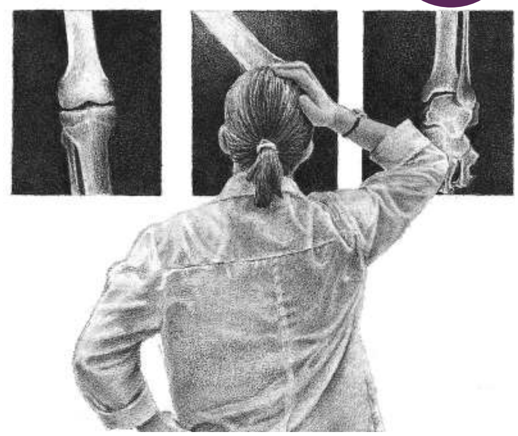
Chapter 2

RADIOLOGIC EVALUATION, SEARCH PATTERNS, AND DIAGNOSIS



CHAPTER OUTLINE

Where Does Radiologic Image Interpretation Begin?[1–21]

Radiologic image interpretation requires foundations in imaging technology, dimensional perceptions of anatomy, characteristic patterns of pathology, and an organized method of visually searching the image for abnormalities. A *search pattern* describes such a methodology.

Learning a tried-and-true search pattern is a good place to start looking at images in a meaningful manner. But it is wise to be a cautious learner. Strict application of an established search pattern might appear to the novice to make diagnosis easy. There are times when diagnosis is easy—a dislocated joint or a fractured bone is plain for anyone to see. Often, however, the normal anatomic variants, complexity of multiple diagnoses, deviations in disease presentation, and insignificant findings that later prove significant (or the opposite) can make interpretation exceedingly difficult.

What Are the Pitfalls of Image Interpretation?

Errors! Errors in radiographic interpretation have been researched for more than 60 years and continue to be studied in an effort to understand and minimize sources of error.[1,2] Errors can be classified as *errors of observation* **or** *errors of interpretation.* Errors of observation can be linked to incomplete or faulty search patterns. Errors in interpretation can be linked to the practitioner's failure to link abnormal radiologic signs to relevant clinical data.

Be aware, however, that errors in reading images are inevitable and should not be confused with carelessness on the part of the reader.[15,16] Rather, errors are a consequence of the physiological process of perception, an unavoidable hazard of the human condition. And despite 21st-century advancements, technology has not solved the problem of perceptual error but only displaced it to newer technologies. Attempts to identify factors that contribute to or reduce errors in reading images are ongoing. One factor known to reduce error is *communication between the clinician and radiologist.*

What Can the Nonradiologist Offer to Image Interpretation?

The nonradiologist can offer expertise from her or his own area of clinical specialty and *collaborate* with the radiologist and others involved in the patient's care to effect a positive patient outcome. An example of this is seen in the military's use of physical therapists as primary musculoskeletal screeners. A 1973 study of more than 2,117 patients presenting with low back pain and screened by physical therapists demonstrated a *decrease* in radiologic examination by more than 50%.[21] These physical therapists had sufficient additional training in basic radiology to assist them in discriminating which differential musculoskeletal diagnoses needed to be defined by radiology and which ones were inconsequential to radiologic examination. The significant factor was the physical therapist's specialty in musculoskeletal physical examination.

Where does radiologic interpretation begin for the nonradiologist? Chapter 1 covered fundamentals of x-ray technology and the perception of three-dimensional anatomy on a two-dimensional image. This chapter covers the fundamentals of a basic search pattern and describes the radiologic characteristics of some common pathologies that often appear in the patient population treated by rehabilitation clinicians. These fundamentals should promote an understanding of what radiology can offer, and they should facilitate interprofessional and intraprofessional communication about the patient. Professional collaboration to enhance the quality of patient care remains the singular most important goal.

Search Pattern: The ABCS of Radiologic Analysis[22–33]

A *search pattern* describes the methodology that one applies to look at an image in an organized fashion. Viewing the radiograph, expecting abnormalities to be conspicuous, is not enough. Consistent use of a search pattern helps to ensure that everything possible to observe has been visually accounted for. Employing a search pattern is equivalent to gathering data—a critical step in the diagnostic process. A popular search pattern for musculoskeletal images exists in the form of the acronym *ABCS* (Table 2-1).

TABLE 2-1 ● *ABCS Search Pattern for Radiologic Image Interpretation*

Division	Evaluates	Look For: *Normal Findings*	Look For: *Variations/Abnormalities*
A: Alignment	General skeletal architecture	• Gross normal size of bones • Normal number of bones	• Supernumerary bones • Absent bones • Congenital deformities • Developmental deformities
	General contour of bone	• Smooth and continuous cortical outlines	• Cortical fractures • Avulsion fractures • Impaction fractures • Spurs • Markings of past surgical sites
	Alignment of bones to adjacent bones	• Normal joint articulations • Normal spatial relationships	• Fracture • Joint subluxation • Joint dislocation
B: Bone Density	General bone density	• Sufficient contrast soft tissue shade of gray and bone shade of gray • Sufficient contrast within each bone, between cortical shell and cancellous center	• General loss of bone density resulting in poor contrast between soft tissues and bone • Thinning or absence of cortical margins
	Textural abnormalities	• Normal trabecular architecture	• Appearance of trabeculae altered; may look thin, delicate, lacy, coarsened, smudged, fluffy
	Local bone density changes	• Sclerosis at areas of increased stress, such as weight-bearing surfaces or sites of ligamentous, muscular, or tendinous attachments	• Excessive sclerosis • Reactive sclerosis that walls off a lesion • Osteophytes
C: Cartilage Spaces	Joint space width	• Well-preserved joint spaces imply normal cartilage or disk thickness	• Decreased joint spaces imply degenerative or traumatic conditions
	Subchondral bone	• Smooth surface	• Excessive sclerosis as seen in degenerative joint disease • Erosions as seen in the inflammatory arthritides
	Epiphyseal plates	• Normal size relative to epiphysis and skeletal age	• Compare contralaterally for changes in thickness that may be related to abnormal conditions or trauma
S: Soft Tissues	Muscles	• Normal size of soft tissue image	• Gross wasting • Gross swelling
	Fat pads and fat lines	• Radiolucent crescent parallel to bone • Radiolucent lines parallel to length of muscle	• Displacement of fat pads from bony fossae into soft tissues indicates joint effusion • Elevation or blurring of fat planes indicates swelling of nearby tissues
	Joint capsules	• Normally indistinct	• Observe whether effusion or hemorrhage distends capsule
	Periosteum	• Normally indistinct • Solid periosteal reaction is normal in fracture healing	• Observe periosteal reactions: solid, laminated or onionskin, spiculated or sunburst, Codman's triangle
	Miscellaneous soft tissue findings	• Soft tissues normally exhibit a water-density shade of gray	• Foreign bodies evidenced by radiodensity • Gas bubbles appear radiolucent • Calcifications appear radiopaque

This approach concisely organizes the essentials of radiologic analysis into four divisions:

A: Alignment
B: Bone density
C: Cartilage spaces
S: Soft tissues

These four divisions can be further subdivided into greater detail, as follows.

