those who die of the neoplasm, 90% have metastases to the lungs, bones, brain, and elsewhere. Unfortunately, the outcome for patients with metastases, recurrent disease or secondary osteosarcoma is still poor (<20% 5-year survival rate).

Cartilage-Forming Tumors

Although osteosarcoma is the most common primary malignant tumor of the bones, cartilage tumors account for the majority of primary bone tumors (both benign and malignant). They are characterized by the formation of hyaline or myxoid cartilage; fibrocartilage and elastic cartilage are rare components. As in most types of bone tumors, benign cartilage tumors are much more common than malignant ones.

Osteochondroma

Osteochondroma, also known as an *exostosis*, is a benign cartilage-capped tumor that is attached to the underlying skeleton by a bony stalk. It is the most common benign bone tumor; about 85% are solitary. The remainder is seen as part of the *multiple hereditary exostosis syndrome*, which is an autosomal dominant hereditary disease. Solitary osteochondromas are usually first diagnosed in late adolescence and early adulthood, but multiple osteochondromas become apparent during childhood. Men are affected three times more often than women. Osteochondromas develop only in bones of endochondral origin and arise from the metaphysis near the growth plate of long tubular bones, especially near the knee. Occasionally, they develop from bones of the pelvis, scapula, and ribs, and in these sites they are frequently sessile and have short stalks. Osteochondromas present as slow-growing masses, which can be painful if they impinge on a nerve or if the stalk is fractured. In many cases they are detected incidentally. In multiple hereditary exostosis the underlying bones may be bowed and shortened, reflecting an associated disturbance in epiphyseal growth.

Pathogenesis. Hereditary exostoses are associated with germline loss-of-function mutations in either the *EXT1* or the *EXT2* gene and subsequent loss of the remaining wild type allele in chondrocytes of the growth plate. Reduced expression of EXT1 or EXT2 has also been observed in sporadic osteochondromas. These genes encode enzymes that synthesize heparan sulfate glycosaminoglycans. The reduced or abnormal glycosaminoglycans may prevent normal diffusion of the factor Indian hedgehog (Ihh), a local regulator of cartilage growth, thereby disrupting chondrocyte differentiation and local skeletal development.

MORPHOLOGY

Osteochondromas are sessile or pedunculated, and range in size from 1 to 20 cm. The cap is composed of benign hyaline cartilage varying in thickness (Fig. 26-26) and is covered peripherally by perichondrium. The cartilage has the appearance of disorganized growth plate and undergoes enchondral ossification, with the newly made bone forming the inner portion of the head and stalk. The cortex of the stalk merges with the cortex of the host bone, so that the medullary cavity of the osteochondroma and bone from which it arises are in continuity.

Clinical Course. Osteochondromas usually stop growing at the time of growth plate closure (Fig. 26-27). Symptomatic tumors are cured by simple excision. Rarely in sporadic cases, but more commonly in those with multiple hereditary exostosis (5% to 20%), osteochondromas progress to chondrosarcoma.

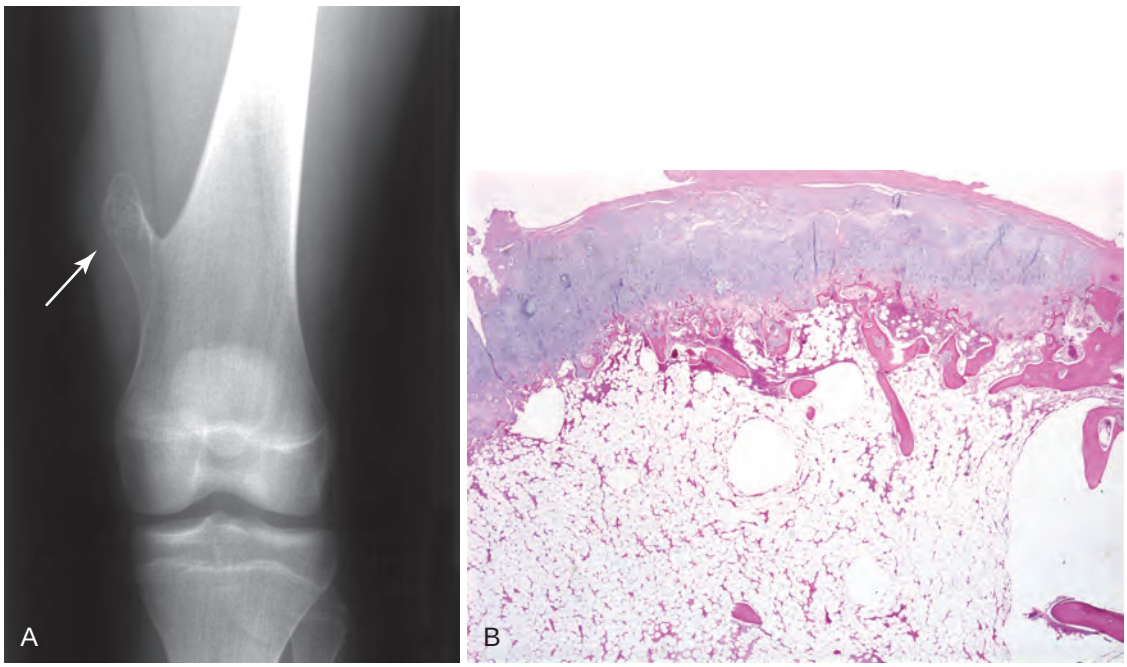

Figure 26-26 Osteochondroma. **A,** Radiograph of an osteochondroma arising from the distal femur (arrow). **B,** The cartilage cap has the histologic appearance of disorganized growth plate-like cartilage.