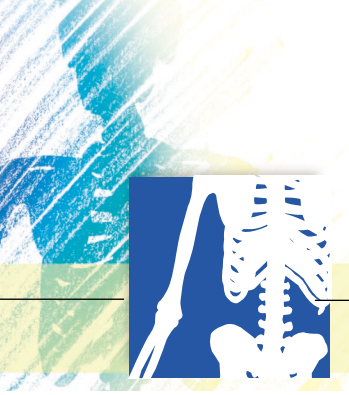
12 Joints



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GENERAL CLINICAL FEATURES CONCERNING JOINTS

Examination of Joints

When examining a patient, the clinician should assess the normal range of movement of all joints. When the bones of a joint are no longer in their normal anatomic relationship with one another, then the joint is said to be **dislocated.**

Dislocation of Joints

Some joints are particularly susceptible to dislocation because of lack of support by ligaments, the poor shape of the articular surfaces, or the absence of adequate muscular support. The shoulder joint, temporomandibular joint, and acromioclavicular joints are good examples. Dislocation of the hip is usually congenital, being caused by inadequate development of the socket that normally holds the head of the femur firmly in position.

Presence of Cartilaginous Discs within Joints

The presence of cartilaginous discs within joints, especially weightbearing joints, as in the case of the knee, makes them particularly susceptible to injury in sports. During a rapid movement the disc loses its normal relationship to the bones and becomes crushed between the weightbearing surfaces.

Loss of Joint Innervation

In certain diseases of the nervous system (e.g., **syringomyelia**), the sensation of pain in a joint is lost. This means that the warning sensations of pain felt when a joint moves beyond the normal range of movement are not experienced. This phenomenon results in the destruction of the joint.

Value of Joint Classification

Knowledge of the classification of joints is of great value because, for example, certain diseases affect only certain types of joints. **Gonococcal arthritis** affects large synovial joints such as the ankle, elbow, or wrist, whereas **tuberculous arthritis** also affects synovial joints and may start in the synovial membrane or in the bone.

Joint Pain and Joint Innervation

Remember that more than one joint may receive the same nerve supply. For example, the hip and knee joints are both supplied by the obturator nerve. Thus, a patient with disease limited to one of these joints may experience pain in both.

TEMPOROMANDIBULAR JOINT

Clinical Significance of the Temporomandibular Joint

The temporomandibular joint lies immediately in front of the external auditory meatus. The great strength of the lateral temporomandibular ligament prevents the head of the mandible from passing backward and fracturing the tympanic plate when a severe blow falls on the chin.

The **articular disc** of the temporomandibular joint may become partially detached from the capsule, and this results in its movement becoming noisy and producing an audible click during movements at the joint.

Dislocation of the Temporomandibular Joint

Dislocation sometimes occurs when the mandible is depressed. In this movement, the head of the mandible and the articular disc both move forward until they reach the summit of the articular tubercle. In this position, the joint is unstable, and a minor blow on the chin or a sudden contraction of the lateral pterygoid muscles, as in yawning, may be sufficient to pull the disc forward beyond the summit. In bilateral cases the mouth is fixed in an open position, and both heads of the mandible lie in front of the articular tubercles. Reduction of the dislocation is easily achieved by pressing the gloved thumbs downward on the lower molar teeth and pushing the jaw backward. The downward pressure overcomes the tension of the temporalis and masseter muscles, and the backward pressure overcomes the spasm of the lateral pterygoid muscles.

JOINTS OF THE VERTEBRAL COLUMN

Abnormal Curves of the Vertebral Column

Kyphosis is an exaggeration in the sagittal curvature present in the thoracic part of the vertebral column. It can be caused by muscular weakness, by structural changes in the vertebral bodies, or by intervertebral discs. In sickly adolescents, for example, where the muscle tone is poor, long hours of study or work over a low desk can lead to a gently curved kyphosis of the upper thoracic region. The person is said to be "round-shouldered." Crush fractures or tuberculous destruction of the vertebral bodies leads to acute angular kyphosis of the vertebral column. In the aged, **osteoporosis** (abnormal rarefaction of bone) and/or degeneration of the intervertebral discs leads to **senile kyphosis,** involving the cervical, thoracic, and lumbar regions of the column.

Lordosis is an exaggeration in the sagittal curvature present in the lumbar region. Lordosis may be caused by an increase in the weight of the abdominal contents, as with the gravid uterus or a large ovarian tumor, or it may be caused by disease of the vertebral column such as spondylolisthesis. The possibility that it is a postural compensation for a kyphosis in the thoracic region or a disease of the hip joint (congenital dislocation) must not be overlooked.

Scoliosis is a lateral deviation of the vertebral column. This is most commonly found in the thoracic region and may be caused by muscular or vertebral defects. Paralysis of muscles caused by poliomyelitis can cause severe scoliosis. The presence of a congenital hemivertebra can cause scoliosis. Often scoliosis is compensatory and may be caused by a short leg or hip disease.

Dislocations of the Vertebral Column

Dislocations without fracture occur only in the cervical region because the inclination of the articular processes of the cervical vertebrae permits dislocation to take place without fracture of the processes. In the thoracic and lumbar regions, dislocations can occur only if the vertically placed articular processes are fractured.

Dislocations commonly occur between the fourth and fifth or fifth and sixth cervical vertebrae, where mobility is greatest. In unilateral dislocations the inferior articular process of one vertebra is forced forward over the anterior margin of the superior articular process of the vertebra below. Because the articular processes normally overlap, they become locked in the dislocated position. The spinal nerve on the same side is usually nipped in the intervertebral foramen, producing severe pain. Fortunately, the large size of the vertebral canal allows the spinal cord to escape damage in most cases.

Bilateral cervical dislocations are almost always associated with severe injury to the spinal cord. Death occurs immediately if the upper cervical vertebrae are involved because the respiratory muscles, including the diaphragm (phrenic nerves C3 to C5), are paralyzed.

Fractures of the Vertebral Column

Fractures of the Spinous Processes, Transverse Processes, or Laminae

Fractures of the spinous processes, transverse processes, or laminae are caused by direct injury or, in rare cases, by severe muscular activity.

Anterior and Lateral Compression Fractures

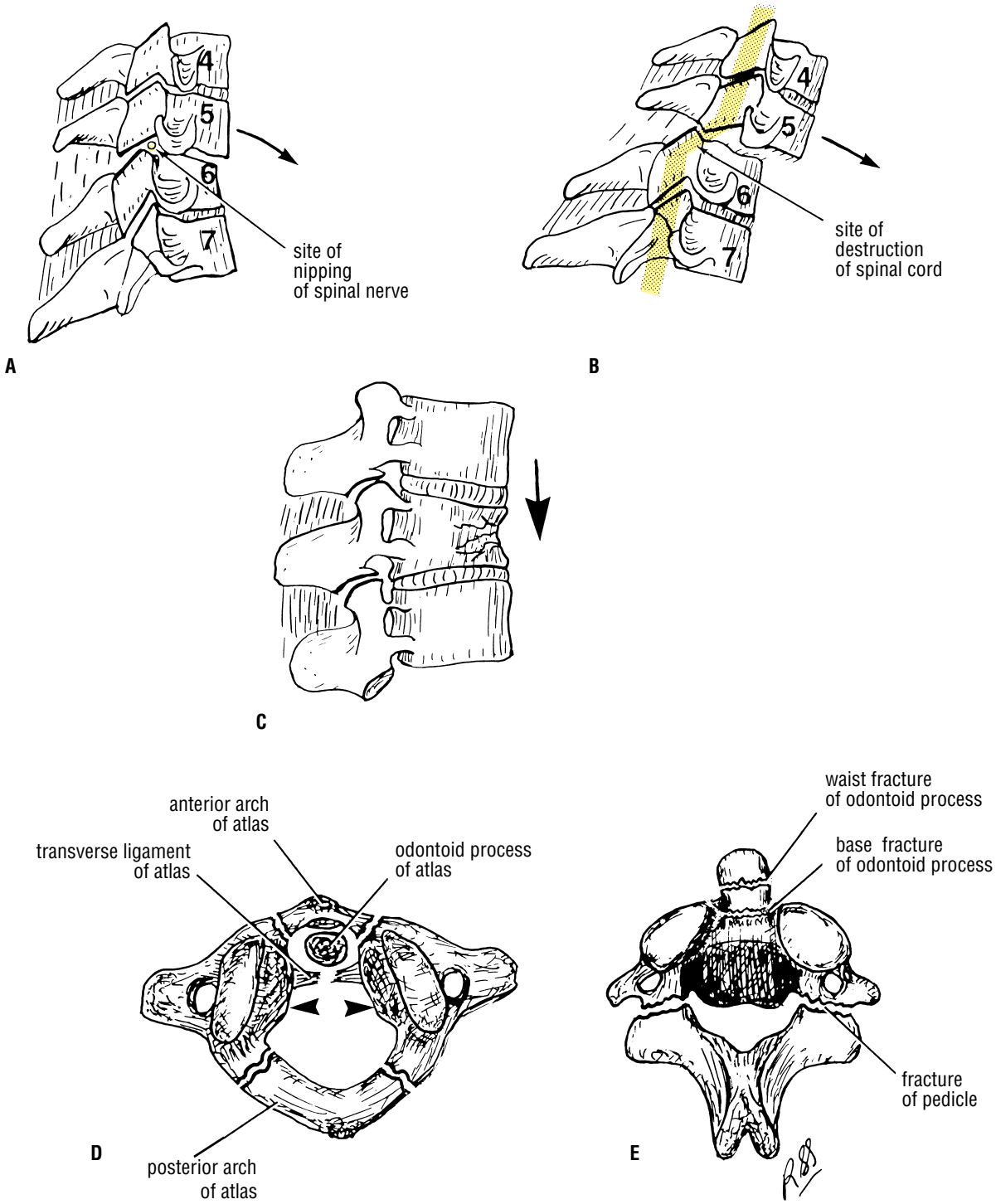
Anterior compression fractures of the vertebral bodies are usually caused by an excessive flexion compression type of injury and take place at the sites of maximum mobility or at the junction of the mobile and fixed regions of the column. It is interesting to note that the body of a vertebra in such a fracture is crushed, whereas the strong posterior longitudinal ligament remains intact. The vertebral arches remain unbroken and the intervertebral ligaments remain intact so that vertebral displacement and spinal cord injury do not occur. When injury causes excessive lateral flexion in addition to excessive flexion, the lateral part of the body is also crushed.