A: Alignment

Alignment analysis includes evaluation of each item in the following three lists.

1. General Skeletal Architecture

Assess gross normal size, appearance, and number of bones. Look for all of the following:

- *Aberrant size* of bones. Gross enlargement of bone is seen in conditions such as gigantism, acromegaly, or Paget's disease (Fig. 2-1). Grossly undersized bone may similarly be related to congenital, metabolic, or endocrine abnormalities.
- *Supernumerary bones.* For example, an extra navicular may be found among the tarsals or an extra digit (polydactyly) may occur (Fig. 2-2).
- *Congenital anomalies.* Examples include a cervical rib or a transitional vertebra present at the lumbosacral junction.
- *Absence of any bones.* Bones may be missing as a result of amputation or congenital deformities (Fig. 2-3).
- *Developmental deformities.* Examples include scoliosis, genu valgum, and pronated feet.

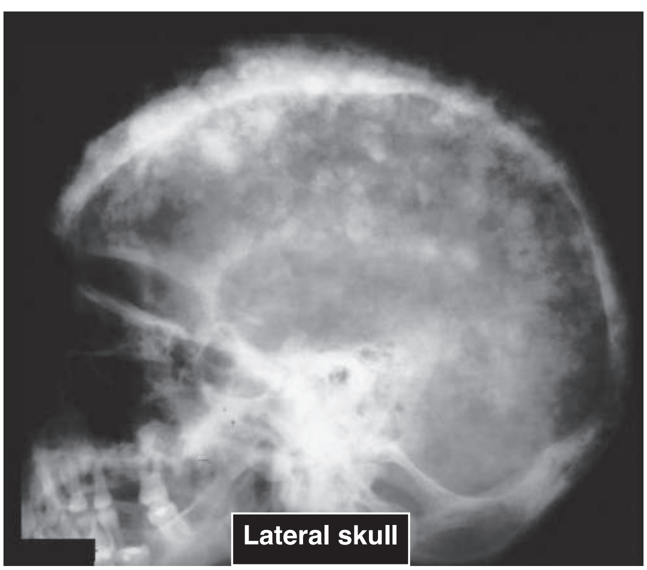


Figure 2-1 *Paget's disease.* The random proliferation of both osteoblastic and osteoclastic activity produces the curious fluffy sclerosis of the enlarged skull in this elderly man with Paget's disease. This lateral view of the skull gives an appearance of spots of "cotton wool"—a classic radiographic finding during the later stages of the disease.

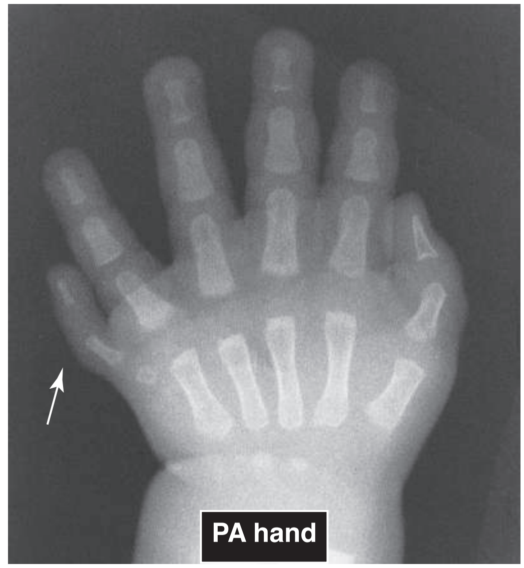


Figure 2-2 Polydactyly in a 10-month-old child. Note the extra sixth digit indicated by the arrow.

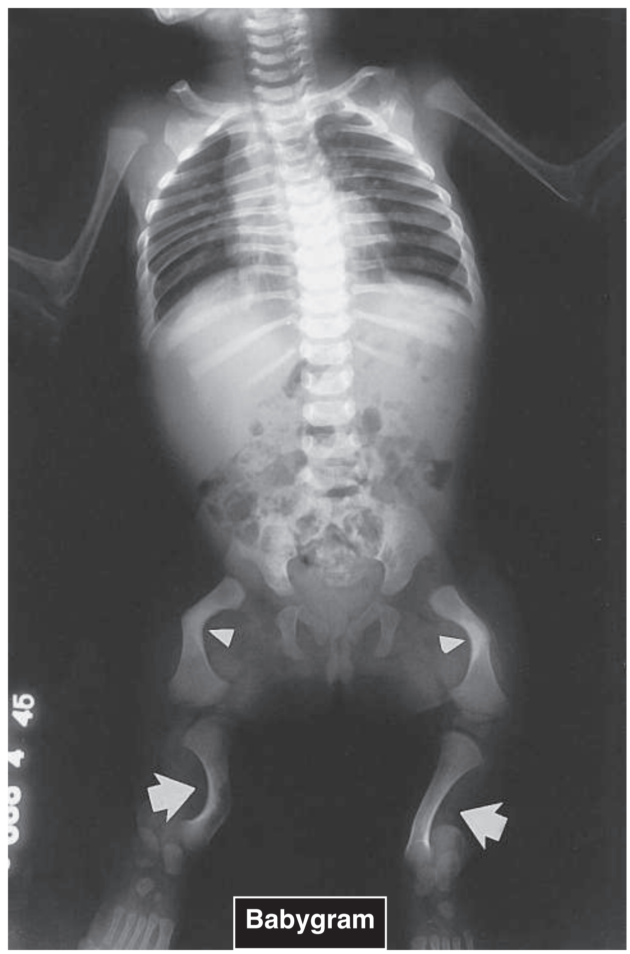


Figure 2-3 *Congenital deformities* in an 8-month-old girl include bowing of the femurs (*arrowheads*) and bowing of the tibias with absence of the fibulas (*large arrows*).

2. General Contour of Bone

Assess each bone for normal shape and contour. Look for all of the following:

- *Internal or external irregularities.* These may be related to pathological, traumatic, developmental, or congenital factors.
- The *cortical outline* of each bone. The outline should be *smooth and continuous.*
- *Osteophytes* are outgrowths of bone at joint margins associated with degeneration of cartilage. A *spur* is an osteophyte that looks isolated and pointed, and forms from tension at areas of tissue attachment (Fig. 2-4).
- *Breaks in continuity of the cortex,* signifying cortical *fracture* (Fig. 2-5). Sharp angles in the cortex may be a sign of *impaction fracture* (Fig. 2-6). The sites of attachment of muscles, tendons, and ligaments are noted in trauma cases to evaluate for *avulsion fractures* (Fig. 2-7).

