, painful, or atrophied.

Diagnosis. History and physical examination are often enough to make the diagnosis of meniscal tear but may be less clear when adjacent knee structures are simultaneously injured. Differentials in a knee that clicks include osteoarthritis, chondromalacia patella, and a tight hamstring tendon. For optimal treatment, concomitant cruciate or capsular injury must also be ruled in or out.

Plain film radiography helps to rule out fractures, osteoarthritis, and chondromalacia patella. MRI and especially arthrography, aid in determining the extent and location of injury. Arthrography is also useful in detecting discoid menisci. These are normal variants that may be induced by trauma. Clinically, there may be snapping or locking, and an arthrogram may demonstrate a large joint space with a large thick meniscus (92).

Treatment of meniscal tears remains controversial. The conservative treatment of incomplete or partial tears varies. In the asymptomatic or sedentary individual, periodic monitoring and symptomatic treatment, such as cryotherapy and rest, are all that may be indicated. Even in more substantial meniscal tears, surgery may not be performed and the conservative route taken. Initially, the doctor should evaluate the knee for femoral or tibial subluxation and if present, adjunctive correction should be performed. Standard acute injury therapeutics such as cryotherapy, compression, and protective bracing should be implemented. Quadriceps and hamstring sets may be performed immediately after injury. Standard lower extremity strengthening should be initiated when ROM increases and pain and inflammation subside.

Because clinical results can vary greatly from individual to individual, the patient should be advised of other potential treatment options. The age, activity level, and possible presence of rotatory instability are important considerations when pondering possible surgical referral.

PLICA SYNDROMES

Definition. Synovial plica of the knee have been reported in the literature to have an incidence of 18 to 60% in the general population (93). The broad use of nonspecific terminology and the failure to describe a distinct clinical picture are some of the reasons the diagnosis of synovial plica syndrome remains difficult.

The following use of the term plica syndrome or synovial plica refers to a clinically symptomatic knee and not merely to the presence of abnormal capsular thickening.

A synovial plica exists as an abnormal folding and thickening in a portion of the knee joint capsule due to a failure of complete involution of the embryonic septae (94–95). The fact that the symptomatic plica may mimic other knee disorders also makes diagnosis difficult.

Etiology. The synovial plica syndrome may be the result of direct trauma to the knee or an overuse type injury triggered by an increased training schedule or the high demands of competition (96). With an injury, the nonsymptomatic synovial plica becomes inflamed and edematous. Synovitis may develop, leading to fibrous tissue replacement, resulting in a thickened inelastic plica that snaps over the femoral condyles with knee movement. At this point the plica is symptomatic and the synovitis has the potential to erode the articular cartilage or the inferior surface of the patella producing chondromalacia (96).

Anatomic Considerations. There are three main types of synovial plica that vary in size, shape, and location, but all are named for the embryonic tissue from which they arose. In descending order of their frequency, they are the medial patellar, suprapatellar, and infrapatellar plica. The medial patellar plica is located in the medial knee joint capsule, parallel to the patella, and inserts into the synovium that covers the infrapatellar fat pad.

The suprapatellar plica also known as the “plica synovialis suprapatellaris” may exist as a plica that forms a compartment distinct from the rest of the joint, a septae with a small hole in it, or a fold inferior to the quadriceps tendon that inserts distally into the medial capsular wall (97–98). The asymptomatic forms of these plica appear thin, pink, and elastic, whereas the symptomatic plica are thick, white, and fibrotic (96).

The infrapatellar plica courses anterior to the anterior
cruciate ligament (ACL) and inserts over the infrapatellar fat pad distally. The infrapatellar plica is not responsible for the plica syndrome but can make diagnosis or treatment more difficult by obstructing the arthroscopic or mimicking an intact ACL in the presence of complete ACL injury (98).

**Symptoms.** The clinical picture of a patient with plica syndrome is highly variable and mimics many conditions. Symptoms occur at any age but are most commonly found in adolescence. The patient may complain of stiffness or an achy knee that simulates an osteoarthritis condition. Many of the patient’s symptoms are often worsened with activity. For example, the patient may complain of increased pain, swelling, or snapping after running, jumping or other forms of exercise. The plica syndrome is often exacerbated by ascending or descending stairs, because the large degree of flexion and extension increases capsular stress and deformation. In addition to snapping, the patient may complain of intermittent instability, another symptom mimicking meniscal injury. The patient may also describe a feeling of the patella catching during knee flexion or extension. Finally, the patient may complain of pain after long periods of sitting, mimicking the “theatre sign” associated with chondromalacia patella.

**Clinical Findings.** Because of the syndrome’s ability to mimic many disorders of the knee, the importance of careful orthopaedic examination to detect synovial plica syndrome cannot be overemphasized. With a long-term plica syndrome, quadriceps atrophy may be present (96). On history, or during the exam, the presence of increased pain after performing resisted knee extension implicates plica syndrome. Tenderness to palpation, and sometimes thickening over the medial femoral condyle or the medial or lateral aspect of the superior pole of the patella, helps to localize the plica. In addition, the location of the pain aids in differentiating meniscal injury which is associated with joint line tenderness. This is important because Apley’s and McMurray’s tests are often found to be positive in synovial plica syndrome in the absence of meniscal injury. Nevertheless, careful localization of the pain will demonstrate that it is above the joint line (99). A positive plica stuffer test is characterized by a palpatory jumping or stuttering of the patella between 60° and 45° when the knee is actively extended (73). In the presence of effusion, however, which is not common, this test may be falsely negative. Pain with patellar compression or passive medial movement of the patella (mediopatellar plica test) may be present in plica syndrome. The positive test is the result of the plica being pinched between the patella and the femoral condyle. Hughston’s plica test is similar to the stuffer test, but the leg is medially rotated and medial pressure is applied to the patella (73). A positive test is indicated with palpatory popping over the femoral condyle caused by the synovial plica.

**Diagnosis.** The diagnosis of synovial plica syndrome of the knee is one of exclusion and is usually made with the history, examination, and arthrography. Differential diagnoses include meniscal injury ruled out by location of the pain, osteoarthritis ruled out by history, physical exam and x-ray, inflammatory conditions such as rheumatoid arthritis which may actually cause plica syndrome ruled in with laboratory findings, chondromalacia patella demonstrated by x-ray studies, and chronic internal knee disorders such as cruciate or capsular injury detected by history, physical examination, and special tests. Plain film radiographs are usually negative in plica syndrome, but again, aid in differential diagnosis. Arthrography and fluoroscopy are the best objective tests used to visualize synovial plica; however, the finding of a synovial plica in an asymptomatic individual is not clinically significant (100).

**Treatment.** Treatment of a patient suffering from plica is aimed at minimizing inflammation and increasing the flexibility of the plica. Rest or abstaining from activities that require large ranges of knee flexion and extension may help prevent inflammation. Ice massage can aid in the reduction of inflammation. Underwater ultrasound, as well as transverse frictional massage are used to decrease local adhesions and increase the pliability of the plica. Stretching the hamstrings and quadriceps may also decrease symptoms. Quadriceps strengthening by means of terminal leg extensions (extension of the knees through the final 30° of extension) and quadriceps sets (isometric contractions of the quadriceps) to reduce compressive forces on the patella and anterior knee.

Further, the femorotibial joint should be analyzed for fixation dysfunction, and if present, corrective surgery should follow. If conservative treatment is unsuccessful, arthroscopic removal of the plica should be considered.