Fracture Dislocations

Fracture dislocations are usually caused by a combination of a flexion and rotation type of injury; the upper vertebra is excessively flexed and twisted on the lower vertebra. Here again, the site is usually where maximum mobility occurs, as in the lumbar region, or at the junction of the mobile and fixed region of the column, as in the lower lumbar vertebrae. Because the articular processes are fractured and the ligaments are torn, the vertebrae involved are unstable, and the spinal cord is usually severely damaged or severed, with accompanying paraplegia.

Vertical Compression Fractures

Vertical compression fractures occur in the cervical and lumbar regions, where it is possible to fully straighten the



CD Figure 12-1 Dislocations and fractures of the vertebral column. **A.** Unilateral dislocation of the fifth or the sixth cervical vertebra. Note the forward displacement of the inferior articular process over the superior articular process of the vertebra below. **B.** Bilateral dislocation of the fifth on the sixth cervical vertebra. Note that 50% of the vertebral body width has moved forward on the vertebra below. **C.** Flexion compression–type fracture of the vertebral body in the lumbar region. **D.** Jefferson's-type fracture of the atlas. **E.** Fractures of the odontoid process and the pedicles (hangman's fracture) of the axis.

vertebral column (CD Fig. 12-1). In the cervical region, with the neck straight, an excessive vertical force applied from above will cause the ring of the atlas to be disrupted and the lateral masses to be displaced laterally (**Jefferson's fracture**). If the neck is slightly flexed, the lower cervical vertebrae remain in a straight line and the compression load is transmitted to the lower vertebrae, causing disruption of the intervertebral disc and breakup of the vertebral body. Pieces of the vertebral body are commonly forced back into the spinal cord.

It is possible for nontraumatic compression fractures to occur in severe cases of osteoporosis and for pathologic fractures to take place.

In the straightened lumbar region, an excessive force from below can cause the vertebral body to break up, with protrusion of fragments posteriorly into the spinal canal.

Fractures of the Odontoid Process of the Axis

Fractures of the odontoid process are relatively common and result from falls or blows on the head (see CD Fig. 12-1). Excessive mobility of the odontoid fragment or rupture of the transverse ligament can result in compression injury to the spinal cord.

Fracture of the Pedicles of the Axis (Hangman's Fracture)

Severe extension injury of the neck, such as might occur in an automobile accident or a fall, is the usual cause of hangman's fracture. Sudden overextension of the neck, as produced by the knot of a hangman's rope beneath the chin, is the reason for the common name. Because the vertebral canal is enlarged by the forward displacement of the vertebral body of the axis, the spinal cord is rarely compressed (see CD Fig. 12-1).

Spondylolisthesis

In spondylolisthesis, the body of a lower lumbar vertebra, usually the fifth, moves forward on the body of the vertebra below and carries with it the whole of the upper portion of the vertebral column. The essential defect is in the pedicles of the migrating vertebra. It is now generally believed that, in this condition, the pedicles are abnormally formed and accessory centers of ossification are present and fail to unite. The spine, laminae, and inferior articular processes remain in position, whereas the remainder of the vertebra, having lost the restraining influence of the inferior articular processes, slips forward. Because the laminae are left behind, the vertebral canal is not narrowed, but the nerve roots may be pressed on, causing low backache and sciatica. In severe cases the trunk becomes shortened, and the lower ribs contact the iliac crest.

JOINTS OF THE UPPER LIMB

Sternoclavicular Joint

Sternoclavicular Joint Injuries

The strong costoclavicular ligament firmly holds the medial end of the clavicle to the first costal cartilage. Violent forces directed along the long axis of the clavicle usually result in fracture of that bone, but dislocation of the sternoclavicular joint takes place occasionally.

Anterior dislocation results in the medial end of the clavicle projecting forward beneath the skin; it may also be pulled upward by the sternocleidomastoid muscle.

Posterior dislocation usually follows direct trauma applied to the front of the joint that drives the clavicle backward. This type is the more serious because the displaced clavicle may press on the trachea, esophagus, and major blood vessels in the root of the neck.

If the costoclavicular ligament ruptures completely, it is difficult to maintain the normal position of the clavicle once reduction has been accomplished.

Acromioclavicular Joint

Acromioclavicular Joint Injuries

The plane of the articular surfaces of the acromioclavicular joint passes downward and medially so that there is a tendency for the lateral end of the clavicle to ride up over the upper surface of the acromion. The strength of the joint depends on the strong coracoclavicular ligament, which binds the coracoid process to the undersurface of the lateral part of the clavicle. The greater part of the weight of the upper limb is transmitted to the clavicle through this ligament, and rotary movements of the scapula occur at this important ligament.

Acromioclavicular Joint Dislocation

A severe blow on the point of the shoulder, as is incurred during blocking or tackling in football or any severe fall, can result in the acromion being thrust beneath the lateral end of the clavicle, tearing the coracoclavicular ligament. This condition is known as **shoulder separation.** The displaced outer end of the clavicle is easily palpable. As in the case of the sternoclavicular joint, the dislocation is easily reduced, but withdrawal of support results in immediate redislocation.

Shoulder Joint

Stability of the Shoulder Joint

The shallowness of the glenoid fossa of the scapula and the lack of support provided by weak ligaments make this joint an unstable structure. Its strength almost entirely depends on the tone of the short muscles that bind the upper end of the humerus to the scapula—namely, the subscapularis in front, the supraspinatus above, and the infraspinatus and teres minor behind. The tendons of these muscles are fused to the underlying capsule of the shoulder joint. Together, these tendons form the rotator cuff.

The least supported part of the joint lies in the inferior location, where it is unprotected by muscles.

Dislocations of the Shoulder Joint

The shoulder joint is the most commonly dislocated large joint.

Anterior–Inferior Dislocations

Sudden violence applied to the humerus with the joint fully abducted tilts the humeral head downward onto the inferior weak part of the capsule, which tears, and the humeral head comes to lie inferior to the glenoid fossa. During this movement, the acromion has acted as a fulcrum. The strong flexors and adductors of the shoulder joint now usually pull the humeral head forward and upward into the subcoracoid position.

Posterior Dislocations

Posterior dislocations are rare and are usually caused by direct violence to the front of the joint.

On inspection of the patient with shoulder dislocation, the rounded appearance of the shoulder is seen to be lost because the greater tuberosity of the humerus is no longer bulging laterally beneath the deltoid muscle. A subglenoid displacement of the head of the humerus into the quadrangular space can cause damage to the axillary nerve, as indicated by paralysis of the deltoid muscle and loss of skin sensation over the lower half of the deltoid. Downward displacement of the humerus can also stretch and damage the radial nerve.

Shoulder Pain

The synovial membrane, capsule, and ligaments of the shoulder joint are innervated by the axillary nerve and the suprascapular nerve. The joint is sensitive to pain, pressure, excessive traction, and distension. The muscles surrounding the joint undergo reflex spasm in response to pain originating in the joint, which in turn serves to immobilize the joint and thus reduce the pain.

Injury to the shoulder joint is followed by pain, limitation of movement, and muscle atrophy owing to disuse. It is important to appreciate that pain in the shoulder region can be caused by disease elsewhere and that the shoulder joint may be normal; for example, diseases of the spinal cord and vertebral column and the pressure of a cervical rib can cause shoulder pain. Irritation of the diaphragmatic pleura or peritoneum can produce referred pain via the phrenic and supraclavicular nerves.