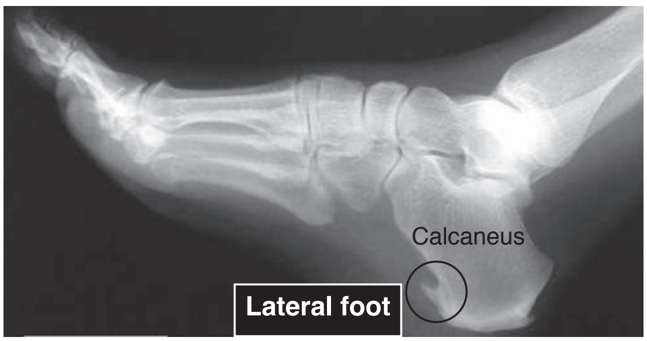


Figure 2-4 A *heel spur* is seen as a radiodense projection at the margin of the anterior inferior surface of the calcaneus (*circle*).

Figure 2-5 An example of a cortical *fracture* seen in the complete fracture of the fifth metacarpal neck (*arrow*). "*Boxer's fracture*" is the *eponym* for this injury for fractures of the fifth metacarpal.

Figure 2-6 An example of an *impaction fracture* is seen in the supracondylar area of the distal humerus (*arrow*).

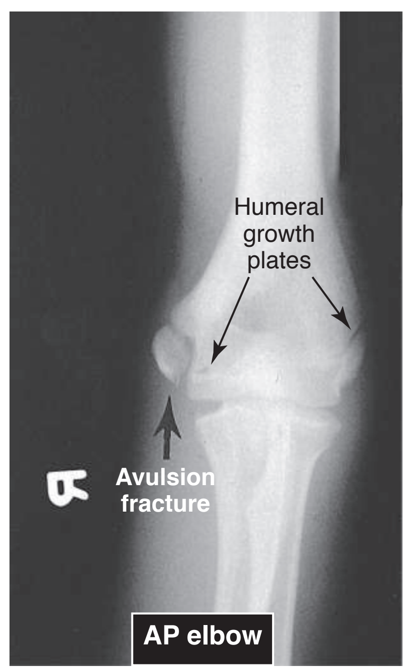


Figure 2-7 An example of an *avulsion fracture* is seen in this medial epicondyle avulsion of the distal humerus of a 10-year-old Little League pitcher. *(From Richardson and Iglarsh,[35] p. 663, with permission.)*

- *Markings of any past surgical sites.* Examples include bone graft donation areas or drill holes for orthopedic appliances (Fig. 2-8).

3. Alignment of Bones Relative to Adjacent Bones

Assess articulating bones for normal positional relationships. Look for the following:

- *Fracture*, which may disrupt joint articulations. Fracture is most often due to trauma.
- *Dislocation* of normal joint articulations. Dislocation is most often due to trauma but can be a consequence of advanced arthritides (Fig. 2-9).
- *Subluxation*, or partial dislocation, of joint surfaces. Common causes of joint subluxation include the inflammatory arthritides or degenerative joint diseases that erode articular cartilage and promote joint laxity (Fig. 2-10).

B: Bone Density

Bone density analysis includes evaluation of each item in the following three lists.

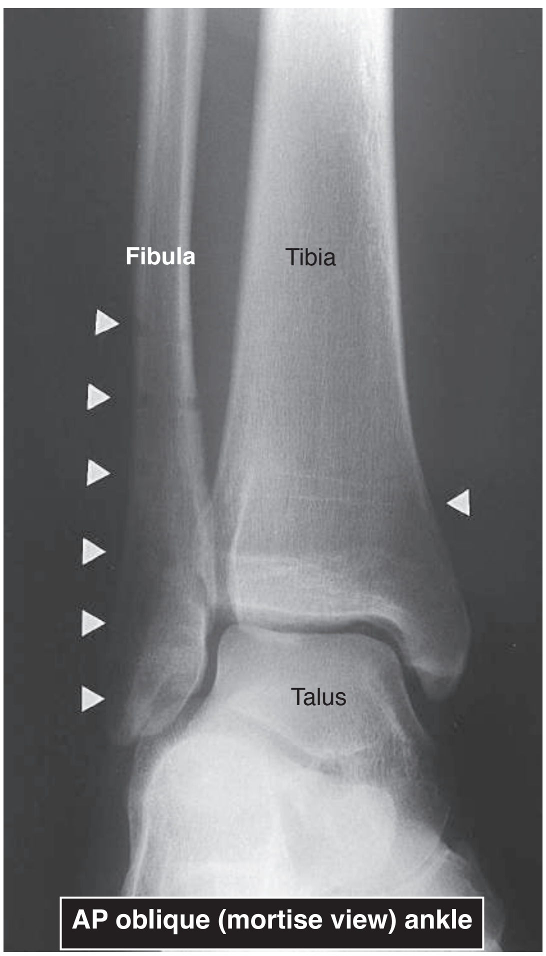


Figure 2-8 Note the odd appearance of *old surgical sites* (*arrowheads*). This patient had a fibular fracture and dislocation, which was repaired with a plate along the shaft of the fibula and a compression screw across the tibia to reestablish the stability of the ankle mortise. Faint remnants of the drill holes are evident on the fibula as radiolucent lines. Faint lines across the tibia are radiodense. Hardware like this is usually not removed unless it becomes problematic as a result of infection or loosening.

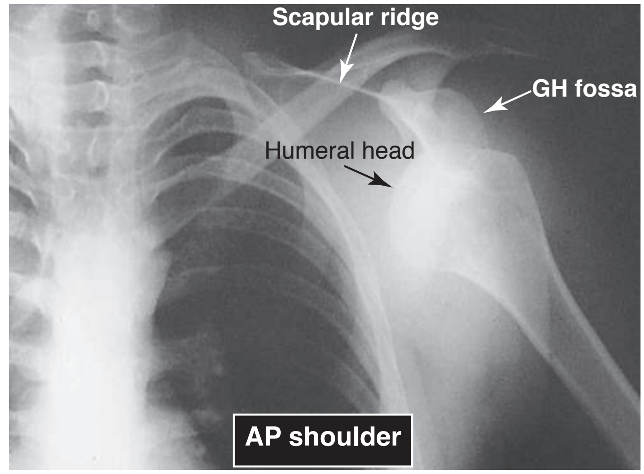


Figure 2-9 Anterior *dislocation* of the glenohumeral joint.