**Rotatory Instability of the Knee**

**Definition.** Rotatory instability to the knee has become one of the most complex knee problems because it is usually misdiagnosed and is therefore mistreated. It often coexists with other knee injuries but goes undiagnosed in the acute stage, thus resulting in a chronic unstable knee. Rotatory instability of the knee joint most commonly exists as anteromedial rotational instability or posterolateral rotational instability but is possible in other directions. Anteromedial rotational instability is the result of damage primarily to the medial capsular ligaments but may involve damage to the vastus medialis retinaculum, anterior cruciate ligament (ACL), or medial meniscus (101). Posterolateral rotational instability results in posterior subluxation of the lateral tibial plateau with combined external tibial spine rotation in the absence of posterior cruciate ligament (PCL) injury (102). The instability is the result of injury to the arcuate ligament complex. Concurrent distal biceps femoris tendon or iliotibial band injury may be present (102).
**Etiology** Anteromedial rotatory instability is created by a valgus force to the knee. The degree of knee flexion determines which portion of the medial capsular ligament will be injured. The less the amount of knee flexion, the greater the risk of extracapsular ligamentous injury (e.g., ACL, tibial collateral, medial meniscus). A varus force directed posterolaterally, contact hyperextension, and noncontact hyperextension with external tibial rotation result in posterolateral rotational instability.

**Anatomic Considerations.** Because rotational instability involves more than one plane of motion, several ligamentous structures must be taken into account. Postero-lateral stability is provided mainly by the arcuate ligament complex, comprised of the lateral head of the gastrocnemius muscle, popliteus tendon, lateral collateral ligament, and the arcuate ligament (103,104). The biceps femoris muscle or iliobibial band may also be important, depending on the degree of knee flexion. The medial side of the knee is stabilized primarily by the various portions of the medial capsular ligament. The anterior portion of the medial joint capsule and the vastus medialis retinaculum help prevent anteromedial instability. The middle or deep portion of the medial joint capsule (meniscofemoral/tibial ligaments) and the coronary ligament also help prevent rotatory instability of the medial knee. The cruciates and menisci also provide rotational support to the knee. Functionally, the collaterals are looser, allowing for increased tibiofemoral rotation when the knee is flexed.

**Symptoms.** The patient with rotational instability of the knee will probably report a past history of trauma that was either surgically or nonsurgically treated but continues to give them problems. The patient most commonly reports a feeling of giving way, especially into hyperextension, rather than pain. Climbing stairs or cutting maneuvers are very difficult. Knee joint line tenderness is a common complaint. With posterolateral rotatory instability, medial joint line tenderness is more common, leading the clinician to a misdiagnosis of medial meniscus tear (105). The patient with posterolateral instability may present with foot drop or sensory changes of the anterolateral lower leg and foot from peroneal nerve damage.

**Clinical Findings.** On physical examination of the knee, joint line palpation may reveal medial or lateral tenderness, as well as a tender arcuate ligament complex. The posterolateral tibia may be more prominent on palpation. A careful orthopaedic examination that stresses multiple structures is essential in formulating a correct diagnosis of rotational instability. A positive lateral pivot shift test (Test of MacIntosh) reproduces the giving-way sensation described by the patient and indicates anterior rotational instability (73).

The posterior medial and lateral drawer test, performed with the foot in internal and external rotation respectively, is indicative of posterior rotatory instability when laxity is present. The reverse pivot shift test (Jakob's test) is also used to detect posterior rotatory instability.

Visual inspection of the patient standing or walking may reveal a hyperextended genu varus or externally rotated tibia if posterolateral instability is present. This knee position is also reproduced by the external rotation recurvatum test. A positive abduction stress test at 0° and 30° of knee flexion also indicates posterolateral instability. Rotational instability of the knee can result in tibiofemoral misalignment with fixation. Static observation may reveal the tibiofemoral misalignment. Motion palpation of the joint line should be performed with the patient sitting and the knee flexed. The tibia is internally and externally rotated by the examiner, and tibiofemoral motion is compared bilaterally.

Motion palpation of the tibiofemoral joint is also performed by stabilizing the patient's foot with the examiner's feet and applying light ab/adduction forces with the fingers in the joint line on the medial and lateral side. Restricted motion or fixation on the medial or lateral side, compared with the opposite extremity, corresponds with anterior or posterior medial/lateral instability, respectively. For example, with posterolateral instability one might expect to find fixation in the lateral tibiofemoral joint with posterior rotation or misalignment of the tibia on the femur.

**Diagnosis.** The aforementioned orthopaedic tests are representative of the more common stress tests for rotational instability of the knee. Furthermore, rotational instability of the knee is rarely the result of a single ligamentous injury. Differential diagnosis includes cruciate, meniscal, iliobibial band and biceps femoris tendon injury. A thorough history and comprehensive examination that tests capsular ligaments as well as the cruciates, menisci, and musculotendinous components of the knee are imperative for proper diagnosis and treatment.

Plain film radiography, including an anterior-posterior bilateral weight-bearing knee film, is sometimes helpful in determining tibiofemoral misalignment. MRI or arthrogram may be necessary to determine cruciate or meniscal injury.

**Treatment.** Conservative treatment of rotatory instability of the knee initially involves correction of any subluxated and dysfunctional osseous component. When correcting tibial or femoral subluxations, it is important that the doctor contacts along with the segmental contact point the joint line and underlying meniscus. Cryotherapy should be implemented to control inflammation, especially after activity. The use of a derotation brace limits possible aggravating positions. Standard strength and flexibility rehabilitation of the involved extremity should include:

1. Full ROM hip, knee, and ankle static stretching;
2. Isotonic quadriceps and hamstring exercises;
3. Forward step-ups;
4. Lateral step-ups;
5. Bicycling;
6. Rope jumping;
CHAPTER 16: EXTRAROTEREBRAL DISORDERS: UPPER AND LOWER EXTREMITIES

7. Walking; and

The patient should demonstrate a positive response to conservative treatment within 4 to 6 weeks (8–12 treatments). Failure of conservative treatment requires referral for outside consultation and possible reconstructive surgery.

ANKLE

The ankle and foot form a complex comprised of some 28 bones and 35 articulations. Because of the complexity and number of articulations, this discussion will be limited to the major joints of the region.

The ankle is a mortise-type joint that is formed by the distal fibula, distal tibia, and proximal talus. The tibia is concave anterior to posterior and flat along the medial malleolus. The fibular surface is flat as well. The talar surfaces are convex anterior to posterior and flat on both the medial and lateral sides. The dome of the talus is wider anteriorly more than posteriorly. This renders the ankle joint less stable in plantarflexion (13) (Fig. 16. 48A-B).

During ankle plantarflexion, the talus glides anteriorly. Dorsiflexion causes the talus to glide posteriorly. Ligaments, as well as bony configurations, are instrumental in guiding and controlling motion at the ankle joint. There are three master ligaments on the lateral side of the ankle which are called to attention:

1. The anterior talofibular ligament originates at the anterior portion of the fibula and attaches to the lateral head of the talus. It is the most commonly sprained ligament in the body, and during plantarflexion, it becomes taut and resists inversion.

2. The calcaneofibular ligament attaches the distal tip of the fibula to the calcaneus and further aids in resisting inversion of the ankle joint. It is stronger than the anterior talofibular ligament but still is commonly injured.

3. The posterior talofibular ligament runs from the posterior tip of the fibula to the posterior calcaneus. This structure offers mild stabilization during ankle inversion (8, 13) (Fig. 16.49A-C).

Medially, the ankle is supported by a fan-shaped group of ligaments collectively known as the deltoid ligament. This structure runs from the medial malleolus to the navicular talus and calcaneus. Also known as the medial collateral ligament of the ankle, it is very tough and stabilizes the ankle in eversion.

The ankle joint is a uniaxial joint consisting of plantarflexion and dorsiflexion. Normal ranges of motion are 30° to 50° for plantarflexion and 15° to 20° for dorsiflexion (8,13).