Elbow Joint

Stability of the Elbow Joint

The elbow joint is stable because of the wrench-shaped articular surface of the olecranon and the pulley-shaped trochlea of the humerus; it also has strong medial and lateral ligaments. When examining the elbow joint, the physician must remember the normal relations of the bony points. In extension, the medial and lateral epicondyles and the top of the olecranon process are in a straight line; in flexion, the bony points form the boundaries of an equilateral triangle.

Dislocations of the Elbow Joint

Elbow dislocations are common, and most are posterior. Posterior dislocation usually follows falling on the outstretched hand. Posterior dislocations of the joint are common in children because the parts of the bones that stabilize the joint are incompletely developed. Avulsion of the epiphysis of the medial epicondyle is also common in childhood because then the medial ligament is much stronger than the bond of union between the epiphysis and the diaphysis.

Arthrocentesis of the Elbow Joint

The anterior and posterior walls of the capsule are weak, and when the joint is distended with fluid, the posterior aspect of the joint becomes swollen. Aspiration of joint fluid can easily be performed through the back of the joint on either side of the olecranon process.

Damage to the Ulnar Nerve with Elbow Joint Injuries

The close relationship of the ulnar nerve to the medial side of the joint often results in its becoming damaged in dislocations of the joint or in fracture dislocations in this region. The nerve lesion can occur at the time of injury or weeks, months, or years later. The nerve can be involved in scar tissue formation or can become stretched owing to lateral deviation of the forearm in a badly reduced supracondylar fracture of the humerus. During movements of the elbow joint, the continued friction between the medial epicondyle and the stretched ulnar nerve eventually results in ulnar palsy.

Radiology of the Elbow Region after Injury

In examining lateral radiographs of the elbow region, it is important to remember that the lower end of the humerus is normally angulated forward 45° on the shaft; when examining a patient, the physician should see that the medial epicondyle, in the anatomic position, is directed medially and posteriorly and faces in the same direction as the head of the humerus.

Radioulnar Joint

Radioulnar Joint Disease

The proximal radioulnar joint communicates with the elbow joint, whereas the distal radioulnar joint does not communicate with the wrist joint. In practical terms, this means that infection of the elbow joint invariably involves the proximal radioulnar joint. The strength of the proximal radioulnar joint depends on the integrity of the strong anular ligament. Rupture of this ligament occurs in cases of anterior dislocation of the head of the radius on the capitulum of the humerus. In young children, in whom the head of the radius is still small and undeveloped, a sudden jerk on the arm can pull the radial head down through the anular ligament.

Wrist Joint

Wrist Joint Injuries

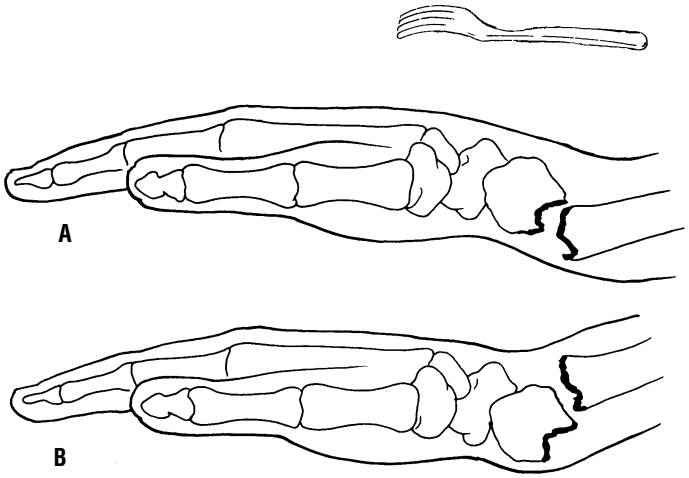
The wrist joint is essentially a synovial joint between the distal end of the radius and the proximal row of carpal bones. The head of the ulna is separated from the carpal bones by the strong triangular fibrocartilaginous ligament, which separates the wrist joint from the distal radioulnar joint. The joint is stabilized by the strong medial and lateral ligaments.

Because the styloid process of the radius is longer than that of the ulna, abduction of the wrist joint is less extensive than adduction. In flexion–extension movements, the hand can be flexed about 80° but extended to only about 45°. The range of flexion is increased by movement at the midcarpal joint.

A fall on the outstretched hand can strain the anterior ligament of the wrist joint, producing synovial effusion, joint pain, and limitation of movement. These symptoms and signs must not be confused with those produced by a fractured scaphoid or dislocation of the lunate bone, which are similar.

Falls on the Outstretched Hand

In falls on the outstretched hand, forces are transmitted from the scaphoid to the distal end of the radius, from the radius across the interosseous membrane to the ulna, and from the ulna to the humerus; thence, through the glenoid fossa of the scapula to the coracoclavicular ligament and the clavicle, and finally, to the sternum. If the forces are excessive, different parts of the upper limb give way under the strain. The area affected seems to be related to age. In a young child, for example, there may be a posterior displacement of the distal radial epiphysis; in the teenager the clavicle might fracture; in the young adult the scaphoid is commonly fractured; and in the elderly the distal end of the radius is fractured about 1 in. (2.5 cm) proximal to the wrist joint (Colles' fracture) (CD Fig. 12-2).



CD Figure 12-2 Fractures of the distal end of the radius. **A.** Colles' fracture. **B.** Smith's fracture.

JOINTS OF THE PELVIS

Changes in the Pelvic Joints with Pregnancy

During pregnancy, the symphysis pubis and the ligaments of the sacroiliac and sacrococcygeal joints undergo softening in response to hormones, thus increasing the mobility and increasing the potential size of the pelvis during childbirth. The hormones responsible are estrogen and progesterone produced by the ovary and the placenta. An additional hormone, called relaxin, produced by these organs can also have a relaxing effect on the pelvic ligaments.

Changes in the Pelvic Joints with Age

Obliteration of the cavity in the sacroiliac joint occurs in both sexes after middle age.

Sacroiliac Joint Disease

The sacroiliac joint is innervated by the lower lumbar and sacral nerves so that disease in the joint can produce low back pain and pain referred along the sciatic nerve (sciatica).

The sacroiliac joint is inaccessible to clinical examination. However, a small area located just medial to and below the posterior superior iliac spine is where the joint comes closest to the surface. In disease of the lumbosacral region, movements of the vertebral column in any direction cause pain in the lumbosacral part of the column. In sacroiliac disease, pain is extreme on rotation of the vertebral column and is worst at the end of forward flexion. The latter movement causes pain because the hamstring muscles hold the hip bones in position while the sacrum is rotating forward as the vertebral column is flexed.

JOINTS OF THE LOWER LIMB

Hip Joint

Referred Pain from the Hip Joint

The femoral nerve not only supplies the hip joint but, via the intermediate and medial cutaneous nerves of the thigh, also supplies the skin of the front and medial side of the thigh. It is not surprising, therefore, for pain originating in the hip joint to be referred to the front and medial side of the thigh. The posterior division of the obturator nerve supplies both the hip and knee joints. This would explain why hip joint disease sometimes gives rise to pain in the knee joint.

Congenital Dislocation of the Hip

The stability of the hip joint depends on the ball-and-socket arrangement of the articular surfaces and the strong ligaments. In congenital dislocation of the hip, the upper lip of the acetabulum fails to develop adequately, and the head of the femur, having no stable platform under which it can lodge, rides up out of the acetabulum onto the gluteal surface of the ilium.

Traumatic Dislocation of the Hip

Traumatic dislocation of the hip is rare because of its strength; it is usually caused by motor vehicle accidents. However, should it occur, it usually does so when the joint is flexed and adducted. The head of the femur is displaced posteriorly out of the acetabulum, and it comes to rest on the gluteal surface of the ilium (posterior dislocation). The close relation of the sciatic nerve to the posterior surface of the joint makes it prone to injury in posterior dislocations.

Hip Joint Stability and Trendelenburg's Sign

The stability of the hip joint when a person stands on one leg with the foot of the opposite leg raised above the ground depends on three factors:

- The gluteus medius and minimus must be functioning normally.
- The head of the femur must be located normally within the acetabulum.
- The neck of the femur must be intact and must have a normal angle with the shaft of the femur.

If any one of these factors is defective, then the pelvis will sink downward on the opposite, unsupported side. The patient is then said to exhibit a positive **Trendelenburg's sign** (CD Fig. 12-3).

Normally, when walking, a person alternately contracts the gluteus medius and minimus, first on one side and then on the other. By this means he or she is able to raise the pelvis first on one side and then on the other, allowing the leg to be flexed at the hip joint and moved forward—that is, the leg is raised clear of the ground before it is thrust forward in taking the forward step. A patient with a right-sided congenital dislocation of the hip, when asked to stand on the right leg and raise the opposite leg clear of the ground, will exhibit a positive Trendelenburg's sign, and the unsupported side of the pelvis will sink below the horizontal. If the patient is asked to walk, he or she will show the characteristic "dipping" gait. In patients with bilateral congenital dislocation of the hip, the gait is typically "waddling" in nature.