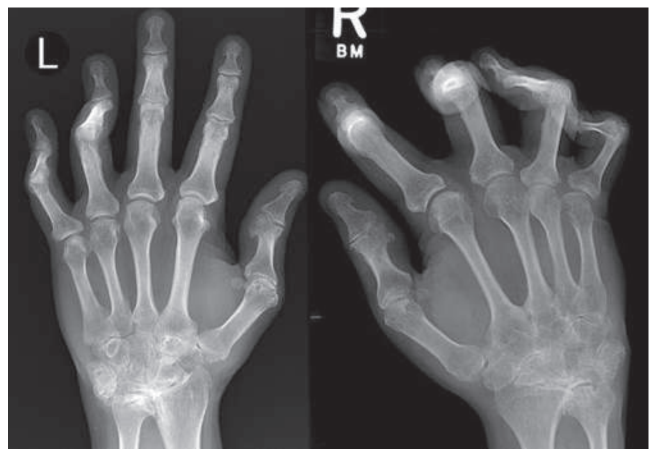


Figure 2-10 Advanced *rheumatoid arthritis* of the hands with joint *subluxations*. Posteroanterior (PA) views of the left and right hands show marked narrowing and erosion of the radiocarpal and intercarpal joints. Both wrists show ulnar carpal "drift" where the position of the scaphoid, normally projecting beyond the radial styloid, has rotated toward the ulnar side of the wrist. Other classic hallmarks of rheumatoid arthritis include symmetrical joint space narrowing, articular erosions, and periarticular osteoporosis. A boutonnière deformity (hyperextension at the distal interphalangeal joint with hyperflexion of the proximal interphalangeal joint) is present in the left fourth and fifth digits and the right second through fifth digits. *(Image courtesy of John C. Hunter, MD, University of California, Davis School of Medicine.)*

1. General Bone Density

Assess each bone for the shade of gray that represents normal density, which implies normal mineral content. Look for each of the following:

- *Sufficient radiographic contrast between the bone and the soft tissue.* Healthy bone and the soft tissue appear with clearly distinct shades of gray.
- *Sufficient contrast within the bone itself* between the denser cortical shell of each bone and its relatively less dense cancellous bone center. Healthy cortex shows up with greater density than cancellous bone and appears as a white margin along bone shafts (Fig. 2-11).

Loss of this distinct cortical image and loss of contrast between bone and soft tissues indicate loss of bone mass.

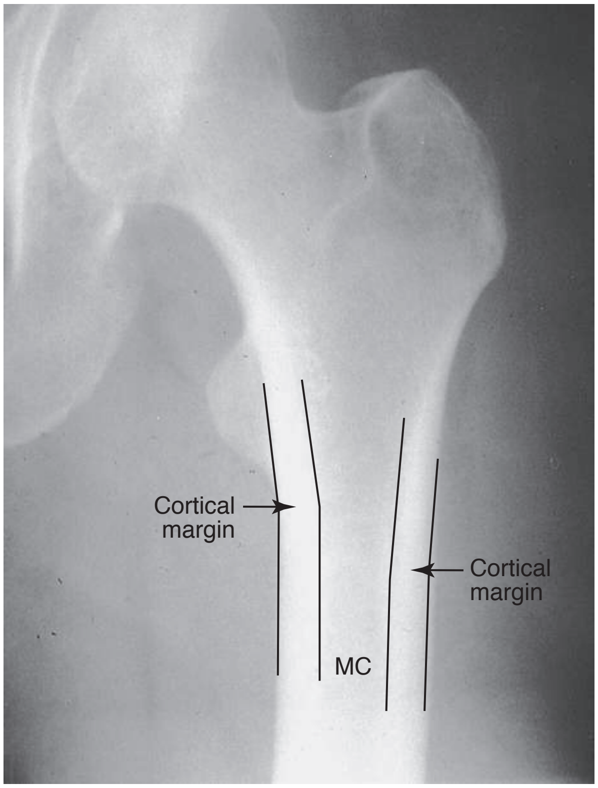


Figure 2-11 Normal image of a proximal femur. Note that *normal bone density* is evident in the increased radiodensity and thickness of the margins of the femoral shaft (*outlined*), in contrast with the normally lesser radiodensity of the medullary cavity (MC).

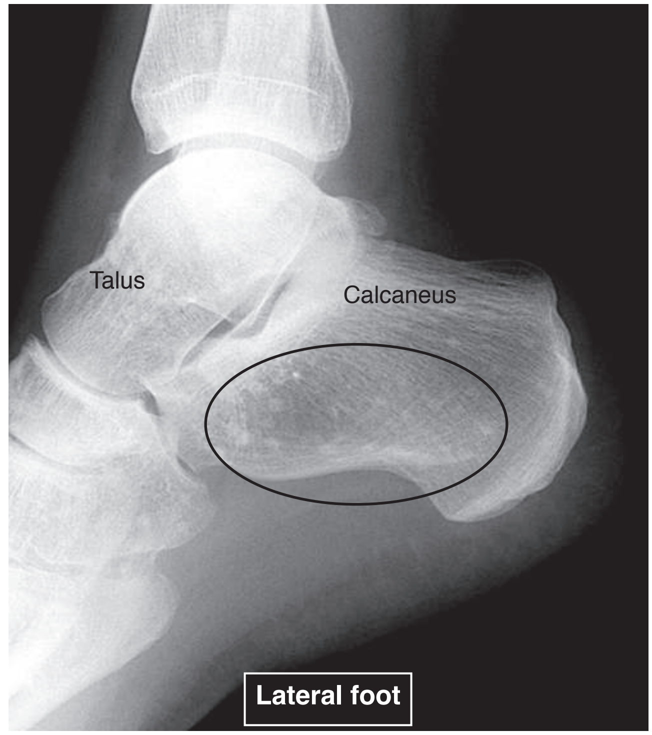


Figure 2-12 *Osteopoikilosis* is a benign bone disease characterized by spotty areas of calcification in bone, as seen in this lateral view of the foot. *(Image courtesy of John C. Hunter, MD, University of California, Davis School of Medicine.)*

The degree of mineralization of bone is directly related to the patient's age, physiological state, and the amount of activity or stress placed on the skeleton. Certain diseases alter the mineral content of the skeleton. An overall increase in skeletal density is seen in some developmental bone disorders, such as osteopetrosis or osteopoikilosis (Fig. 2-12). An overall decrease in skeletal density is seen in osteoporosis and in the hypocalcification characteristic of osteomalacia (Fig. 2-13).

2. Textural Abnormalities

Assess the trabeculae for changes in appearance. When the mineralization of bone is altered, the appearance of the trabeculae is also altered. Altered trabecular appearance is often a radiologic hallmark in the diagnosis of disease processes. The image of the trabeculae is often described in terms likened to texture, such as *thin, delicate, coarsened, smudged,* or *fluffy.* Examples include the following:

- *Fluffy* trabeculae represent the random proliferation of both osteoblastic and osteoclastic activity, as seen in the skull of a patient with Paget's disease (see Fig. 2-1) and in hyperparathyroidism (Fig. 2-14).
- *Smudged* and indistinct trabeculae are a characteristic of osteomalacia (see Fig. 2-13).
- *Coarsening* of trabeculae is often seen in patients with chronic renal failure and osteoporosis. The accentuation of these trabeculae does not signify strength; rather, the loss of surrounding trabeculae causes the remaining trabeculae to appear prominent.
- *Lacy, delicate* appearance of trabeculae is secondary to thalassemia (Cooley's anemia) (Fig. 2-15).