Common Disorders of the Ankle

ANKLE SPRAINS

Definition. The sprained ankle is the most common extremity injury that primary care providers encounter in practice. It ranks second for causing the greatest number of days lost from work (106). For such a common injury, there is still a great deal of confusion and disagreement regarding evaluation and treatment. An ankle sprain is defined as a tear to one or more of the ligaments that stabilize the ankle and can be graded from I-III depending on the severity of the tear. A lateral or inversion sprain is the most common (85%) and is named because of the position of the foot during injury. Medial ligament or eversion sprains are much less common and rarely occur by themselves (107).

Etiology. Inversion ankle sprains most commonly occur in sports like basketball, tennis, volleyball, and football, because there is a great deal of cutting and jumping. The injury occurs when the individual plants the foot to change directions and the weight of the body forces the foot into inversion thereby allowing the individual to roll over onto the foot. This same mechanism occurs after landing on an uneven surface such as another individual's foot.

The eversion sprain is far less common and when it occurs is often associated with distal fibula fractures. Damage to the medial ligaments of the ankle is usually associated with eversion and external rotation of the firmly planted foot.

Anatomic Considerations. An inversion sprain results in damage to the ligaments located on the lateral side of the ankle. The anterior talofibular ligament, either singularly or in conjunction with the calcaneofibular ligament, is the most frequently damaged ligament. These ligaments prevent excessive inversion of the talus. In more severe inversion sprains, the posterior talofibular ligament is involved. With extensive capsular tears, the talus dislocates or subluxates to the anterior and lateral (108). In the absence of subluxation, the ends of avulsed
Figure 16.49.  
ligaments remain in close proximity to allow for good healing.

Eversion sprains involve injury to the ligaments on the medial side of the ankle joint. The medial collateral ligament of the ankle is made up of the deltoid ligament, which is actually four separate ligaments. It connects the tibia to the navicular, calcaneus, and the talus anteriorly and posteriorly. The deltoid ligament is one of the strongest ligaments in the body. Because of this, fracture of the distal fibula often occurs before the deltoid ruptures. The tendon of the tibialis posterior muscle runs superficial to the deltoid ligament and may be injured with an eversion sprain (108).

Also of anatomic importance are the tibiofibular syndesmosis, calcaneocuboid joint, peroneus muscles, and the nerve fibers that control ankle joint proprioception.

**Symptoms.** The patient with lateral ligament injury will report sudden ankle inversion with pain and possibly a popping sound. With mild sprains, and some moderate ones, the patient will be able to continue the activity with varying degrees of pain. After completing the activity, and on removal of the shoe, the ankle begins to swell rapidly. As the swelling increases, the pain may become more severe and is usually located at the lateral or anterolateral aspect of the ankle. The function of the ankle joint decreases with increased swelling and the patient may be unable to bear weight on the ankle because of pain or instability.

The patient with medial ankle pain describes an eversion injury such as catching a cleat while sliding. The injury is often severe and the patient is unable to continue activity because of pain. The injury is often associated with distal fibular fracture and significant tibiofibular ligament injury in addition to the deltoid ligament components (109).

**Clinical Findings.** The most common clinical finding is swelling on the lateral side of the ankle under the distal fibula and just anterior to it. With more severe sprains the swelling also encompasses the medial ankle around the medial malleolus. Varying degrees of ecchymosis will be visualized, depending on how soon the patient is seen after the initial injury.

Palpable tenderness around the distal fibula is almost always present and is the result of damaged anterior talofibular and calcaneofibular ligaments. Eversion injuries present with tenderness over the deltoid ligament. The distal tibia and fibula should be palpated, as well as the base of the fifth metatarsal, to rule out possible fracture. Active range of motion of the ankle varies from full in mild injuries to highly decreased in severe injuries. The most clinically relevant orthopaedic tests for inversion sprains are the anterior drawer and talus tilt test. The patient should be observed weight-bearing with the eyes open and closed to assess ankle stability and possible proprioceptive interruption (73,110). Resisted muscle testing, especially of the peroneals (inversion sprain) and the tibialis posterior muscle (eversion sprain) should be performed. Finally, the talus, calcaneus, navicular, and cuboid should be palpated for misalignment and fixation. The presence of fixation, especially in inversion sprains, significantly decreases the function of the ankle joint and may be a major contributor to the altered proprioception associated with chronic inversion sprains. The most common fixation/misalignment patterns associated with inversion sprains are an anterolateral talus, an inferior and externally rotated cuboid (referring to the plantar aspect), a posterior or anterior and inferior calcaneus, and a medial inferior navicular.

Based on symptomatology and clinical findings the sprain may be classified as mild, moderate, or severe (Grades I, II, III). A Grade I sprain involves minimal pain and swelling, full range of motion (ROM), and no instability. A Grade II injury is characterized by moderate pain and swelling, decreased ROM, difficulty bearing weight, and a mild anterior drawer test. Grade III inversion sprain is characterized by a positive anterior drawer and talar tilt tests, a high degree of instability, and more severe pain and swelling. It is important to note the same classification can be used with medial ligament injuries as well.

**Diagnosis.** The diagnosis of an inversion or eversion sprain is fairly easy; however, assessing the degree of injury and all of the involved tissues is more difficult. The determination of the severity of the injury is essential for successful treatment. The differential diagnosis of ankle sprains includes fibular, proximal fifth metatarsal, and osteochondral dome fractures, as well as osteochondritis desiccans of the talus, and subluxation of the peroneal tendons.

Plain film radiographs are indicated in all but the most minor cases of ankle sprain. The films should include the distal tibia, fibula, and the base of the fifth metatarsal, as these areas may be fractured. The doctor must examine the films for focal soft tissue swelling or periosteal reaction over the distal tibia or fibula. Stress views of the ankle can be taken and compared bilaterally to assess the degree of instability. No normals have been established, however, and the views may be limited by pain, spasm, or swelling (110). Because many ankle ligament tears are midsubstance, plain films are not useful in detecting complete tears in the absence of avulsion. The use of arthrography may be helpful but becomes less valuable if it is not performed immediately (111).

**Treatment.** The Doctor of Chiropractic can manage both Grade I and Grade II injuries. Grade III injuries are generally referred for surgical consultation. The first and foremost goal when treating ankle sprains is controlling inflammation. Hourly ice bath submersion for 20 minutes along with compression and elevation are indicated until the acute inflammatory phase passes (24 to 96 hours). With severe sprains, the patient should avoid weight-bearing until pain permits. The use of crutches may be required for up to 2 weeks. The patient must be evaluated for lower extremity osseous subluxation/dysfunction and if present, these conditions must be cor-
rected as soon as possible. Most commonly, the patient suffering from an ankle sprain will present with concomitant subluxation of the talus, cuboid, navicular, calcaneus, distal tibiofibular articulation, or proximal tibiofibular articulation. As weight bearing becomes possible, the use of protective taping or bracing (i.e., lace-up brace or air splint) is indicated. When pain and inflammation diminish satisfactorily, a standard ankle rehabilitation program can be implemented:

1) ROM exercises:
   a. Toe gripping and spreading
   b. Writing alphabet with foot
   c. Ankle circumduction
   d. Towel exercises
2) Strengthening exercises:
   a. Manual resistance
   b. Toe raises
   c. Heel raises
   d. Wobble board
   e. Rope jumping
   f. Walking/jogging
   g. Figure of eight jogging

Return to activity is possible only in the absence of pain and inflammation and the patient’s ability to perform all of the rehabilitative exercises satisfactorily.

FOOT

The foot is divided into three distinct regions: The hindfoot, the midfoot, and the forefoot. The hindfoot is comprised of the talus and calcaneus. The midfoot consists of the navicular, the cuboid, and the three cuneiforms. The forefoot is made up of the metatarsals and phalanges (Fig. 16.50A-B).

The bones of the foot form three arches (the medial longitudinal, the lateral longitudinal, and the anterior transverse) that allow it to absorb shock and adapt to varying terrain during the stance phase of the gait cycle.

