5.1 Bone

5.1.1 Histologic Considerations

All bones consist of peripheral cortical (compact) bone and central medullary (trabecular or cancellous) bone. In long bones, there is an inverse relationship between the amount of cortical and cancellous bone at any given site: in the diaphysis, the cortical bone is thick whereas the trabecular bone is sparse; conversely, metaphyseal and epiphyseal regions are characterized by thin cortical bone and prominent cancellous bone. In addition to bone trabeculae, the medullary cavity contains bone marrow, including yellow marrow (housing fat and connective tissue) and red marrow (consisting of hematopoietic cells, fat and connective tissue). The distribution of hematopoietic and fatty marrow is dependent on age and metabolic state (Ricci et al. 1990). The outer surface of cortical bone is invested by the periostea—a dense fibrous connective tissue layer that is anchored to the cortical bone by means of perforating Sharpey fibers—which plays a role in allowing rapid healing of fractures. The periostea thickness varies depending on age: it is thicker and more active in children. Nutrient arteries and emissary veins cross the cortical bone through the nutrient foramina. In mature long bones, they are most often observed at the diaphysis level. In terms of histogenesis, the bone develops from two distinct processes referred to as intramembranous and endochondral ossification (Erickson 1997). Intramembranous ossification occurs through direct mineralization of vascular connective tissue and is responsible of the growth of flat bones; it also contributes to the width of the shaft of long bones. Endochondral ossification arises within a cartilage model and is responsible for the longitudinal growth of long bones and the formation of the axial skeleton (Fig. 5.1).
5.1.2 Normal US Anatomy and Scanning Technique

There is no doubt that radiography is the first-line imaging modality for assessment of bone disorders: it allows a panoramic, low-cost and reproducible evaluation of bone. More accurate analysis can be obtained by means of CT, especially if complex anatomic areas must be examined. While CT allows an optimal assessment of the bone cortex, MR imaging is the technique of choice to evaluate the bone marrow. US has intrinsic limitations in the assessment of bone. In some applications, however, it can be useful to assess selected bone disorders, especially if performed as a complement to standard radiographs (Cho et al. 2004). With US, the interface between soft tissue and cortical bone is highly echogenic because of an inherent high acoustic impedance mismatch (Erickson 1997). The bone cortex appears as a regular continuous bright hyperechoic line with strong posterior acoustic shadowing and some reverberation artifact (Fig. 5.2). Deeper structures, such as the internal cortical architecture, the endosteum and the underlying trabecular bone, remain inaccessible with US, except for rare pathologic conditions in which the cortex is extremely thinned or destroyed in its full thickness. In normal adults, the perios- teum cannot be detected as a separate structure with US. Using very high frequency probes, it may appear as a thin hypoechoic line apposed to the bone cortex at certain sites in children.

Given the straight and continuous appearance of the bright echo of the bony cortex, subtle surface irregularities and sites of penetration of nutrient vessels can be visualized (Fig. 5.3). A careful scanning technique and Doppler imaging allow easy depiction of the vessels entering the bone. The posterior acoustic shadowing of sesamoids or calcifications

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**Fig. 5.1a–d. Endochondral ossification.** a,b Coronal 12–5 MHz US images over the lateral midfoot with c,d schematic drawing correlation show the growing cuboid at a,c 1 year of age and b,d at the end of development. The cuboid is a square bone with right angles (arrowheads). Initially, the cartilage (asterisks) forms a square model reflecting the definitive appearance of bone. The primary center of ossification is visible in the center of the future bone as a hyperechoic rounded image (arrows). During growth, endochondral ossification advances toward each end of the cartilaginous model. At the end of this process, the primary center has reached the ends of the cartilaginous model and assumes the definitive square shape.