Arthritis of the Hip Joint

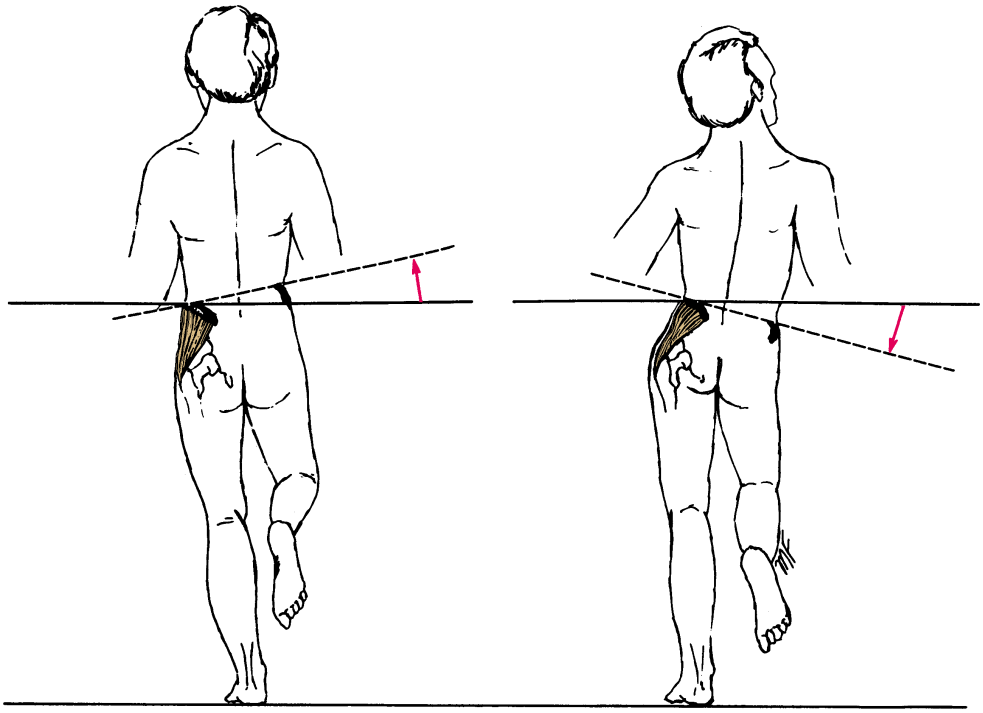
A patient with an inflamed hip joint will place the femur in the position that gives minimum discomfort—that is, the position in which the joint cavity has the greatest capacity to contain the increased amount of synovial fluid secreted. The hip joint is partially flexed, abducted, and externally rotated.

Osteoarthritis, the most common disease of the hip joint in the adult, causes pain, stiffness, and deformity. The pain may be in the hip joint itself or referred to the knee (the obturator nerve supplies both joints). The stiffness is caused by the pain and reflex spasm of the surrounding muscles. The deformity is flexion, adduction, and external rotation and is produced initially by muscle spasm and later by muscle contracture.

Knee Joint

Strength of the Knee Joint

The strength of the knee joint depends on the strength of the ligaments that bind the femur to the tibia and on the tone of the muscles acting on the joint. The most important muscle group is the quadriceps femoris; provided that this is well



CD Figure 12-3 Trendelenburg's test.

developed, it is capable of stabilizing the knee in the presence of torn ligaments.

Knee Injury and the Synovial Membrane

The synovial membrane of the knee joint is extensive, and if the articular surfaces, menisci, or ligaments of the joint are damaged, the large synovial cavity becomes distended with fluid. The wide communication between the suprapatellar bursa and the joint cavity results in this structure becoming distended also. The swelling of the knee extends three or four fingerbreadths above the patella and laterally and medially beneath the aponeuroses of insertion of the vastus lateralis and medialis, respectively.

Ligamentous Injury of the Knee Joint

Four ligaments—the medial collateral ligament, the lateral collateral ligament, the anterior cruciate ligament, and the posterior cruciate ligament—are commonly injured in the knee. Sprains or tears occur depending on the degree of force applied.

Medial Collateral Ligament

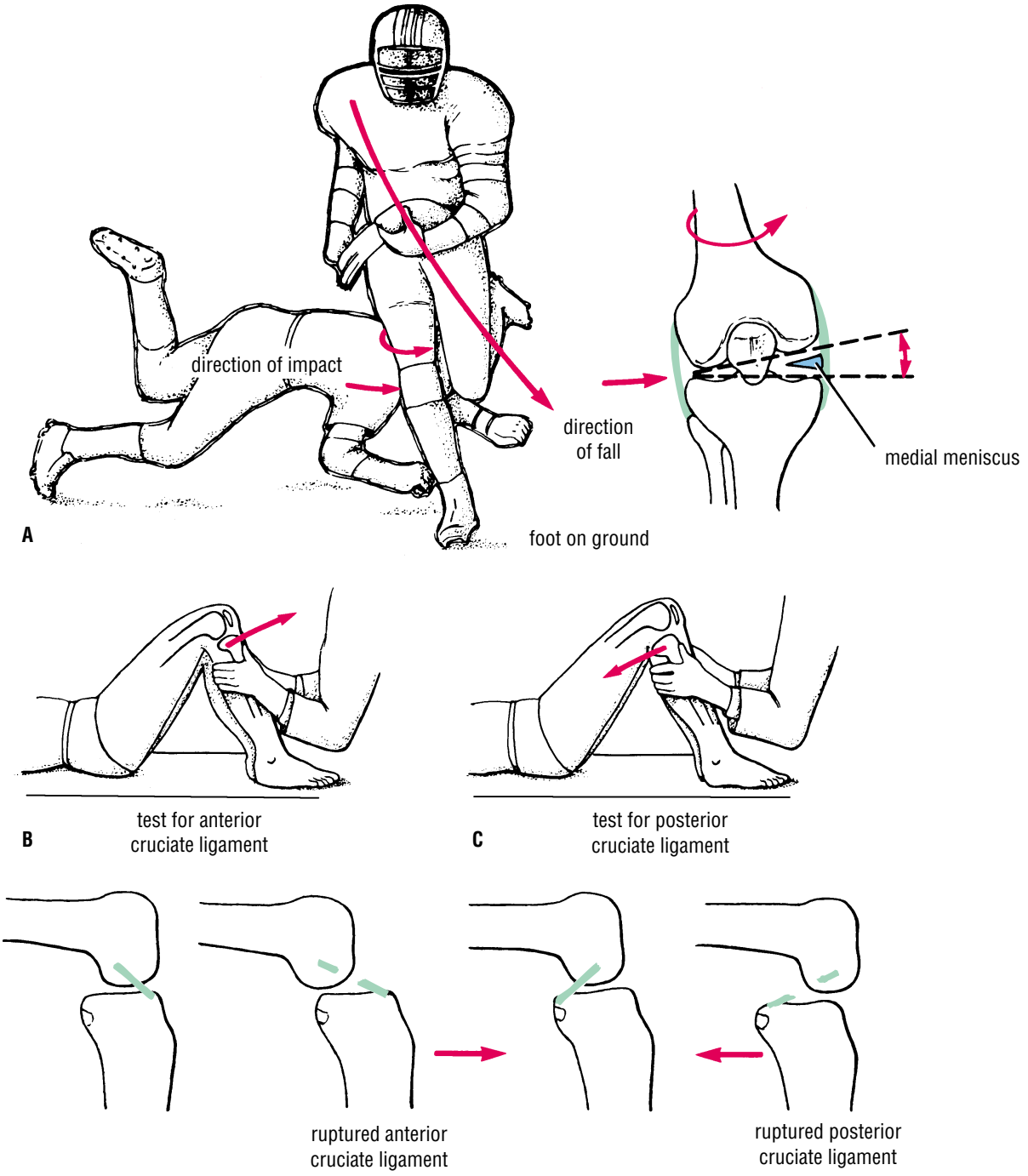
Forced abduction of the tibia on the femur can result in partial tearing of the medial collateral ligament, which can occur at its femoral or tibial attachments. It is useful to remember that tears of the menisci result in localized tenderness on the joint line, whereas sprains of the medial collateral ligament result in tenderness over the femoral or tibial attachments of the ligament.

Lateral Collateral Ligament

Forced adduction of the tibia on the femur can result in injury to the lateral collateral ligament (less common than medial ligament injury).