Within the inferior surface of the hindfoot region, the articulation between the inferior surface of the talus and the superior surface of the calcaneus is known as the subtalar joint. This joint is considered the keystone of the foot because much of the motion of the entire foot and lower leg are dependent on its normal functional capacity. An interosseous ligament which connects the calcaneus and talus lies in the trumpet-shaped canal formed by the two bones known as the sinus tarsi. The talus articulates with the calcaneus by posterior facets on the superior surface of the calcaneus and inferior surface of the talus; a middle facet on the superior aspect of the sustentaculum tali of the calcaneus articulates with a middle facet on the inferior surface of the talus; an anterior facet on the superior calcaneus articulates with an inferior facet at the level of the talar neck. The subtalar joint allows the talus to rock into an everted, adducted, and plantarflexed attitude in a closed kinetic chain (walking) (8,13).

Examination of the subtalar joint should reveal a 2:1 ratio of inversion to eversion. There is a wide variation of range of motion of this joint, but normal values are considered to be 20° for inversion and 10° for eversion.

The midtarsal (transverse tarsal) joint marks the imaginary junction of the hindfoot and the midfoot. This complex involves 4 bones and 2 joints (talus-navicular and calcaneus-cuboid). Clinically, the axes of motion for each of these joints behave similarly because the joints act as a single unit. Structurally, the dome-shaped head of the talus complements the concave articular surface of the posterior navicular, while the posterior cuboid and anterior calcaneus form a saddle joint.

Major ligaments of note in the region include: 1) the plantar calcaneonavicular (spring) ligament, which runs from the sustentaculum tali to the inferior surface of the navicular; 2) the bifurcated ligament, which spans from the anterodorsal surface of the calcaneus to the plantar lateral aspect of the navicular and the medial aspect of the cuboid; and 3) the plantar calcaneocuboid ligament; which runs from the anterior surface of the calcaneus to the plantar surface of the cuboid (Fig. 16.51).

Although there is considerable debate about the motions that occur at the midtarsal joint, there is basic agreement in the literature that there are two separate axes around which motion can occur: 1) longitudinal, around which inversion or eversion is the primary motion, and 2) oblique, around which dorsiplantar flexion and abduction-adduction occur.

As stated earlier, the midtarsal joint is the proximal boundary of the midfoot. In addition to the navicular and cuboid, the midfoot is also formed by the medial, inter-
mediate, and lateral cuneiform; their primary functional role is allowing range of motion in plantarflexion and dorsiflexion.

The forefoot is composed of the five metatarsals and fourteen phalanges (two on the first rays and three on the second through fifth rays). Along with the three cuneiform, the primary function of the rays of the forefoot is to offer plantarflexion-dorsiflexion.

**Common Disorders of the Foot**

**PLANTAR FASCITIS**

**Definition.** Plantar fascitis is an inflammatory reaction of the fascial support located at the plantar aspect of the foot. A heel spur often forms at the calcaneal tuberosity where the plantar fascia inserts due to calcification resulting from traction of the plantar fascia on the periosteum.

**Etiology.** The condition can occur in adolescents or adults and is the result of a strain or force along the longitudinal arch of the foot that increases tension on the plantar fascia. This inflammatory condition may be the result of an acute strain to the fascia as seen with rapid acceleration or deceleration of the foot but more commonly is caused by overuse or biomechanical stresses. The condition most commonly occurs in runners who may have recently increased their mileage (112). Excessive walking can also become a problem, especially if the individual hyperpronates. Hyperpronation, pes cavus, or pes planus results in an increased tension on the plantar fascia (112).

**Anatomic Considerations.** The plantar fascia is a tendon-like structure that supports the arch of the foot. It is comprised of three bands that attach proximally to the calcaneal tuberosity and distally to the base of the proximal phalanges. Other anatomic considerations are the apophyseal attachment of the Achilles tendon, the subtalar joint, and the calcaneocuboid joint.

**Symptoms.** The patient most often reports insidious onset of heel pain or pain on the medial plantar aspect of the foot but may report a sudden onset of pain and tightness after an acute trauma such as stepping off a curb or into a hole (112). The pain is most often present during or after running or long periods of walking. It may also be present with the first steps out of bed or after walking after prolonged sitting. In the latter, the pain is usually more pronounced and makes walking difficult. Pain may be reported at the insertion of the Achilles tendon with an associated tenosynovitis. Less frequently, pain radiates up the leg or towards the toes (112).

**Clinical Findings.** The most clinically helpful finding is palpatory tenderness on the medial side of the heel at the insertion of the medial band or the abductor hallucis.
muscle (112). Palpatory tenderness may also be elicited over the entire plantar aspect of the calcaneus, at the insertion of the central or lateral fascial band, or at the insertion of the achilles tendon. Visual inspection of the patient weight-bearing should be performed to rule out hyperpronation, pes planus, or pes cavus deformities, which place abnormal tension on the plantar fascia. Functional leg length imbalance, a hypertonic gastrocnemius muscle or weak peroneal muscles can all cause hyperpronation resulting in plantar fascitis. The subtalar and calcaneocuboid joint should be tested for fixation and misalignment which can result in hyperpronation and abnormal foot mechanics. In the patient with radiating foot or leg pain, Tinel’s test for the posterior tibial and medial calcaneal nerve is performed to rule out Tarsal Tunnel Syndrome. Examination of the lumbosacral area is indicated to rule out referred pain syndromes.

**Diagnosis.** The differential diagnosis of plantar fasciitis includes, but is not limited to, acute strain, plantar bursitis, entrapment neuropathy, lumbosacral pathology, or rheumatic disease (112). In addition to the history and physical examination, plain film radiographs of the foot aid in the diagnosis of plantar fascitis. The most common finding is a spur at the calcaneal tuberosity (Fig. 16.52). By itself, this spur is not the cause of the pain and is also present in rheumatic diseases (112,113). If inflammatory disease (e.g., Reiter’s, AS, RA, or psoriatic arthritis) is suspected, laboratory tests should be performed.

**Treatment.** Treatment of plantar fasciitis initially involves the reduction and control of local inflammation by means of ice massage and ice bath submersion. The patient should be evaluated for the presence of a posterior calcaneus, inferolateral cuboid, or inferior navicular. Supportive taping or in-shoe arch supports should be used as long as symptoms persist. Toe raises and heel raises help strengthen lower leg muscles thus supporting the arch (Fig. 16.53). Towel exercises can aid in strengthening the intrinsic muscles of the foot. Rolling the arch over a wooden dowel or golf ball loosens local adhesions and provides mild symptomatic relief. In the presence of a heel spur the patient may be instructed to wear a heel cup or doughnut heel pad to reduce direct pressure on the spur. Surgical intervention is sometimes required with persistent symptomatic spurs.

**HALLUX VALGUS**

**Definition.** Hallux valgus is a subluxation of the first metatarsal phalangeal joint characterized by lateral deviation of the great toe with or without rotation, callus formation, and medial deviation of the first metatarsal head. It occurs in females more than males and may be familial or hereditary (73).

**Etiology.** Hallux valgus is rarely seen in societies in which shoes are not worn, and the implication of shoe wear as a primary external cause of hallux valgus is well supported by the literature (73,114). Of particular note are high heels, cowboy boots, and other narrow-toed shoes. Other causes of hallux valgus include tarsal/metatarsal fixation and misalignment, pes planus, achilles tendon contracture, and other structural abnormalities.

**Anatomic Considerations.** The first metatarsophalangeal joint and its supporting structures are of primary importance in hallux valgus formation. Attached by ligaments to the plantar aspect of the first metatarsal head and enveloped in the flexor hallucis brevis tendon are sesamoid bones. As the hallux valgus deformity begins to develop, the distal aspect of the great toe deviates laterally and the first metatarsal head deviates medially exposing the metatarsal head and sliding off the sesamoid complex (114). With continued external forces, a bunion is formed due to ligamentous thickening and may progress to the formation of an adventitious bursa.