3. Local Density Changes

Assess localized areas of density changes. Look for each of the following:

- *Sclerosis,* or normal local increases in bone density seen in areas subjected to increased physical stress, such as the weight-bearing areas of joints. These areas of localized sclerosis are actually signs of *repair*—extra bone is deposited to fortify bony architecture to withstand the forces of weight-bearing.
- *Excessive sclerosis* may be evident in normal conditions, such as at the site of a healing fracture as callus is formed and new bone is remodeled. Excessive sclerosis may also be seen in abnormal conditions, as in the degeneration of an osteoarthritic joint (Fig. 2-16).
- *Reactive sclerosis* is present when the body acts to surround and contain a diseased area, such as a tumor or infection (Fig. 2-17).

C: Cartilage Spaces

The articular cartilage of joints and the cartilaginous intervertebral disks of the spine are not well demonstrated on radiographs because of their waterlike density. Cartilages and disks can be analyzed, however, by examining the space they occupy. Cartilage space analysis includes evaluation of the items on the following lists.

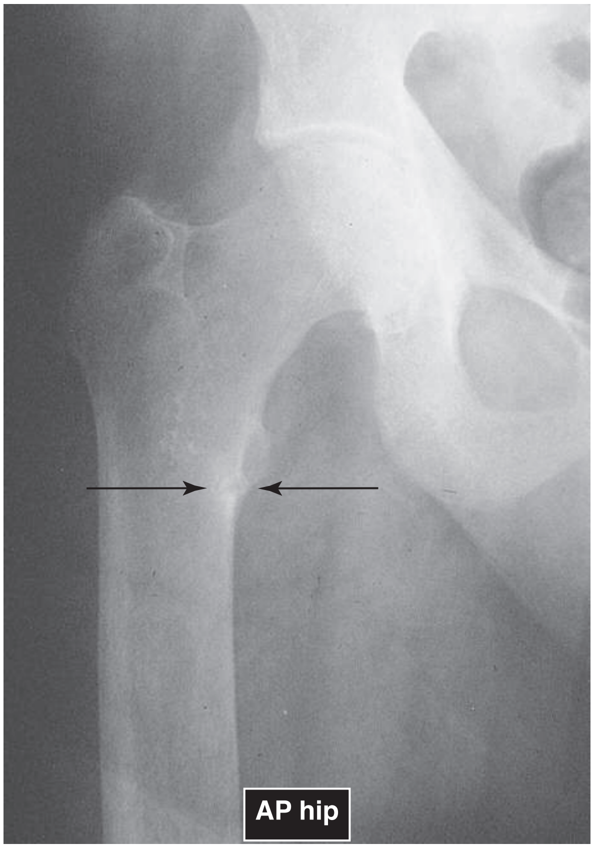


Figure 2-13 *Osteomalacia*, also known as "adult rickets," is a hypocalcification disorder. As seen in this proximal femur, the body is able to produce bone but is unable to calcify it. The result here is a very wide but porous femur. A classic radiologic finding is a *Looser's zone*, a radiolucent band transverse to the cortex that is an insufficiency stress fracture related to the demineralized cortex (*arrow*). The slight increased radiodensity on either side of the fracture line is the bone's attempt to repair that area of stress.

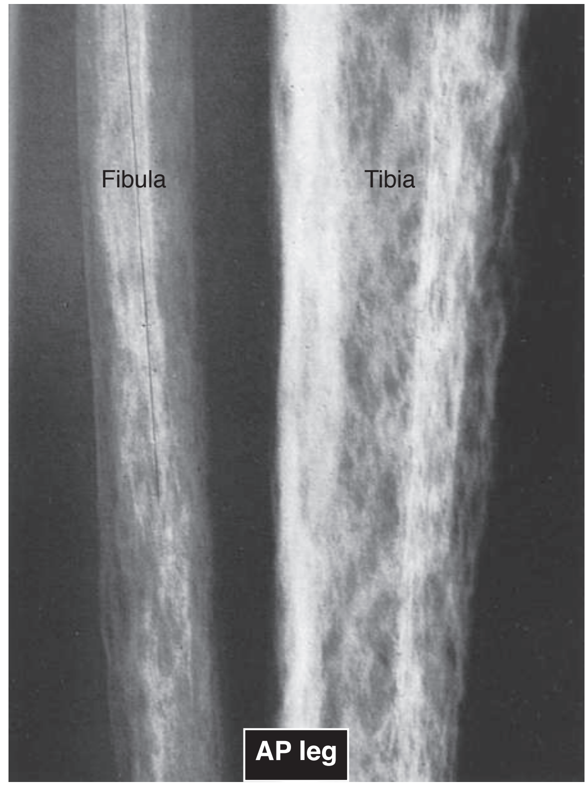


Figure 2-14 *Hyperparathyroidism*. A previously healthy 21-year-old man had been troubled for the preceding 18 months by increasing loss of strength in the lower extremities. Patient was found to have primary hyperparathyroidism secondary to a tumor of the parathyroid. Radiograph of his leg shows generalized skeletal changes with considerable decalcification of the bones and erosions of the cortex. *(From Eiken, M: Roentgen Diagnosis of Bones: A Self-Teaching Manual. FADLs, Forlag, AS, Copenhagen, 1975, p. 39, with permission.)*

1. Joint Space Width

Assess joint spaces for normal thickness. Look for each of the following:

- A *well-preserved joint space* implies that the cartilage or disk is of normal thickness.
- A *decreased joint space* implies that the cartilage or disk is thinned down as a result of degenerative processes (Fig. 2-18).

Joint space is also referred to as the *potential space* or the *radiographic joint space*. The term *radiographic joint space* is specific in that it encompasses both the cartilage and any actual space present in the joint (such as the space due to skin traction when the patient is supine on the x-ray table). Evaluation of weight-bearing joints is best done *during weight-bearing* for accurate assessment of the articular cartilages, because this will eliminate any actual space from the image and present the true dimensions of the cartilage.

2. Subchondral Bone

Assess the subchondral bone (subjacent to the articular cartilage) for density changes or irregularities. Structural changes in the subchondral bone are significant in the radiologic diagnosis of different arthritides. Look for the following:

- *Increased sclerosis.* In the degenerative arthritides such as osteoarthritis, subchondral bone becomes increasingly sclerotic as new bone is formed to help withstand the increased stresses directed at it because of the loss of articular cartilage (Fig. 2-19).
- *Erosions.* In the inflammatory arthritides such as rheumatoid arthritis or gout, very little reparative sclerosis is seen in the subchondral bone. Rather, erosions of the subchondral bone form radiolucencies at the joint margins (Fig. 2-20).