Cruciate Ligaments

Injury to the cruciate ligaments can occur when excessive force is applied to the knee joint. Tears of the anterior cruciate ligament are common; tears of the posterior cruciate ligament are rare. The injury is always accompanied by damage to other knee structures; the collateral ligaments are commonly torn or the capsule may be damaged. The joint cavity quickly fills with blood (hemarthrosis) so that the joint is swollen. Examination of patients with a ruptured anterior cruciate ligament shows that the tibia can be pulled excessively forward on the femur; with rupture of the posterior cruciate ligament, the tibia can be made to move excessively backward on the femur (CD Fig. 12-4). Because the stability of the knee joint depends largely on the tone of the quadriceps femoris muscle and the integrity



CD Figure 12-4 **A.** Mechanism involved in damage to the medial meniscus of the knee joint from playing football. Note that the right knee joint is semiflexed and that medial rotation of the femur on the tibia occurs. The impact causes forced abduction of the tibia on the femur, and the medial meniscus is pulled into an abnormal position. The cartilaginous meniscus is then ground between the femur and the tibia. **B.** Test for integrity of the anterior cruciate ligament. **C.** Test for integrity of the posterior cruciate ligament.

of the collateral ligaments, operative repair of isolated torn cruciate ligaments is not always attempted. The knee is immobilized in slight flexion in a cast, and active physiotherapy on the quadriceps femoris muscle is begun at once. Should, however, the capsule of the joint and the collateral ligaments be torn in addition, early operative repair is essential.

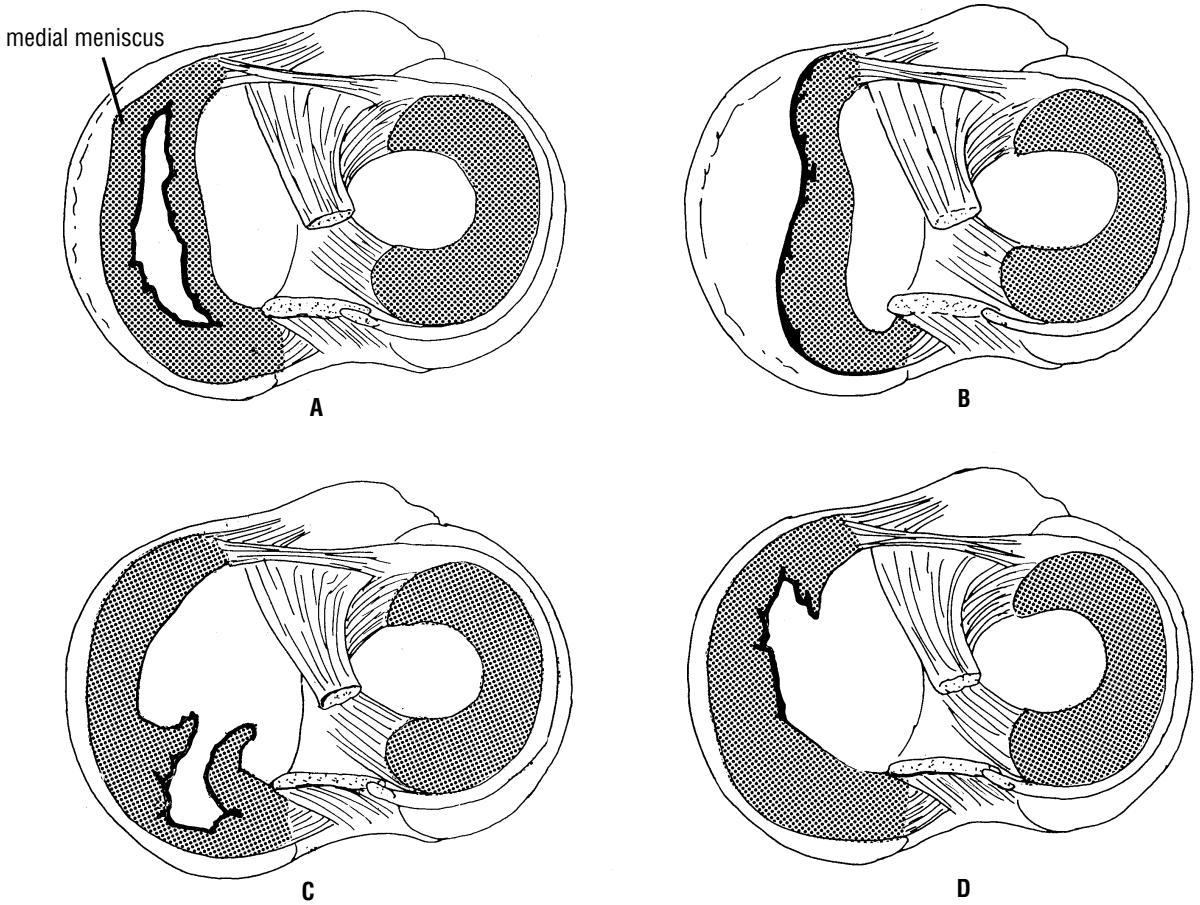
Meniscal Injury of the Knee Joint

Injuries of the menisci are common. The medial meniscus is damaged much more frequently than the lateral, and this is probably because of its strong attachment to the medial collateral ligament of the knee joint, which restricts its mobility. The injury occurs when the femur is rotated on the tibia, or the tibia is rotated on the femur, with the knee joint partially flexed and taking the weight of the body. The tibia is usually abducted on the femur, and the medial meniscus is pulled into an abnormal position between the femoral and tibial condyles (CD Fig. 12-4A). A sudden movement between the condyles results in the meniscus being subjected to a severe grinding force, and it splits along its length (CD Fig. 12-5). When the torn part of the meniscus becomes wedged between the articular surfaces, further movement is impossible, and the joint is said to "lock."

Injury to the lateral meniscus is less common, probably because it is not attached to the lateral collateral ligament of the knee joint and is consequently more mobile. The popliteus muscle sends a few of its fibers into the lateral meniscus, and these can pull the meniscus into a more favorable position during sudden movements of the knee joint.

Pneumoarthrography of the Knee Joint

Air can be injected into the synovial cavity of the knee joint so that soft tissues can be studied. This technique is based on the fact that air is less radiopaque than structures such as the medial and lateral menisci, so their outline can be visualized on a radiograph (see text Fig. 12-43).



CD Figure 12-5 Tears of the medial meniscus of the knee joint. **A.** Complete bucket handle tear. **B.** The meniscus is torn from its peripheral attachment. **C.** Tear of the posterior portion of the meniscus. **D.** Tear of the anterior portion of the meniscus.

Arthroscopy of the Knee Joint

Arthroscopy involves the introduction of a lighted instrument into the synovial cavity of the knee joint through a small incision. This technique permits the direct visualization of structures, such as the cruciate ligaments and the menisci, for diagnostic purposes.

Ankle Joint

Ankle Joint Stability

The ankle joint is a hinge joint possessing great stability. The deep mortise formed by the lower end of the tibia and the medial and lateral malleoli securely holds the talus in position.

Acute Sprains of the "Lateral Ankle"

Acute sprains of the lateral ankle are usually caused by excessive inversion of the foot with plantar flexion of the ankle. The anterior talofibular ligament and the calcaneofibular ligament are partially torn, giving rise to great pain and local swelling.

Acute Sprains of the "Medial Ankle"

Acute sprains of the medial ankle are similar to but less common than those of the lateral ankle. They may occur to the medial or deltoid ligament as a result of excessive eversion. The great strength of the medial ligament usually results in the ligament pulling off the tip of the medial malleolus.

Fracture Dislocations of the Ankle Joint

Fracture dislocations of the ankle are common and are caused by forced external rotation and overeversion of the foot. The talus is externally rotated forcibly against the lateral malleolus of the fibula. The torsion effect on the lateral malleolus causes it to fracture spirally. If the force continues, the talus moves laterally, and the medial ligament of the ankle joint becomes taut and pulls off the tip of the medial malleolus. If the talus is forced to move still farther, its rotary movement results in its violent contact with the posterior inferior margin of the tibia, which shears off.

Other less common types of fracture dislocation are caused by forced overeversion (without rotation), in which the talus presses the lateral malleolus laterally and causes it to fracture transversely. Overinversion (without rotation), in which the talus presses against the medial malleolus, produces a vertical fracture through the base of the medial malleolus.