**Symptoms.** The primary complaint is pain over the medial metatarsophalangeal joint. The patient may report varying degrees of swelling with an inability to wear certain types of shoes. The patient may experience pain at the plantar aspect of the foot in long-standing cases in which metatarsosesamoid joint degeneration has developed (114). Numbness is occasionally present in the great toe if the sensory nerves are affected.

**Clinical Findings.** The examination of the patient with hallux valgus should be performed weight-bearing to

![Figure 16.52. Radiograph of a calcaneal heel spur.](image-url)
accentuate structural and functional foot problems. The most prominent visual findings are lateral deviation of the great toe, medial deviation of the first metatarsal head, and callus formation with a large medial prominence. The first phalanx may actually overlap the second phalanx. Visual inspection may reveal hyperpronation, hammer toes, corns, or subluxation of the toes. The distance between the first and second metatarsals can appear increased. Tenderness over the bunion is present in the symptomatic patient. Neurologic and vascular examination of the foot should also be performed. The joints of the foot, particularly the subtalar, talonavicular, first tarsometatarsal, and metatarsophalangeal joints should be examined for fixation.

**Diagnosis.** The diagnosis of hallux valgus can be made by history and physical exam alone. The use of plain film radiography is useful in determining degenerative joint disease of the metatarsophalangeal joint. It is also helpful in detecting structural misalignment and in measuring the metatarsophalangeal and intermetatarsal angles.

**Treatment.** The conservative management of hallux valgus is directed toward relieving symptomatology first and possibly correcting dysfunction. The symptomatic patient should be instructed to avoid narrow-toed shoes. The primary treatment consists of correcting fixation dysfunction of the foot and ankle. Clinically, the first metatarsophalangeal joint (MPJ) is commonly subluxated. Correction of the MPJ should initially consist of passive joint mobilization and stretching followed by more vigorous corrective assistive procedures. The patient commonly presents with overpronation of the involved foot and corrective measures, such as in-shoe arch supports or an orthotic appliance, should be considered. Strengthening exercises for the lower leg and intrinsic foot muscles can be instituted.

**TARSAL TUNNEL SYNDROME**

**Definition.** The Tarsal Tunnel Syndrome (TTS) is a peripheral nerve entrapment that may cause foot pain, sensory changes, or muscular weakness. The syndrome is the result of entrapment of the posterior tibial nerve as it passes through the tarsal tunnel on the medial side of the ankle.

**Etiology.** Peripheral nerve entrapments often occur at areas where the nerve is more susceptible to injury or compression. The tarsal tunnel is an opening created by bone and fascia that allows tendons, blood vessels, and nerves to pass through it. In the event of traumatic swelling and fibrous tissue deposition, however, the opening becomes narrowed and is incapable of expanding.

The syndrome may be caused by acute pronation, a varus heel with a pronated forefoot, inflammatory diseases, thrombophlebitis, benign tumors, or postcalcaneal fracture (115,116). The most common cause is after an ankle sprain. The results of the trauma are swelling and fibrous tissue infiltration which narrows the tunnel and compresses the posterior tibial nerve. The scar tissue decreases the elasticity as well as the blood supply of the nerve, thus resulting in slowed nerve conduction (117). The authors have seen posterior calcaneal or anterior talar misalignments commonly in patients suffering from TTS.

**Anatomic Considerations.** The tarsal tunnel is located on the medial side of the ankle and is created by the medial malleolus, calcaneus, and the tibiocalcaneal portion of the medial collateral ligament (laciniate ligament or flexor retinaculum). Contained within the TTS are the tendons of the flexor digitorum longus, flexor hallucis longus, posterior tibialis muscles, and the posterior tibial artery, vein and nerve (Fig. 16.54). The posterior tibial nerve branches off distal to the tunnel into medial and lateral plantar and calcaneal nerves that carry sensa-
Figure 16.54. A coronal section of the ankle and rear foot. Located between the tendons of flexor hallucis longus and flexor digitorum longus is the posterior tibial nerve, artery, and vein. Modified from Warwick R, Williams P. Gray's anatomy. 35th British ed. Philadelphia: WB Saunders, 1980:496.

The plantar aspect of the foot and motor impulses to the intrinsic foot muscles, respectively (118). Also of anatomic importance is the architecture of the foot. Patients with a varus heel and forefoot pronation seem to be more susceptible to developing TTS (115).

**Symptoms.** The onset of symptoms is usually insidious even though the cause is most often traumatic. The initial symptoms are usually intermittent and worse at the end of the day or after long periods of standing. As the condition becomes chronic, the pain becomes more intense and may even wake the patient up at night. Pain, numbness, and paresthesias are located on the plantar aspect of the foot and toes, and occasionally may radiate up the calf (115). The patient often describes a burning sensation under the ball of the foot. Activity exacerbates the symptoms, and removing the shoes or massaging the feet may relieve them. If weakness of the toe flexors is present, the patient may report difficulty in toe standing.

**Clinical Findings.** Examination of the lumbosacral spine must be performed to rule out referred pain. Visual inspection of the weight-bearing patient may reveal pronation or heel varus of the foot. The patient may experience tenderness to palpation where the nerve travels behind the medial malleolus. The symptoms are increased by forcing the foot into a valgus position and minimized with a varus position (117).

The most clinically useful objective tests are Tinel’s and sensory testing. Tinel’s test is positive when paresthesias are produced by tapping the posterior tibial nerve where it travels through the tarsal tunnel. Sensory testing to light touch, pinprick, and Wartenburg pinwheel over the plantar aspect of the foot may be positive. Weakness of the toe flexors and foot intrinsics can be discovered by resisted muscle testing. Atrophy of the foot intrinsics is also possible. Controversy exists about how common sensory and motor changes are. Applying a tourniquet above the ankle sometimes reproduces the symptoms (117). It is important to examine the skin and pulses of the foot and ankle to help differentiate vascular causes of the syndrome.

**Diagnosis.** Because of vague symptomatology and very few objective tests, the diagnosis of TTS is difficult. The differential diagnosis includes inflammatory disease, healing fractures, benign tumors, thrombophlebitis, and other peripheral neuropathies. Plain film radiography is useful in detecting benign tumors and posttraumatic bony changes. The most useful special test is EMG, which demonstrates slowed conduction and demyelination in Tarsal Tunnel Syndrome. Sensory nerve conduction studies are thought to be more reliable than those performed on motor nerves (119). Laboratory tests prove helpful in differentiating TTS from diabetic and heavy metal neuropathies, as well as inflammatory arthritides.

**Treatment.** The initial goal of treatment is to reduce local inflammation by means of local ice massage and submersion in an ice bath. Histologic examination often reveals soft tissue remodeling and scar tissue infiltration of the calcaneofibular ligament, the lateral talocalcaneal ligament, and the interosseous talocalcaneal ligament (120). Transverse frictional massage and manual mobilization of the subtalar joint also aids in the destruction of local scar tissue.
Biomechanical analysis of the subtalar joint often will reveal a posteromedially subluxated calcaneus. In this event, manual adjustment of the calcaneus is required. During the adjunctive phase of care, which generally consists of two adjustments per week for 1 to 4 weeks, the use of supportive taping is advised. A figure-of-eight procedure using 2-inch self-adhering elastic tape stabilizes the subtalar joint after the adjustment. The patient should be instructed to wear the tape for 12 to 24 hours postadjustment. Supination should be controlled by use of a lateral heel wedge or an orthotic device. Supination is an aggravating factor as it stresses the interosseous talocalcaneal ligament.

Reeducation of the peroneal muscle group and soleus muscles via elastic tubing and a wobble board can help stabilize the area.

If failure to resolve this condition arises, the doctor should consider a podiatric or orthopaedic referral for further evaluation, and if appropriate, treatment.