3. Epiphyseal Plates

Although the previous points were made with regard to joints, physeal growth plates in a child are temporarily cartilaginous and thus fit into this category. Look for the following:

- The *position* of the growth plate as designated by the relationship of the ossified portion of the secondary epiphysis to the metaphysis (Fig. 2-21)
- The *size of the epiphyses* in relation to both skeletal maturity and chronological age
- A smooth margin at the *borders of the epiphyses,* with a band of sclerosis indicating increased bone activity associated with linear growth

Figure 2-15 The lacy, delicate appearance of the trabeculae of the upper extremity of this child is secondary to *thalassemia* (Cooley's anemia), an inherited blood disorder that results in destruction of red blood cells. The metacarpals and phalanges reveal cortical thinning and osteopenia. Marrow proliferation results in a loss of normal tubulation, which results in squared or sausage-shaped configuration of each bone, as seen here.

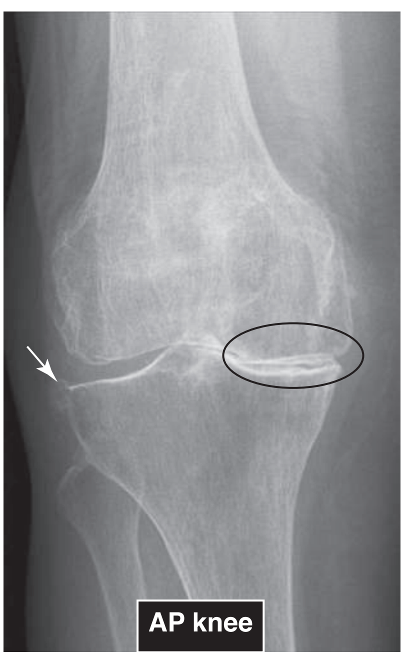


Figure 2-16 *Degenerative joint disease* of the knee. On this anteroposterior view of the knee, note the classic radiographic hallmarks of this arthritis, demonstrated by a decreased medial joint space combined with sclerotic subchondral bone of the medial tibial plateau (*oval*). The whitish *sclerosis* of the subchondral bone is a reparative response to the thinning of the articular cartilage. Marginal spurs can also result from this repair attempt (*arrow*).

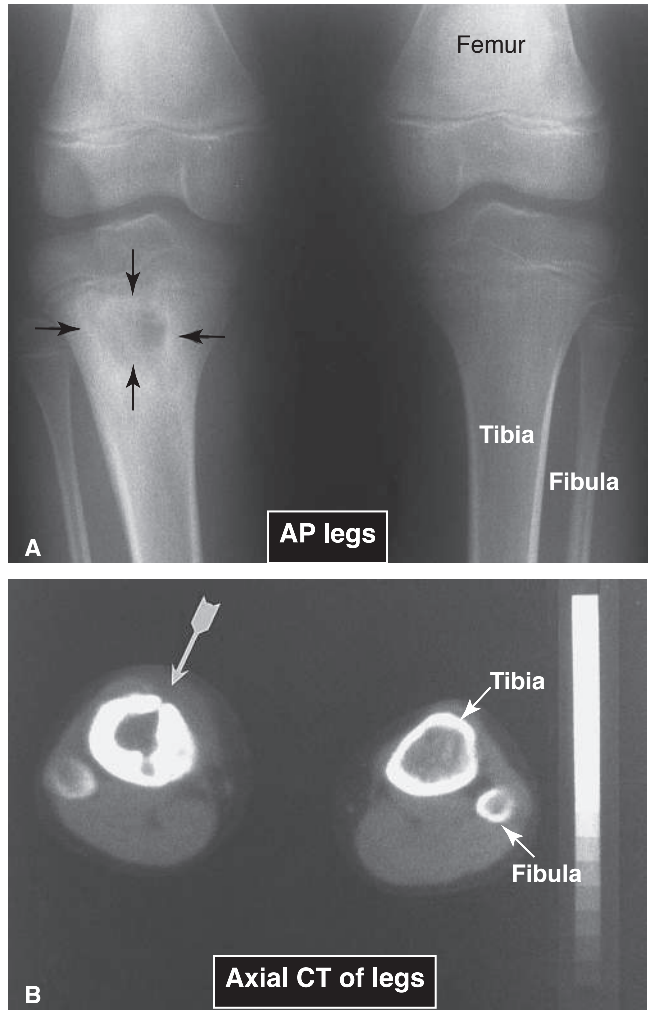


Figure 2-17 *Osteomyelitis*. **(A)** This 9-year-old girl had a 6-month history of progressive, enlarging soft tissue swelling at the right proximal tibia. She was diagnosed with osteomyelitis of the proximal tibia. Note how the lesion is well circumscribed by the *reactive sclerosis* of bone in an attempt to surround and wall off the infected area (*arrows*). **(B)** The CT axial image further demonstrates the reactive sclerosis of the left tibia and also reveals a draining defect (*white arrow*), which was formed to relieve the pressure of the pus in the bone. This pus drained out into the soft tissues, enlarging the circumference of the leg, as seen on the axial view.

- Disruptions in the growth plates from trauma or metabolic disease, which can be difficult to diagnose and may require contralateral films for comparison.

S: Soft Tissues

Soft tissues do not image with specific distinction on conventional radiographs because the densities of all soft tissues in the body are too similar. Enough of an image is created, however, to permit observation of some extreme conditions. Soft tissue analysis includes evaluation of several types of tissue discussed in the following paragraphs.

1. Muscles

Assess the soft tissue image of muscles for the following:

- *Gross muscle wasting*, which may suggest a primary muscle disease, paralysis, inanition associated with severe illnesses, or disuse atrophy secondary to trauma (Fig. 2-22)

Figure 2-18 *Degenerative disk disease* of the cervical spine. This lateral view of the cervical spine shows the classic hallmarks of degenerative disk disease at C5–C6, including a narrowed joint space and osteophyte formation at the vertebral end-plates (*arrow*).