Joints of the Foot

Metatarsophalangeal Joint of the Big Toe

Hallux valgus, which is a lateral deviation of the great toe at the metatarsophalangeal joint, is a common condition. Its incidence is greater in women than in men and is associated with badly fitting shoes. It is often accompanied by the presence of a short first metatarsal bone. Once the deformity is established, it is progressively worsened by the pull of the flexor hallucis longus and extensor hallucis longus muscles. Later, osteoarthritic changes occur in the metatarsophalangeal joint, which then becomes stiff and painful; the condition is then known as **hallux rigidus.**

Clinical Examination of the Arches of the Foot

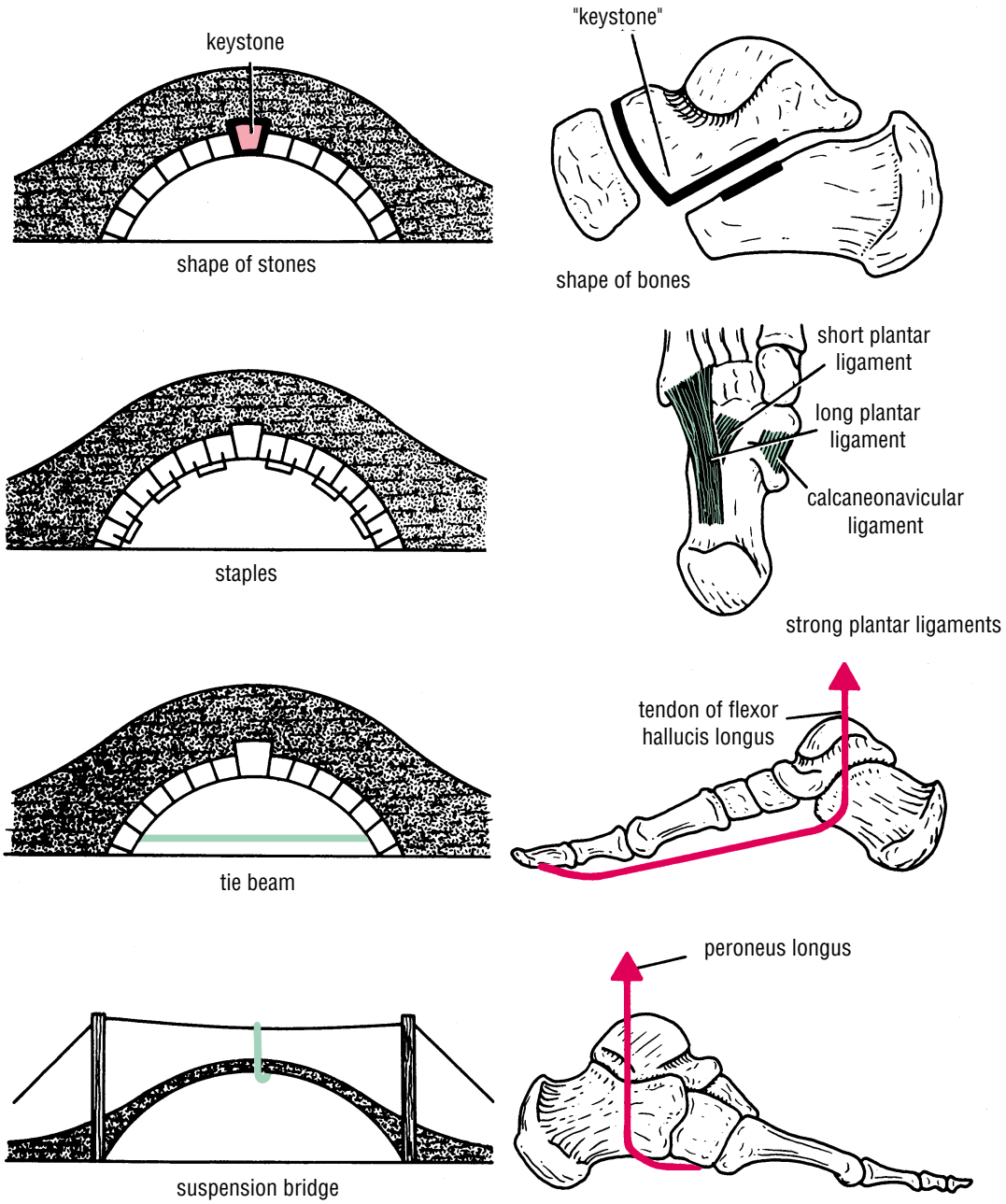
On examination of the imprint of a wet foot on the floor made with the person in the standing position, one can see that the heel, the lateral margin of the foot, the pad under the metatarsal heads, and the pads of the distal phalanges are in contact with the ground (see text Figs. 12-41 and 12-42). The medial margin of the foot, from the heel to the first metatarsal head, is arched above the ground because of the important medial longitudinal arch. The pressure exerted on the ground by the lateral margin of the foot is greatest at the heel and the fifth metatarsal head and least between these areas because of the presence of the low-lying lateral longitudinal arch. The transverse arch involves the bases of the five metatarsals and the cuboid and cuneiform bones. This is, in fact, only half an arch, with its base on the lateral border of the foot and its summit on the foot's medial border. The foot has been likened to a half-dome, so that when the medial borders of the two feet are placed together, a complete dome is formed.

From this description, it can be understood that the body weight on standing is distributed through a foot via the heel behind and six points of contact with the ground in front, namely, the two sesamoid bones under the head of the first metatarsal and the heads of the remaining four metatarsals.

The "Stone Bridge" Mechanisms for Arch Support

Examination of the design of any stone bridge reveals the following engineering methods used for its support (CD Fig. 12-6).

- **The shape of the stones:** The most effective way of supporting the arch is to make the stones wedge shaped, with the thin edge of the wedge lying inferiorly. This applies particularly to the important stone that occupies



CD Figure 12-6 Different methods by which the arches of the foot may be supported.

the center of the arch and is referred to as the "keystone."

- **The inferior edges of the stones are tied together:** This is accomplished by interlocking the stones or binding their lower edges together with metal staples. This method effectively counteracts the tendency of the lower edges of the stones to separate when the arch is weightbearing.
- **The use of the tie beams:** When the span of the bridge is large and the foundations at either end are insecure, a tie beam connecting the ends effectively prevents separation of the pillars and consequent sagging of the arch.
- **A suspension bridge:** Here, the maintenance of the arch depends on multiple supports suspending the arch from a cable above the level of the bridge.

Using the bridge analogy, one can now examine the methods used to support the arches of the feet (see CD Fig. 12-6).

Maintenance of the Medial Longitudinal Arch

- **Shape of the bones:** The sustentaculum tali hold up the talus; the concave proximal surface of the navicular bone receives the rounded head of the talus; the slight concavity of the proximal surface of the medial cuneiform bone receives the navicular. The rounded head of the talus is the keystone in the center of the arch (see CD Fig. 12-6).
- **The inferior edges of the bones are tied together** by the plantar ligaments, which are larger and stronger than the dorsal ligaments. The most important ligament is the plantar calcaneonavicular ligament (see CD Fig. 12-6). The tendinous extensions of the insertion of the tibialis posterior muscle play an important role in this respect.
- **Tying the ends of the arch together** are the plantar aponeurosis, the medial part of the flexor digitorum brevis, the abductor hallucis, the flexor hallucis longus, the medial part of the flexor digitorum longus, and the flexor hallucis brevis (see CD Fig. 12-6).
- **Suspending the arch from above** are the tibialis anterior and posterior and the medial ligament of the ankle joint.

Maintenance of the Lateral Longitudinal Arch

- **Shape of the bones:** Minimal shaping of the distal end of the calcaneum and the proximal end of the cuboid. The cuboid is the keystone.
- **The inferior edges of the bones are tied together** by the long and short plantar ligaments and the origins of the short muscles from the forepart of the foot (see CD Fig. 12-6).
- **Tying the ends of the arch together** are the plantar aponeurosis, the abductor digiti minimi, and the lateral part of the flexor digitorum longus and brevis.
- **Suspending the arch from above** are the peroneus longus and the brevis (see CD Fig. 12-6).

Maintenance of the Transverse Arch

- **Shape of the bones:** The marked wedge shaping of the cuneiform bones and the bases of the metatarsal bones (see text Fig. 12-42)
- **The inferior edges of the bones are tied together** by the deep transverse ligaments, the strong plantar ligaments, and the origins of the plantar muscles from the forepart of the foot; the dorsal interossei and the transverse head of the adductor hallucis are particularly important in this respect.
- **Tying the ends of the arch together** is the peroneus longus tendon.
- **Suspending the arch from above** are the peroneus longus tendon and the peroneus brevis.

PHYSIOLOGIC NOTE

Muscle Tone and the Arches of the Foot

The arches of the feet are maintained by the shape of the bones, strong ligaments, and muscle tone. Which of these factors is the most important? Basmajian and Stecko demonstrated electromyographically that the tibialis anterior, the peroneus longus, and the small muscles of the foot play no important role in the normal static support of the arches. They are commonly totally inactive. However, during walking and running, all these muscles become active. Standing immobile for long periods, especially if the person is overweight, places excessive strain on the bones and ligaments of the feet and results in fallen arches or flat feet. Athletes, route-marching soldiers, and nurses are able to sustain their arches provided that they receive adequate training to develop their muscle tone.

Clinical Problems Associated with the Arches of the Foot

Of the three arches, the medial longitudinal is the largest and clinically the most important. The shape of the bones, the strong ligaments, especially those on the plantar surface of the foot, and the tone of muscles all play an important role in supporting the arches. It has been shown that in the active foot the tone of muscles is an important factor in arch support. When the muscles are fatigued by excessive exercise (a long-route march by an army recruit), by standing for long periods (waitress or nurse), by being overweight, or by illness, the muscular support gives way, the ligaments are stretched, and pain is produced.

Pes planus (flat foot) is a condition in which the medial longitudinal arch is depressed or collapsed. As a result, the forefoot is displaced laterally and everted. The head of the talus is no longer supported, and the body weight forces it downward and medially between the calcaneum and the navicular bone. When the deformity has existed for some time, the plantar, calcaneonavicular, and medial ligaments of the ankle joint become permanently stretched, and the bones change shape. The muscles and tendons are also permanently stretched. The causes of flat foot are both congenital and acquired.