SPECIFIC ADJUSTMENTS AND MOBILIZATIONS OF THE APPENDICULAR SKELETON

There exist virtually hundreds of various extremity adjustments that may be clinically effective. To avoid the stereotypical "jack-of-all-trades-master-of-none" label, the clinician should select maneuvers that can consistently be performed competently. This section will address a series of standard extremity adjustments which are a compilation of the authors' clinical experience.

**Indications:** Localized anterior chest pain and or swelling, increased pain on deep inspiration, history of trauma to the rib cage.

**Contraindications:** All other listings, hypermobility, instability, rib fracture, history of pneumothorax.

**Patient position:** The patient is supine.

**Doctor's position:** The doctor stands facing the patient opposite the side of involvement.

**Contact point:** The doctor uses a thumb-over-thumb contact with the superior hand.

**Segmental contact point:** Directly over the anteriorly displaced costal cartilage.

**Pattern of thrust:** The maneuver is a light to moderate compression during complete expiration followed with an anterior to posterior and superior to inferior thrust.

**Category by algorithm:** Short lever specific contact procedure.

**Name of technique:** Gonstead

**Name of technique procedure:** Costosternal Separation (Fig. 16.55).

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**Name of technique:** Gonstead

**Name of technique procedure:** Anterosuperior Proximal Clavicle Adjustment (Fig. 16.56).

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**Figure 16.55.** Adjustment procedure for a costosternal separation.

**Figure 16.56.** Adjustment procedure for an anterosuperior proximal clavicle.
Indications: Sternoclavicular joint pain and or swelling.

Contraindication: All other listings, hypermobility, instability, osseous fracture.

Patient position: The patient is supine, the glenohumeral joint of the involved side is positioned slightly over the edge of the bench.

Doctor’s position: The doctor stands at the head of the table facing the patient while slightly favoring the involved side.

Contact point: The thenar eminence of the medial hand.

Segmental contact point: The anterosuperior aspect of the proximal end of the clavicle.

Supporting hand: The lateral hand of the doctor stabilizes the involved extremity by grasping the wrist and guiding the arm into full horizontal abduction.

Pattern of thrust: From the fully abducted position the involved extremity is slightly adducted by the supporting hand while the contact hand delivers a thrust in an anterior to posterior and superior to inferior direction.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Superior Distal Clavicle Adjustment (acromioclavicular joint sprain) (Fig. 16.57A-B).

Indications: Acromioclavicular joint sprain with associated clavicular displacement.

Contraindication: All other listings, hypermobility, instability, fracture.

Patient position: The patient is seated in a cervical chair with the back in the full vertical position.

Doctor’s position: The doctor stands behind the patient slightly favoring the involved side.

Contact point: The pisiform of the medial hand.

Segmental contact point: The superior aspect of the distal clavicle.

Supporting hand: The doctor’s lateral hand grasps the elbow of the involved extremity which is flexed to 90° and abducts the arm to 90°.

Pattern of thrust: The lateral hand externally rotates the humerus as the medial hand initially compresses and then thrusts in a superior to inferior direction.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Anteroinferior Humerus Adjustment (Fig. 16.58A-C).

Indications: Anterior shoulder pain, generalized shoulder pain, bicipital tendonitis, rotator cuff tendonitis, prior shoulder dislocation, shoulder pain after lifting an object, difficulty in abduction of shoulder and arm especially above 90°.

Contraindications: All other listings, hypermobility, instability, advanced impingement syndrome, soft tissue rupture, acromioclavicular sprain, adhesive capsulitis (frozen shoulder), fracture, dislocation.

Figure 16.57A-B. Adjustment procedure for a superior distal clavicle.
both hands are placed on the medial and lateral aspects of the forearm of the involved side. The posterior aspect of the scapula on the involved side is firmly stabilized by compressing against the patient’s back with the doctor’s chest.

Pattern of thrust: The doctor circumducts the involved shoulder two to five times and slightly flexes and adducts the humerus while fully flexing the elbow. The thumbs of the doctor are used to externally rotate the humerus externally. The doctor slowly lifts the arm inferior to superior to bring the glenohumeral joint to tension and then applies a light inferior to superior and anterior to posterior thrust.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Posterosuperior Humerus Adjustment (Fig. 16.59).

Indications: History of falling on an outstretched arm, history of posterior shoulder dislocation, impingement syndrome.

Contraindications: All other listings, hypermobility, instability, ligamentous and or tendonous rupture, fracture.

Patient position: The patient is seated.

Doctor’s position: The doctor stands behind the patient favoring the involved extremity.
Contact point: The doctor takes a thumb web contact with the medial hand.

Segmental contact point: Posterosuperior aspect of the humeral head.

Supporting hand: The lateral hand stabilizes the involved side at the elbow. The involved limb is abducted to approximately 90° and should remain essentially parallel to the floor.

Pattern of thrust: The joint is taken to the end of joint play, directing the force of the contact hand in a posterior to anterior and superior to inferior direction. If the joint does not reduce at this point, a light thrust is delivered in the same direction.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Superomedial or Superolateral Scapula Adjustment (Fig. 16.60A-B).

Indications: Direct trauma, long-term spasm and/or myofascitis of the rhomboids, trapezius, and levator scapulae, abnormal scapulohumeral motion.

Contraindications: All other listings, hypermobility, instability, fracture.

Patient position: The patient is prone.

Doctor’s position: The doctor stands on the opposite side of involvement reaching across the patient to the involved scapula (superomedial adjustment).

Contact point: The thenar eminence of the medial hand.

Segmental contact point: Superolateral aspect of the scapula.

Supporting hand: The lateral hand stabilizes the dorsum of the contact hand.

Pattern of thrust: A moderate thrust is delivered in a superior to inferior and medial to lateral direction while torquing superior to inferior.

Category by algorithm: Short lever specific contact procedure.
Name of technique: Gonstead

Name of technique procedure: Posterolateral Ulna Adjustment (Fig. 16.61).

Indications: Elbow trauma, inflammation of olecranon bursa, decreased elbow extension range of motion, hyperflexion injury to the elbow, history of throwing motions and sports participation.

Contraindications: All other listings, hypermobility, instability, fracture.

Patient position: The patient is seated.

Doctor’s position: The doctor sits or stands slightly favoring the involved side.

Contact point: The thenar eminence of the medial hand.

Segmental contact point: The posterior aspect of the olecranon process.

Supporting hand: The lateral hand of the doctor stabilizes the involved extremity by grasping the wrist and maintaining it in full supination.

Pattern of thrust: A light thrust in a posterior to anterior and superior to inferior direction is delivered to a slightly flexed elbow.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Medioinferior Ulna Adjustment (Fig. 16.62).

Indications: Ulnar nerve paresthesia, wrist or elbow trauma, medial elbow pain, restricted elbow extension range of motion, history of throwing motion, sports participation.

Contraindications: All other listings, hypermobility, instability, fracture.

Patient position: The patient is seated.

Doctor’s position: The doctor sits or stands facing the patient slightly favoring the involved side.

Contact point: The thenar eminence of the medial hand.

Segmental contact point: The posteromedial aspect of the olecranon process.

Supporting hand: The lateral hand of the doctor stabilizes the involved extremity by grasping the wrist and maintaining it in full supination.

Pattern of thrust: A light high velocity thrust is delivered to the slightly flexed joint in an inferior to superior and medial to lateral direction.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Posterolateral Radial Head Adjustment (Fig. 16.63).

Indications: Lateral epicondylitis, radial head pain and or swelling, decreased and/or painful wrist supination, history of elbow trauma, history of throwing motion, sports participation or inability to fully supinate.

Contraindications: All other listings, hypermobility, instability, fracture.
Patient position: The patient is seated.

Doctor’s position: The doctor sits or stands facing the patient slightly favoring the involved extremity.