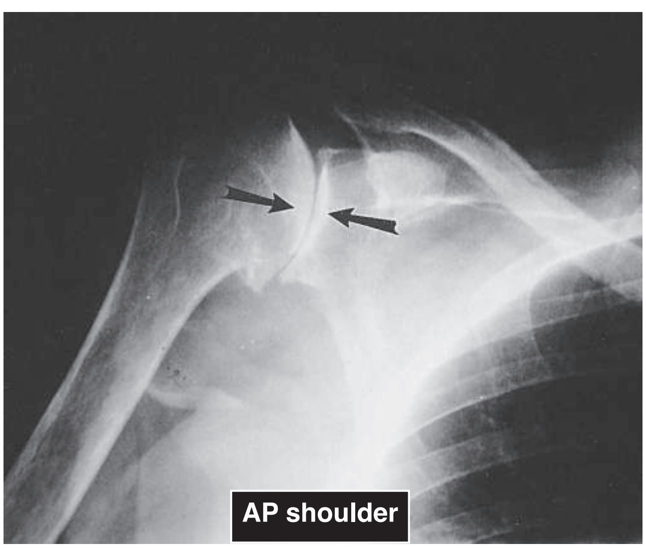


Figure 2-19 *Osteoarthritis* of the glenohumeral joint. Note the radiographic hallmarks of osteoarthritis, including decreased joint space, sclerotic subchondral bone (*arrows*), and osteophyte formation on the inferior joint margins. The severity of these degenerative changes is usually more common in weight-bearing joints. The arthritic changes here may have been accelerated by prior trauma.

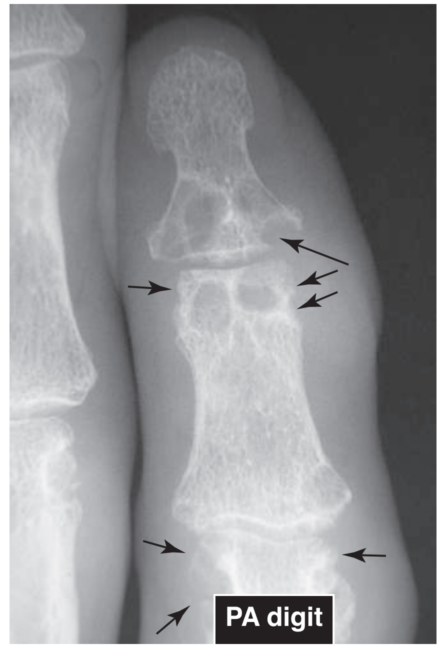


Figure 2-20 *Gout* at the interphalangeal joints of the index finger. Joint erosions in gout and other *inflammatory arthritides* show no subchondral sclerosis as seen in osteoarthritic conditions. Rather, *erosions of the subchondral bone*, seen as radiolucent cysts in the articular and periarticular regions, are the predominant characteristic (*arrows*).

- *Gross swelling of muscles and soft tissues,* which may be indicative of inflammation, edema, hemorrhage, or tumor (Fig. 2-23).

2. Fat Pads and Fat Lines

Assess *effacement* or displacement of fat lines or fat pads from their normal positions into the soft tissues. This displacement usually is due to swelling and is a clue to an adjacent abnormality. Examples include the following:

- Displacement of the pronator quadratus fat line at the wrist usually indicates a wrist fracture.
- Displacement of the fat pads at the elbow (from the olecranon fossa posteriorly and from the coronoid and radial fossae anteriorly) often indicates hemarthrosis associated with fracture (Fig. 2-24).

3. Joint Capsules

Normally rather indistinct, joint capsules will become visible under abnormal conditions when *distended by effusion.* This is seen in exacerbations of arthritic conditions, infection, hemophilia, and acute joint trauma.

Effusion from the trauma of an *intra-articular* fracture may produce a *lipohemarthrosis* in the joint capsule. Lipohemarthrosis is the mixture of fat and blood from the marrow, which enters the joint space through an osteochondral defect. Because fat is less dense than blood, it floats on the surface of blood. On a radiograph, this is referred to as a fat–fluid level or fat–blood interface (FBI sign). When seen on a radiograph, this sign is a strong indicator for a potentially overlooked intra-articular fracture (Fig. 2-25). (However, an even more specific finding of free fat in the joint is possible with advanced imaging. A third level of fluid, representing the mixed serum and synovial liquid, will be visible *between* the fat

Figure 2-21 Normal radiographic appearance of hand of an 8-year-old child. The *epiphyseal plates* are evidenced by the radiolucent zones adjacent to the maturing epiphyses. The borders of epiphyses are normally bounded by a smooth margin with a band of sclerosis indicating increased bone activity. This is how they are distinguished from fracture fragments. Discriminating epiphyseal plate regions from fracture lines can at times be difficult; contralateral images may be needed for comparison.

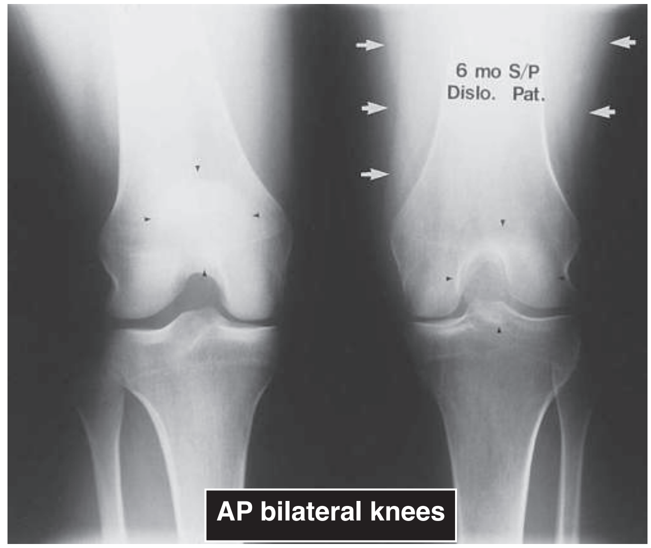


Figure 2-22 *Disuse atrophy* of the quadriceps secondary to traumatic patellar dislocation is evidenced by the shrunken and concave appearance of the soft tissue outline of the thigh. Note the inferior position of the patella (*patella baja*) related to *quadriceps insufficiency*. Normal patella position is marked on the other leg.

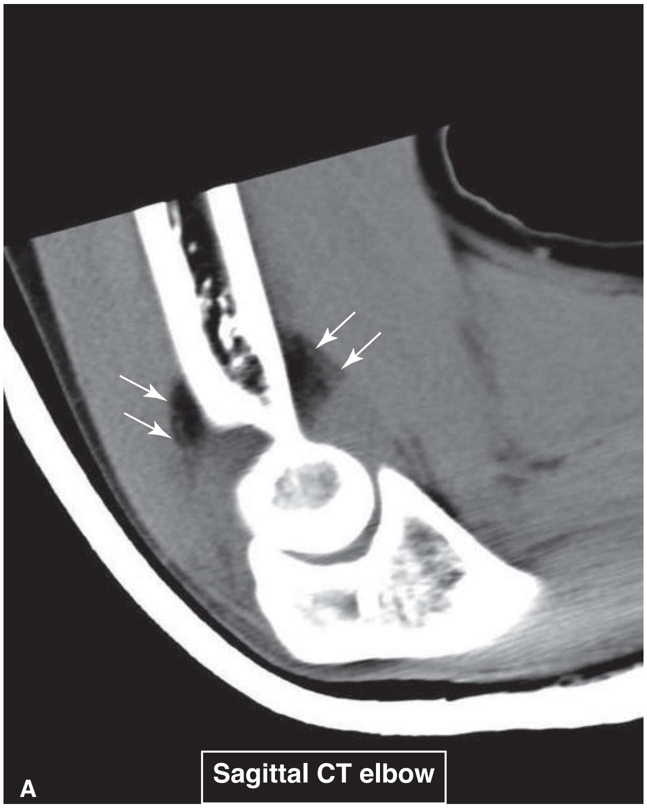
and blood layers on computed tomography [CT], magnetic resonance imaging [MRI], or ultrasound [US]. This is known as the "parfait" or "Neapolitan" sign.)