Pes cavus (clawfoot) is a condition in which the medial longitudinal arch is unduly high. Most cases are caused by muscle imbalance, in many instances resulting from poliomyelitis.

Clinical Problem Solving Questions

Read the following case histories/questions and give the best answer for each.

General Joint Questions

A 31-year-old woman has a history of poliomyelitis affecting the anterior horn cells of the lower thoracic and lumbar segments of the spinal cord on the left side. On examination, she has severe right lateral flexion deformity of the vertebral column.

1. The following statements are true about this case **except** which?
   A. The virus of poliomyelitis attacks and destroys the motor anterior horn cells of the spinal cord.
   B. The disease resulted in the paralysis of the muscles that normally laterally flex the vertebral column on the left side.
   C. The muscles on the right side of the vertebral column are unapposed.
   D. The right lateral flexion deformity is caused by the slow degeneration of the sensory nerve fibers originating from the vertebral muscles on the right side.

A 20-year-old woman severely sprains her left ankle while playing tennis. When she tries to move the foot so that the sole faces medially, she experiences severe pain.

2. What is the correct anatomic term for the movement of the foot that produces the pain?
   A. Pronation
   B. Inversion
   C. Supination
   D. Eversion

Joints of the Skull

3. An exhausted medical student decided to brush up on gross anatomy by attending a lecture given by an old and revered visiting professor. After 45 minutes the lecture began to bore him, and his mind began to wander. He could not forget the attractive brunette nurse in the surgical clinic whom he had dated the previous evening. After 5 more minutes he found he just could not keep his eyes open. When would this lecture end? Just then, he involuntarily opened his mouth wide and yawned. To his great consternation he could not close his mouth. His jaw was stuck in the open position. What is your diagnosis?

Joints of the Vertebral Column

An 11-year-old boy was showing off in front of friends by diving into the shallow end of a swimming pool. After one particularly daring dive, he surfaced quickly and climbed out of the pool, holding his head between his hands. He said that he had hit the bottom of the pool with his head and now had severe pain in the root of the neck, which was made worse when he tried to move his neck. A lateral radiograph revealed that the right inferior articular process of the fifth cervical vertebra was forced over the anterior margin of the right superior articular process of the sixth cervical vertebra, producing a unilateral dislocation with nipping of the right sixth cervical nerve.

4. The following symptoms and signs confirmed the diagnosis **except** which?
   A. The head was rotated to the right.
   B. There was spasm of the deep neck muscles on the right side of the neck, which were tender to touch.
   C. The patient complained of severe pain in the region of the back of the neck and right shoulder.
   D. The slightest movement produced severe pain in the right sixth cervical dermatome.
   E. The large size of the vertebral canal in the cervical region permitted the spinal cord to escape injury.

A 50-year-old coal miner was crouching at the mine face when a large rock suddenly became dislodged from the roof of the mine shaft and struck him on the upper part of his back. The emergency department physician suspected a displacement of the upper thoracic spines on the sixth thoracic spine.

5. The following physical signs confirmed a diagnosis of fracture dislocation between the fifth and sixth thoracic vertebrae **except** which?
   A. A lateral radiograph revealed fractures involving the superior articular processes of the sixth thoracic vertebra and the inferior articular processes of the fifth thoracic vertebra.
   B. Considerable forward displacement of the body of the fifth thoracic vertebra on the sixth thoracic vertebra occurred.
   C. The patient had signs and symptoms of spinal shock.
   D. The large size of the vertebral canal in the thoracic region leaves plenty of space around the spinal cord for bony displacement.
   E. The patient later showed signs and symptoms of paraplegia.

A 66-year-old woman was seen in the emergency department complaining of a burning pain over the upper part of her right arm. The pain had started 2 days previously and had progressively worsened. Physical examination revealed weakness and wasting of the right

deltoid and biceps brachii muscles. The patient also had hyperesthesia in the skin over the lower part of the right deltoid and down the lateral side of the arm. Radiologic examination showed extensive spur formation on the bodies of the fourth, fifth, and sixth cervical vertebrae. These signs and symptoms suggested severe osteoarthritis of the cervical vertebral column.

6. This disease produced the following changes in the vertebrae and related structures **except** which?
   A. Repeated trauma and aging had resulted in degenerative changes at the articulating surfaces of the fourth, fifth, and sixth cervical vertebrae.
   B. Extensive spur formation resulted in narrowing of the intervertebral foramina with pressure on the nerve roots.
   C. The burning pain and hyperesthesia were caused by pressure on the third and fourth cervical posterior roots.
   D. The weakness and wasting of the deltoid and biceps brachii muscles were caused by pressure on the fifth and sixth cervical anterior roots.
   E. Movements of the neck intensified the symptoms by exerting further pressure on the nerve roots.
   F. Coughing or sneezing raised the pressure within the vertebral canal and resulted in further pressure on the roots.

A medical student offered to move a grand piano for his landlady. He had just finished his final examinations in anatomy and was in poor physical shape. He struggled with the antique monstrosity and suddenly experienced an acute pain in the back, which extended down the back and outer side of his left leg. On examination in the emergency department, he was found to have a slight scoliosis with the convexity on the right side. The deep muscles of the back in the left lumbar region felt firmer than normal. No evidence of muscle weakness was present, but the left ankle jerk was diminished.

7. The symptoms and signs of this patient strongly suggest a diagnosis of prolapsed intervertebral disc **except** which?
   A. The pain was the worst over the left lumbar region opposite the fifth lumbar spine.
   B. The pain was accentuated by coughing.
   C. With the patient supine, flexing the left hip joint with the knee extended caused a marked increase in the pain.
   D. A lateral radiograph of the lumbar vertebral column revealed nothing abnormal.
   E. A magnetic resonance imaging study revealed the presence of small fragments of the nucleus pulposus that had herniated outside the anulus in the disc between the fifth lumbar vertebra and the sacrum.
   F. The pain occurred in the dermatomes of the third and fourth lumbar segments on the left side.

A 22-year-old student was driving home from a party and crashed his car head on into a brick wall. On examination in the emergency department, he was found to have a fracture dislocation of the seventh thoracic vertebra, with signs and symptoms of severe damage to the spinal cord.

8. On recovery from spinal shock, he was found to have the following signs and symptoms **except** which?
   A. Fracture dislocation of the seventh thoracic vertebra, which would result in severe damage to the seventh thoracic segment of the spinal cord
   B. A band of cutaneous hyperesthesia extending around the abdominal wall on the left side at the level of the umbilicus that was caused by the irritation of the cord immediately above the site of the lesion
   C. On the right side, total analgesia, thermoanesthesia, and partial loss of tactile sense of the skin of the abdominal wall below the level of the umbilicus involving the whole of the right leg
   D. Upper motor neuron paralysis of his left leg
   E. Unequal sensory and motor losses on the two sides, which indicate a left hemisection of the spinal cord

Joints of the Ribs

9. A 36-year-old woman went sailing with her husband and they were caught in a severe gale. While the husband at the helm desperately managed to keep the boat under control, the wife tried to get the sails down. Eventually the squall died down and they were able to return safely to port. The next morning, the woman woke up with severe pain over the left side of her chest. On being examined in the emergency department of the local hospital for a suspected myocardial infarction, the physician found that the patient was acutely tender over her left costal margin, which was made worse on taking a deep breath. What is the possible diagnosis?

Joints of the Upper Extremity

10. Separation of the acromioclavicular joint is common in football and soccer players. Explain why such separations are unstable after reduction.

A father, seeing his 3-year-old son playing in the garden, ran up and picked him up by both hands and swung him around in a circle. The child's enjoyment suddenly turned to tears, and he said his left elbow hurt. On examination, the child held his left elbow joint semiflexed and his forearm pronated.

11. The following statements concerning this case are consistent with the diagnosis of dislocation of the superior radioulnar joint **except** which?
   A. The head of the radius was pulled out of the anular ligament.

B. At age 3 years, the child's anular ligament has a large diameter and the head of the radius can easily be pulled out of the ligament by traction.
C. The incidence of this condition is equal in both sexes.
D. The pain from the joint caused reflex contraction of the surrounding muscles to protect the joint from further movement.
E. The subluxation of the joint can be treated by pulling downward on the forearm and at the same time performing the movement of pronation and supination. Finally, the elbow joint is flexed and held in that position.

A 60-year-old woman fell down the stairs and was admitted to the emergency department with severe right shoulder pain. On examination, the patient was sitting up with her right arm by her side and her right elbow joint supported by the left hand. Inspection of the right shoulder showed loss of the normal rounded curvature and evidence of a slight swelling below the right clavicle. Any attempt at active or passive movement of the shoulder joint was stopped by severe pain in the shoulder. A diagnosis of dislocation of the right shoulder joint was made.