Contact point: The distal phalanx of the thumb of the lateral hand.

Segmental contact point: Posterolateral aspect of the radial head.

Supporting hand: The medial hand of the doctor stabilizes the involved extremity by grasping the wrist and maintaining it in full supination.

Pattern of thrust: A moderate thrust is delivered in a posterior to anterior and lateral to medial direction.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Distal Radioulnar Separation (Fig. 16.64A-B).

Indications: Wrist sprain, wrist trauma, decreased wrist range of motion, pain and/or swelling of the distal radioulnar articulation, carpal tunnel syndrome.

Contraindications: All other listings, hypermobility, instability, fracture, presence of avascular necrosis of an adjacent carpal bone.

Patient position: The patient is seated. The elbow of the involved side is flexed to 90° with the thumb pointing up.

Doctor’s position: The doctor sits or stands facing the patient slightly favoring the involved side.

Contact point: The doctor interlocks the fingers and wraps them and both thumbs around the distal ulna and radius. The thumbs overlie the distal radius while the intertwined fingers cradle the distal ulna.

Pattern of thrust: The distal radius and ulna are approximated by a quick “squeezing” thrust delivered by both hands of the doctor.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Anterior Carpal Adjustment (Fig. 16.65).

Indications: Wrist sprain, anterior wrist pain and/or swelling, ganglion cyst, loss of wrist range of motion (especially flexion), carpal tunnel syndrome.

Contraindications: All other listings, hypermobility, instability, osseous fracture, avascular necrosis of involved carpal bone, advanced osteoarthritis.

Patient position: The patient is seated.

Doctor’s position: The doctor is seated or standing, facing the patient.
Contact point: The doctor takes a thumb-over-thumb contact.
Segmental contact point: The anterior aspect of the involved carpal.
Supporting hand: The fingers of both hands wrap around the hand of the involved wrist and guide the wrist from extension into flexion during the adjustment.
Pattern of thrust: The wrist is guided into slight flexion followed by a moderate thrust in an anterior to posterior direction.
Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead
Name of technique procedure: Posterior Carpal Adjustment (Fig. 16.66).
Indications: Wrist sprain, posterior wrist pain, ganglion cyst, limitation of wrist motion (primarily extension).

Contraindications: All other listings, hypermobility, instability, osseous fracture, avascular necrosis of involved carpal bone, advanced osteoarthritis.

Patient position: The patient is seated.
Doctor’s position: The doctor is seated or standing, facing the patient.
Contact point: The doctor takes a thumb-over-thumb contact.
Segmental contact point: The posterior aspect of the involved carpal.
Supporting hand: The fingers of both hands wrap around the hand of the involved wrist and guide the wrist from flexion into extension during the adjustment.
Pattern of thrust: The wrist is guided into slight extension followed by a moderate thrust in a posterior to anterior direction.
Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead
Name of technique procedure: Posterolateral Proximal First Metacarpal Adjustment (Fig. 16.67).
Indications: Pain, swelling, and/or decreased range of motion of the metacarpophalangeal articulation, deQuarvain’s disease, thumb sprain.
Contraindications: All other listings, hypermobility, instability, fracture.

Patient position: The patient is seated.
Doctor's position: The doctor is standing or seated facing the patient.

Contact point: The distal phalanx of the thumb of the lateral hand. The 2nd through 5th digits wrap around the involved 1st digit.

Segmental contact point: The posterolateral aspect of the proximal end of the first metacarpal.

Supporting hand: The thumb of the medial hand overlaps the contact thumb. The 2nd through 5th digits wrap around and support the hand of the involved extremity.

Pattern of thrust: Initially the involved metacarpal is distracted, followed by a thrust delivered by the thumb of the medial hand.

Category of algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Anteromedial (AIn) Distal Femur Adjustment (Fig. 16.68A-B).

Indications: Medial collateral ligament sprain, medial knee pain and/or swelling, joint fixation.

Contraindications: All other listings, hypermobility, instability, ligament rupture, fracture, advanced meniscal tear.

Patient position: Patient is seated.

Doctor's position: The doctor stands facing the patient favoring the subluxated knee.

Doctor's contact point: The lateral aspect of the proximal phalanx of the second digit of the medial hand or the thenar eminence.

Segmental contact point: The anteromedial aspect of the distal femur.

Supporting hand: The lateral hand stabilizes the distal tibia in external rotation.

Pattern of thrust: As the doctor slightly distracts the lower leg, the medial hand thrusts anterior to posterior and medial to lateral. Care must be taken to not thrust a semiflexed knee as to avoid hyperextending the joint.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Posterolateral (PEx) Proximal Tibia Adjustment (Fig. 16.69).

Indications: Lateral collateral ligament injury, posterolateral rotatory instability, lateral knee pain, joint fixation.

Contraindications: All other listings, hypermobility, instability, ligament rupture, fracture.

Patient position: Patient is prone with feet extending over the end of the pelvic bench.

Doctor's position: The doctor stands facing the patient on the opposite side of the table as the subluxated knee.

Contact point: The palmar aspect of the distal phalanx of the third digit of the superior hand.

Segmental contact point: The doctor reaches under the patient's leg from medial to lateral, contacting the posterior lateral tibia and the lateral joint line. Care should be taken not to contact the proximal fibula.

Supporting hand: The free hand supports the posterior ankle while internally rotating the lower leg.
Indications: History of anterior knee trauma, history of anterior cruciate ligament sprain, decreased range of motion in flexion of the knee, posterior knee pain or swelling.

Contraindications: All other listings, hypermobility, instability, posterior cruciate ligament sprain, fracture.

Patient position: Patient is placed in the prone position with the involved knee flexed to 40° to 50°.

Doctor's position: The doctor is at the feet of the patient facing cephalad.

Segmental contact point: The posterior aspect of the superior proximal tibia.

Contact point: The doctor interlocks the fingers and uses the anterolateral aspect of the right and left 5th digits to contact the patient.

Stabilization: Stabilization is provided to the lower leg by placing the dorsum of the foot of the involved side on the lateral shoulder of the doctor.

Pattern of thrust: The thrust is a medium to heavy force directed posterior to anterior.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Tibiofemoral Joint Traction (Fig. 16.71).

Indications: Generalized knee pain and stiffness, joint contracture, stable osteoarthritis, mild joint effusion.
Contraindications: All other listings, hypermobility, instability, fracture, patellofemoral disorders.

Patient position: The patient is prone.

Doctor's position: The doctor stands facing the patient on the side of involvement.

Contact point: The doctor uses the thumb-web of the superior hand.

Segmental contact point: The popliteal fossa of the involved knee.

Supporting hand: The inferior hand supports the involved extremity by grasping the ankle.

Pattern of thrust: The knee is slowly flexed and distracted over the contact hand by the supporting hand.

Category by algorithm: Long lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Anteroinferior Proximal Fibula Adjustment.

Indications: Inversion ankle sprain, lateral knee pain on walking, running, or stair climbing. Lateral knee pain on resisted knee flexion and simultaneous tibial rotation.

Contraindications: All other listings, hypermobility, instability, local fracture.

Patient position: The patient is seated.

Doctor's position: The doctor is seated, facing the patient.

Segmental contact point: The anteroinferior aspect of the fibular head.

Contact point: The thenar eminence of the lateral hand.

Supporting hand: The medial hand stabilizes the ankle.

Pattern of thrust: The thrust is directed posterior and superior.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Posterior Lateral Malleolus Adjustment.

Indications: Inversion ankle sprain, direct trauma to anterior distal fibula, dysfunction of the pelvis and/or lumbar spine.

Contraindications: All other listings, hypermobility, instability, fibular fracture.

Patient position: The patient is prone.

Doctor's position: The doctor stands opposite the side of segmental involvement.

Segmental contact point: The posterior border of the lateral malleolus.

