Mimics of Bone and Soft Tissue Neoplasms

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KEYWORDS

• Bone tumor • Soft tissue tumor • Pseudotumor
• Mimic • Imaging • Radiology

Many benign nonneoplastic entities can mimic bone and soft tissue tumors on imaging examinations. Distinguishing between neoplastic and nonneoplastic entities depends on history and physical examination findings as well as imaging findings, and is an important early step in the patient's overall workup and treatment plan. This article describes some of the pseudotumors seen on imaging studies of patients who have been referred to our orthopedic oncology clinic, as well as mimics of bone and soft tissue neoplasms described in the medical literature. Tumor mimics resulting from anatomic and developmental variants, trauma, infection and inflammation, osteonecrosis and myonecrosis, articular and juxta-articular conditions, and miscellaneous causes are discussed. For simplicity, the word tumor is used synonymously with neoplasm throughout this article, representing both benign and malignant entities.

NORMAL IMAGING FEATURES AND DEVELOPMENTAL VARIANTS THAT MIMIC TUMORS

Sites of Muscle/Tendon Attachment and Metaphyseal Cortical Irregularities

Tug lesions refer to cortical irregularities that occur at sites of tendon and muscle attachment. Some appear as small spurlike entities (eg, along the distal femur at the adductor magnus tendon insertion[1] or the fibular neck at the soleus attachment[2]). These lesions may persist into adulthood, mimicking a small exostosis, but do not require a workup. However, a different type of tug lesion has a more sinister radiographic appearance, resulting in irregular cortical ossification that can mimic an aggressive bone tumor, particularly in adolescents. The best known example is the so-called cortical desmoid (also known as metaphyseal cortical irregularity or avulsive cortical irregularity) arising along the medial supracondylar femur (**Fig. 1**).[3,4] The lesion is not a desmoid in the traditional sense of the word; instead, it is self-limiting and considered by some to be a normal developmental variant and by others to result from repetitive traction of the medial head of the gastrocnemius or the aponeurosis of the adductor magnus. It is typically discovered incidentally on knee radiographs in adolescent boys. In most cases, it does not correspond to the site of the patient's knee pain, although mild pain is occasionally localized to the region of the irregularity.[3] On radiographs, the lesion may manifest either as a lucency or a proliferative abnormality[5] with aggressive-appearing features (eg, periosteal reaction and spicules) that mimic osteosarcoma. This variant is generally smaller than most osteosarcomas, does not result in a soft tissue mass, and in most cases, the typical location and appearance of the lesion allow for proper diagnosis and avoidance of workup; however, for equivocal cases, additional imaging may be warranted. Radiographs of the contralateral knee could be considered, because this lesion is bilateral in one-third of cases. Magnetic resonance (MR) imaging excludes a soft tissue mass and medullary invasion, arguing against an aggressive neoplasm. The lesion may be inconspicuous on MR imaging, but typically presents as cortically based low signal intensity on T1-weighted (T1W) images and intermediate to high, sometimes cystic signal intensity on T2-weighted (T2W) images,

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Radiol Clin N Am 49 (2011) 1261–1286
doi:10.1016/j.rcl.2011.07.009

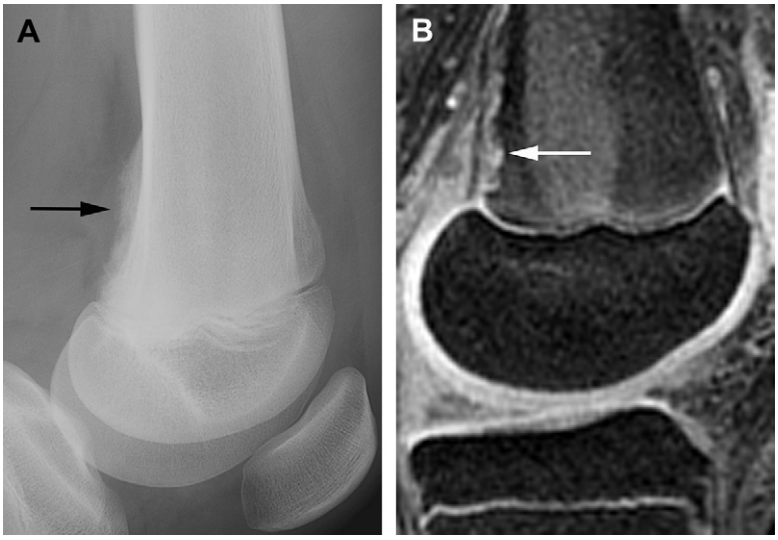

Fig. 1. 12-year-old boy referred with mild knee pain. (*A*) Lateral radiograph of the left knee shows a bony proliferative abnormality (*arrow*) along the posterior aspect of the distal femoral metaphysis. (*B*) Sagittal gradient-echo MR image shows corresponding irregularity of the posterior margin of the femur (*arrow*), but no associated soft tissue mass, confirming cortical desmoid.

with an underlying low signal intensity rim. Enhancement is noted after intravenous gadolinium chelate injection,[6] and adjacent marrow and soft tissue edema may be noted after trauma.[4] Computed tomography (CT) shows small areas of cortical erosion associated with cortical thickening. Lesions may show no activity or slightly increased activity on skeletal scintigraphy; activity may be more pronounced on 2-(fluorine-18)-fluoro-2-deoxy-*D*-glucose positron emission tomography (PET).[7]

Keats and Joyce[8] along with other investigators[9,10] have described a variety of notchlike metaphyseal cortical irregularities in children. Included in this group of irregularities is the cortical desmoid. The investigators suggest that these lesions may represent variations of normal growth rather than by-products of stress or avulsion, citing fenestrations in the metaphyseal cortex in neonatal pathology specimens that could persist beyond the neonatal period. However, other cortical irregularities seem to be associated with chronic forces at sites of musculotendinous attachment, such as those described in asymptomatic gymnasts along the anterior aspect of the proximal humerus at the pectoralis major insertion.[11,12] A spectrum of bone irregularities mimicking malignancy has also been described at the insertions of the deltoid muscle (pseudotumor deltoideus)[13,14] and the latissimus dorsi muscle on the humerus,[15] at the origins of the sartorius and rectus femoris muscles on the ilium, along the ischium at the hamstring origin,[16] and at the insertion of the biceps tendon on the radius.[17] These pseudotumors may result in increased activity on skeletal scintigraphy[18] as well as mild cortical irregularity and eccentric marrow abnormality on MR imaging and CT. The absence of a soft tissue mass combined with the recognition of the site of abnormality as the location of tendon attachment can help to exclude malignancy.

Foramina, Fossae, and Other Radiolucent Tumor Mimics

A foramen is a naturally occurring passageway through or into a bone. Occasionally an anomalous foramen develops in a bone and mimics a lucent lesion. For example, an anomalous foramen in the central portion of the inferior half of the body of the sternum[19] may simulate a small lytic tumor on imaging studies; however, it is often associated with an adjacent thin vertically oriented sclerotic band and, in our experience, is at least partially filled with fat: features that can help distinguish it from tumor. Anomalous foramina also occur in a variety of locations within the scapula, including the neck, superior fossa, and body.[20,21] On radiographs, the resultant lucencies usually have sclerotic margins, which can assist with differentiation from metastasis and myeloma. Normal vascular foramina within the scapula may become particularly prominent at the site of transition between the scapular neck and body, and at the root of the scapular spine.

A fossa represents a depression of a bone. When a fossa becomes unusually prominent, it too may mimic a destructive lesion; such fossae are often at sites of ligamentous attachment. For example, irregularity and concavity of the cortex