4. Periosteum

Normally rather indistinct, the periosteum becomes evident in its response to abnormal conditions. Periosteal reaction (Fig. 2-26) is generally described as being one of four types, named by the characteristic radiographic images. Look for these types of periosteal reaction:

- *Solid:* This reaction indicates an indolent (slow-growing) process; seen in fracture healing and chronic osteomyelitis.
- *Laminated or onionskin:* This reaction indicates repetitive injury, as in the battered child syndrome; it is also associated with sarcomas such as Ewing's sarcoma.

Figure 2-23 *Rheumatoid arthritis* of the hand. Note gross swelling of the hand and the proximal interphalangeal joint of the third digit, indicating an inflammatory phase. *(From American College of Rheumatology Clinical Slide Collection on Rheumatic Disease, 1991.)*



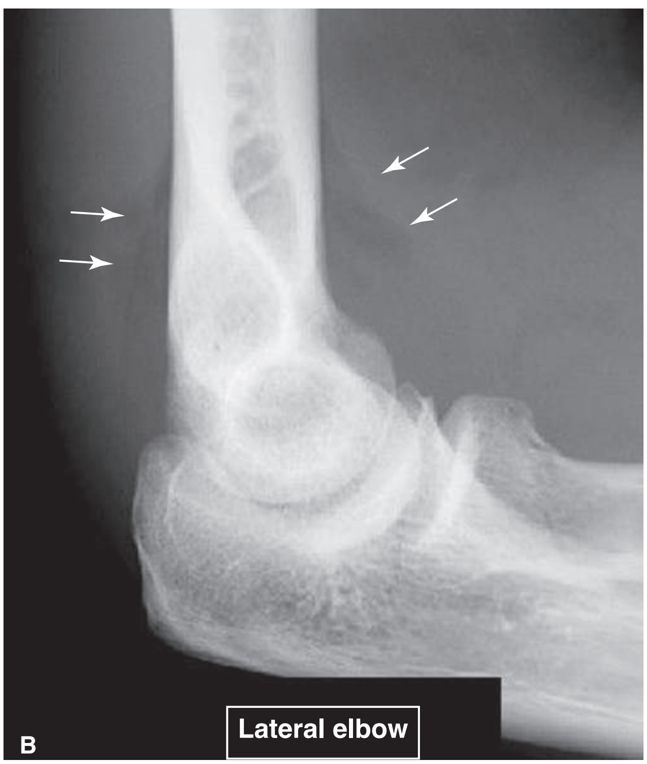


Figure 2-24 Positive *fat pad sign* or *sail sign* at the elbow. **(A)** CT sagittal view of the elbow demonstrating displaced fat pads as radiolucent triangular images present anteriorly and posteriorly to the humeral shaft (*arrows*). **(B)** On radiograph, these displaced fat pads are also visible as radiolucent images in the soft tissues (*arrows*). The *fat pads are displaced as a result of joint effusion*, most commonly instigated by fracture, although other processes, such as infection, can produce gross effusion that displaces the fat pads. *(**A**, Image courtesy of www.radpod.org.)*

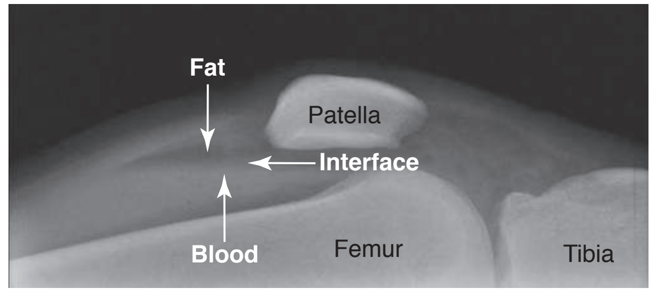


Figure 2-25 *FBI sign.* This non–weight-bearing lateral view of the knee was made with a horizontal x-ray beam tangent to the fluid layers. Marrow fat and blood that seeped through the intra-articular tibial plateau fracture (not visible here) has accumulated in the suprapatellar area of the joint capsule and divided into layers because of differences in fluid density. A fracture must occur for this sign to be present.

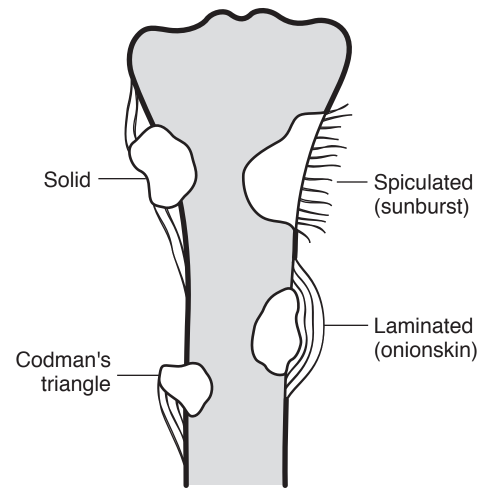


Figure 2-26 *Periosteal reactions* to abnormal conditions appear on radiograph in four characteristic images: solid, spiculated, laminated, or Codman's triangle. *(Adapted from Greenspan,[26] p. 551.)*

- *Spiculated or sunburst:* This reaction is almost always associated with malignant bone lesions, such as osteogenic sarcomas, and is less frequently seen in metastatic squamous cell tumors. The distinct appearance of the periosteum is due to the repeated breakthrough of the neoplastic process followed by new periosteal response.
- *Codman's triangle:* A piece of periosteum elevated by abnormal conditions ossifies in a triangular shape. This may be present in a variety of conditions, including tumor, subperiosteal hemorrhage, and battered child syndrome.

5. Miscellaneous Soft Tissue Findings

Assess any miscellaneous findings within the soft tissue image. Look for the following:

- *Gas* in soft tissues is an indication of gas-forming organisms, as in gangrene or trauma.
- *Calcifications* in soft tissues may be the result of old trauma whereby hemorrhage has coagulated and calcified (Fig. 2-27). Additionally, calcifications occur in vessels and organs, for example, renal calculi, gallstones, or calcifications in the abdominal aorta.
- *Foreign bodies* (such as metal shards) may also be evident in the soft tissues.