Contact point: The pisiform of the inferior hand.

Supporting hand: The superior hand wraps around and supports the wrist of the contact hand.

Pattern of thrust: The thrust is directed posterior to anterior.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Distal Tibiofibular Separation Adjustment.

Indications: Inversion ankle sprain, eversion ankle sprain, pain on forced dorsiflexion.

Contraindications: All other listings, hypermobility, instability, medial or lateral malleolar fracture.

Patient position: The patient is supine or seated.

Doctor's position: The doctor faces the patient, at the feet.

Contact point: Both hands are used in opposition of one another. Contact is made by each thenar.

Segmental contact point: 1) internal hand contacts the medial malleoli; 2) outer hand contacts the lateral malleoli.

Pattern of thrust: The distal tibia and fibula are squeezed together by thrusting from lateral to medial on the fibula, approximating the tibia.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Anterior Talus Adjustment.
Indications: This misalignment is similar to anterior-inferior talus but not as common. Pain is usually localized to anterior aspect of ankle, which worsens with dorsiflexion.

Contraindications: All other listings, hypermobility, instability, talar fracture, medial or lateral malleolar fracture.

Patient position: Seated or supine on bench.

Doctor's position: Doctor is at the foot of patient, facing the patient.

Contact point: The tips of both thumbs.

Segmental contact point: The anterior aspect of the dome of the talus.

Supporting hand: The doctor wraps the 2nd to 5th digits of both hands around the plantar surface of the foot and posterior aspect of the calcaneus.

Pattern of thrust: The adjustment is initiated with the ankle in plantarflexion. The fingers around the calcaneus act as a lever to pull the talus into the mortise as the ankle is dorsiflexed, followed by delivery of a light thrust.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Traction Maneuver for Antero-inferior Talus (aka: lateroinferior talus).

Indications: Inversion sprain, excessive supination, anterior ankle pain, pain on dorsiflexion.

Contraindications: All other listings, hypermobility, instability.

Patient position: Patient is supine.

Doctor's position: Doctor stands at the foot of the patient, facing them.

Contact point: The 4th and 5th fingers of the doctor's medial hand.

Segmental contact point: Contact is made over the anterior-lateral aspect of talus.

Supporting hand: The area is stabilized by placing the fingers over the tops of contact hand fingers.

Pattern of thrust: The mortise joint is lightly distracted superior to inferior, followed by a thrusting action anterior to posterior and lateral to medial.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Antero-inferior Talus Adjustment (aka: lateroinferior talus) (Fig. 16.72).

Indications: Inversion sprain, excessive supination, medial ankle trauma, pain on plantar flexion.

Contraindications: All other listings, hypermobility, instability, malleolar fracture, talar diastasis fracture.

Patient position: The patient is seated or lying supine.

Doctor's position: The doctor stands facing the patient at the feet of the patient.

Contact point: The distal phalanx of lateral thumb.

Segmental contact point: Lateral anterior aspect of the talus.

Supporting hand: Distal phalanx of medial thumb overlaps contact point.

Pattern of thrust: The fingers are used to rock the talus and calcaneus into dorsiflexion as the thumb contact thrusts lateral to medial and anterior to posterior.

Category by algorithm: Short lever specific contact procedure.
Indications: Lateral talocalcaneal joint line pain, loss of eversion range of motion at the subtalar joint, excessive supination, increased outer heel wear on shoes.

Contraindications: All other listings, hypermobility, instability, calcaneal fracture, Sever's disease.

Patient position: The patient is prone with the feet extending over the end of the table.

Doctor's position: The doctor faces patient at the feet of the patient.

Contact point: Thumb web of the outer hand.

Segmental contact point: Posterolateral aspect of the calcaneus.

Supporting hand: Fingers of the inner hand wrap under the anterior ankle and support the mortise joint.

Patterns of thrust: A moderate to heavy thrust is made posterior to anterior and lateral to medial.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Medial Calcaneus Adjustment.

Indications: Medial talocalcaneal joint line pain, loss of inversion range of motion at the subtalar joint, hyperpronation, excessive medial heel wear on shoes.

Contraindications: All other listings hypermobility, instability, calcaneal fracture, Sever's disease.

Patient position: Patient is prone with feet extending over end of the table.

Doctor's position: Doctor is at the feet of the patient facing the patient.

Contact point: Thumb web of the inner hand.

Segmental contact point: Posteromedial aspect of the calcaneus.

Supporting hand: The fingers of the outer hand wrap under the anterior ankle and support the mortise joint.

Pattern of thrust: A moderate to heavy thrust is made posterior to anterior and medial to lateral.

Category by algorithm: Short lever specific contact procedure.
Name of technique: Gonstead

Name of technique procedure: Inferior Navicular Adjustment (Fig. 16.74).

Indications: Arch strain, fallen arches, hyperpronation, some varieties of shin splints.

Contraindications: All other listings, hypermobility, instability, local fracture.

Patient position: The patient is seated with the involved foot positioned in the lap of the doctor.

Doctor’s position: The doctor is seated facing the patient.

Contact point: The doctor makes a double thumb or thenar contact.

Segmental contact point: Inferior-medial aspect of the navicular.

Supporting hand: The fingers of both hands wrap around and support the forefoot and midfoot.

Pattern of thrust: The foot is positioned in plantarflexion and inversion. A moderate thrust is directed inferior to superior and medial to lateral.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Description of technique procedure: Inferior Cuneiform Adjustment (Fig. 16.75).

Indications: Loss of medial or lateral longitudinal arch, local pain and/or swelling, hyperdorsiflexion injury of the foot.

Contraindications: All other listings, hypermobility, instability, local fracture.

Patient position: The patient is prone with the knee of the involved extremity flexed to 60° to 75°.

Doctor’s position: The doctor stands facing the patient at the feet of the patient.

Contact point: The doctor makes a double thumb contact.

Segmental contact point: The inferior aspect of the involved cuneiform.

Supporting hand: The fingers of both hands wrap around and support the dorsum of the foot.

Pattern of thrust: The foot is plantarflexed over the contact point followed by a light to medium inferior to superior thrust.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: Inferior Distal Metatarsal Head Adjustment (Fig. 16.76).

Indications: Hammer toe, corn and callus formation, loss of transverse arch, turf toe.

Contraindications: All other listings, hypermobility, instability, local fracture.

Patient position: The patient is seated with the involved extremity positioned in the lap of the doctor.

Figure 16.74. Adjustment procedure for an inferior navicular.

Figure 16.75. Adjustment procedure for an inferior cuneiform.
Doctor's position: The doctor is seated facing the patient.

Contact point: The lateral side of a flexed second proximal interphalangeal joint on the lateral hand.

Segmental contact point: The inferior aspect of the distal end of the involved metatarsal.

Supporting hand: The thumb of the contact hand wraps over the involved toe and contacts the superior aspect of the proximal end of the proximal phalanx.

Pattern of thrust: The doctor contact point is lightly thrusted inferior to superior as the supporting thumb slightly tractions the toe superior to inferior and distally.

Category by algorithm: Short lever specific contact procedure.

Name of Technique: Gonstead

Name of Technique Procedure: Lateroinferior Cuboid Adjustment (Fig. 16.77).

Indications: Lateral foot pain, loss of lateral transverse arch, arch strain, midfoot dysfunction.

Contraindications: All other listings, hypermobility, instability, local fracture.

Patient position: The patient is seated.

Doctor's position: The doctor is seated facing the patient.

Contact point: Thenar eminence of the lateral hand.

Segmental contact point: Lateroinferior aspect of the cuboid.

Supporting hand: The medial hand supports the dorsum of the foot while flexing the foot over the contact point.

Pattern of thrust: A moderate thrust is delivered in a lateral to medial and inferior to superior direction.

Category by algorithm: Short lever specific contact procedure.

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