12. The following statements concerning this patient are consistent with the diagnosis **except** which?
A. This patient had a subcoracoid dislocation of the right shoulder joint.
B. The head of the humerus was dislocated downward through the weakest part of the capsule of the joint.
C. The pull of the pectoralis major and subscapularis muscles had displaced the upper end of the humerus medially.
D. The greater tuberosity of the humerus no longer displaced the deltoid muscle laterally, and the curve of the shoulder was lost.
E. The integrity of the axillary nerve should always be tested by touching the skin over the upper half of the deltoid muscle.

A 63-year-old man fell down a flight of stairs and sustained a fracture of the lower end of the left radius. On examination the distal end of the radius was displaced posteriorly. This patient had sustained a Colles' fracture.

13. The following statements concerning this case are correct **except** which?
A. Occasionally the styloid process of the ulna is also fractured.
B. The median nerve may be injured at the time of the fall.
C. When the fracture is reduced, the styloid process of the radius should come to lie about 0.75 in. (1.9 cm) proximal to that of the ulna.
D. The fracture produces posterior angulation of the distal fragment of the radius.
E. On reduction of the fracture the distal end of the radius should lie at an angle of 15° anteriorly.
F. The hand should always be splinted in the position of function.

A 22-year-old medical student fell off her bicycle onto her outstretched hand. She thought she had sprained her right wrist joint and treated herself by binding her wrist with an elastic bandage. Three weeks later, however, she was still experiencing pain on moving her wrist and so decided to visit the emergency department. On examination of the dorsal surfaces of both hands, with the fingers and thumbs fully extended, a localized tenderness could be felt in the anatomic snuffbox of her right hand. A diagnosis of fracture of the right scaphoid bone was made.

14. The following statements concerning this patient are correct **except** which?
A. The scaphoid bone is an easy bone to immobilize because of its small size.
B. A bony fragment deprived of its blood supply may undergo ischemic necrosis.
C. Because the scaphoid bone articulates with other bones, the fracture line may enter a joint cavity and become bathed in synovial fluid, which would inhibit repair.
D. The fracture line on the scaphoid bone may deprive the proximal fragment of its arterial supply.
E. Fractures of the scaphoid bone have a high incidence of nonunion.

15. A 46-year-old woman slipped on a shiny floor and sustained a fracture of the fifth metacarpal bone on her left hand. What type of angulation of the fragments is commonly found in fractures at this site? When a splint is applied with the little finger flexed, in which direction should the little finger be pointing?

Joints of the Lower Extremity

A medical student, while playing football, collided with another player and fell to the ground. As he fell, the right knee, which was taking the weight of his body, was partially flexed; the femur was rotated medially; and the leg was abducted on the thigh. A sudden pain was felt in the right knee joint, and he was unable to extend it. The student was diagnosed as having a torn medial meniscus of the knee joint.

16. The following statements concerning this case confirmed the diagnosis **except** which?
A. The right knee joint quickly became swollen.
B. Severe local tenderness was felt along the medial side of the joint line.
C. The medial meniscus split along part of its length, and the detached portion became jammed between the articular surfaces, limiting further extension.

D. The trauma stimulated the production of synovial fluid, which filled the joint cavity.
E. The distension of the suprapatellar bursa was responsible for the large amount of swelling above the injured knee.
F. The pain sensation from the injured knee was confined to the femoral nerve as it ascended to the central nervous system.

A 27-year-old woman was found to have an unstable right knee joint following a severe automobile accident. On examination it was possible to pull the tibia excessively forward on the femur. A diagnosis of ruptured anterior cruciate ligament was made.

17. The following statements concerning this patient are correct **except** which?
    A. The anterior cruciate ligament is attached to the tibia in the anterior part of the intercondylar area.
    B. The anterior cruciate ligament passes upward, backward, and laterally from its tibial attachment.
    C. The anterior cruciate ligament is attached above to the posterior part of the medial surface of the lateral femoral condyle.
    D. The anterior cruciate ligament is more commonly torn than is the posterior cruciate ligament.
    E. Because the cruciate ligaments are located outside the synovial membrane, bleeding from a torn ligament does not enter the joint cavity.

A 25-year-old man was running across a field when he caught his right foot in a rabbit hole. As he fell, the right foot was violently rotated laterally and overeverted. On attempting to stand, he could place no weight on his right foot. On examination by a physician, the right ankle was considerably swollen, especially on the lateral side. After further examination, including a radiograph of the ankle, a diagnosis of severe fracture dislocation of the ankle joint was made.

18. The following statements concerning this patient are correct **except** which?
    A. This type of fracture dislocation is caused by forced external rotation and overeversion of the foot.
    B. The talus is externally rotated against the lateral malleolus of the fibula, causing it to fracture.
    C. The medial ligament of the ankle joint is strong and never ruptures.
    D. The torsion effect on the lateral malleolus produces a spiral fracture.
    E. If the talus is forced to move farther laterally and continues to rotate, the posterior inferior margin of the tibia will be sheared off.

Answers and Explanations

1. **D** is the correct answer. The right lateral flexion deformity is not caused by the slow degeneration of the sensory nerve fibers originating from the vertebral muscle on the right side. It is the motor nerves supplying the vertebral muscles on the left side that are affected in this patient.

2. **B** is the correct answer. Moving the foot at the subtalar and midtarsal joints so that the sole faces medially is called inversion.

3. The student had dislocated his temporomandibular joints on both sides. When he yawned, his lateral pterygoid muscles reflexly contracted forcibly and pulled the head of the mandible and the articular disc forward over the summit of the articular tubercle in each joint. Reduction is easily performed by pressing gloved thumbs downward and backward on the last molar teeth. The lateral pterygoid, the temporalis, and the masseter muscle tension is overcome and the head of the mandible snaps back over the articular tubercle to assume its normal anatomical position.

4. **A** is the correct answer. The right inferior articular process of the fifth cervical vertebra was forced over the anterior margin of the right superior articular process of the sixth cervical vertebra, causing the head of the patient to be rotated to the left.

5. **D** is the correct answer. The vertebral canal in the thoracic region is small and round and little space is around the spinal cord for bony displacement to occur without causing severe damage to the cord.

6. **C** is the correct answer. The burning pain and hyperesthesia were caused by pressure on the fifth and sixth cervical posterior roots.

7. **F** is the correct answer. The pain occurred in the dermatomes of the fifth lumbar and first sacral segments on the left side.

8. **A** is the correct answer. Fracture dislocation of the seventh thoracic vertebra would result in severe damage to the tenth thoracic segment of the spinal cord.

9. The localized tenderness over the left costal margin is strongly suggestive of subluxation of one of the interchondral joints on the costal margin. Subluxation of a joint implies that the ligaments and capsule are stretched or torn but the damage is not so severe that the articulating surfaces lose contact with one another. This condition can be extremely painful and in this patient was secondary to trauma caused by excessive pulling of the muscles connecting the thoracic cage to the upper limb. The sixth, seventh, eighth, ninth, and tenth costal cartilages articulate with each other along their borders by small synovial joints.

10. In subluxation of the acromioclavicular joint, the lateral end of the clavicle elevates and becomes more prominent than normal; there is a definite step down onto the acromion. A dislocation occurs when the damage to the restraining structures is more severe and the articulating surfaces lose contact with one another. In the case of the acromioclavicular joint, the clavicle rises above the acromion and the joint is very unstable.

    The main strength of the acromioclavicular joint depends on the integrity of the strong coracoclavicular ligament (see text Fig. 12-14). Should this ligament be disrupted, the acromioclavicular joint dislocates; the lateral end of the clavicle rides over the acromion and the upper limb is depressed.

11. **B** is the correct answer. Under age 6 years, the child's head of the radius is of a relatively small size and may easily be pulled out of the anular ligament by traction on the forearm.

12. **E** is the correct answer. The integrity of the axillary nerve is tested by touching the skin over the lower half of the deltoid muscle. The skin of the curve of the shoulder, including the skin covering the upper half of the deltoid muscle, is supplied by the supraclavicular nerves.

13. **C** is the correct answer. The normal position of the tip of the styloid process of the radius is about 0.75 in. (1.9 cm) distal to that of the ulna.

14. **A** is the correct answer. The scaphoid bone is a difficult bone to immobilize because of its position and small size.

15. Fractured metacarpal bones show dorsal angulation caused by the forward pull of the long flexor tendons and the lumbricals and interossei on the distal fragment. When flexed individually, all fingers (excluding the thumb) point toward the tubercle of the scaphoid. When a finger is unstable following a fracture, it should be aligned so that its tip points to the scaphoid tubercle; failure to achieve this will result in malfunction.

16. **F** is the correct answer. The sensation of pain from the knee joint ascends to the central nervous system via the femoral, obturator, common peroneal, and tibial nerves.

17. **E** is the correct answer. The synovial membrane covering the cruciate ligaments (see text Fig. 12-31) is torn along with the ligaments, and the joint cavity quickly fills with blood.

18. **C** is the correct answer. Although the medial ligament of the ankle joint is strong, extreme force can result in rupture of the ligament, the ligament can be torn from the medial malleolus, or the pull on the ligament can fracture the medial malleolus.