Left Knee Pain in a 7½-Year-Old Boy

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This case is presented to illustrate the imaging and clinical findings of a condition of interest to orthopedic surgeons. The initial findings are noted on the first 2 pages, along with the diagnostic considerations and differential diagnoses as additional information is obtained as the clinical investigation proceeds. The correct diagnosis is discussed beginning on the third page.

Case Presentation

A 7½-year-old boy was referred to the orthopedic service with a 4-month history of persistent left knee pain and limp. He rated his pain 4 on a 1-to-10 scale (10 = most severe). He denied any specific symptom-precipitating incident involving trauma or strain. The pain did not hinder involvement in sports and other physical activities. Symptoms persisted throughout the day and seemed to worsen in the evenings and with increased activity. A prescribed course of anti-inflammatory medications (ibuprofen) failed to control the pain. Developmental, family, and social histories did not contribute to the current symptomatology.

On physical examination, the boy appeared healthy and in no acute distress. He walked with an antalgic gait, and on examination an area of soft-tissue fullness overlying the medial femoral condyle and adductor tubercle area of the left knee was identified. There was no erythema, warmth, or effusion. Direct palpation revealed tenderness over and proximal to the region of the adductor tubercle. There was no limitation in range of motion of the knee, and there was no evidence on clinical examination of mediolateral or anteroposterior (AP) instability suggesting any possible internal derangement of the knee. Hip examination revealed no abnormalities as well as full range of motion on both sides. Limbs were equal in length, and there was no lymphadenopathy. The neurovascular examination and the remainder of the physical examination were normal.

Hematologic investigations revealed a leukocyte count of 4800 mL (normal, 5000-14,500 mL), hemoglobin of 12.2 g/dL (normal range, 11.5-13.5 g/dL), hematocrit of 37% (normal range, 34%-40%), sedimentation rate of 4 mm/h (normal range, 0-22 mm/h), and C-reactive protein of 0.2 mg/dL (normal, 0-1.0 mg/dL).

Radiographic examinations included plain radiographs, magnetic resonance imaging (MRI), and, computed tomography (CT), which are shown in Figures 1 through 3.

• Given the history, physical examination, and imaging studies, the differential diagnoses at this point are chronic osteomyelitis (Brodie abscess), Langerhans cell histiocytosis, osteoid osteoma, osteoblastoma, osteosarcoma, and periosteal chondroma/juxtacortical chondroma.

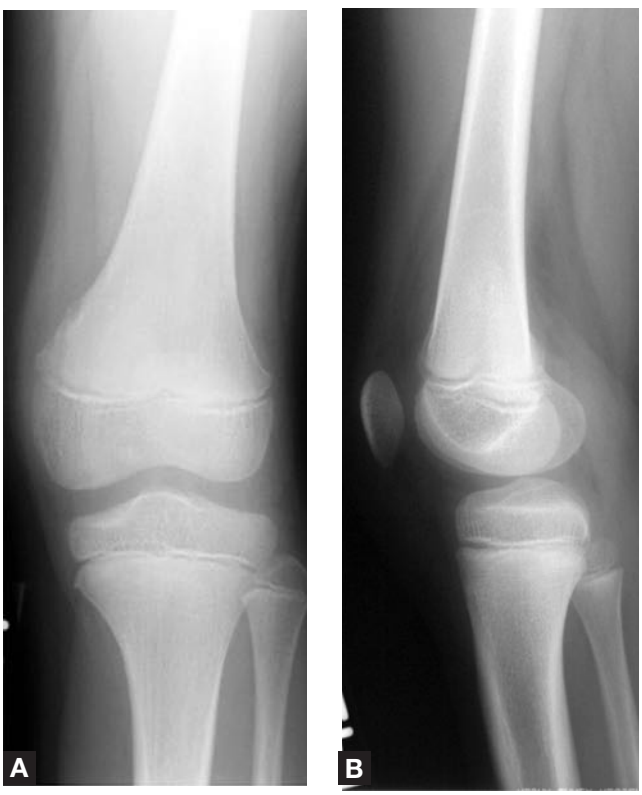

Figure 1. Anteroposterior (A) and lateral (B) plain films of the knee demonstrate an area of cortical irregularity at the medial aspect of the distal femur with a more focal area of rounded lucency within the cortex.

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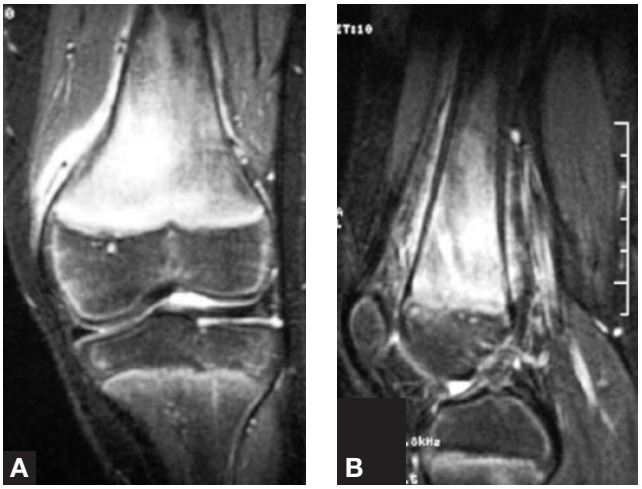

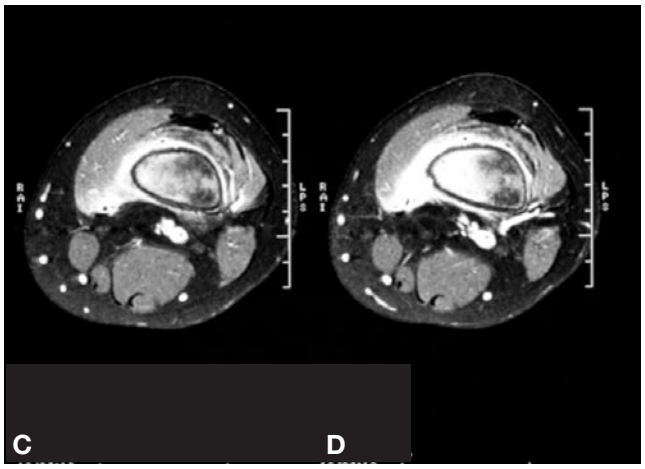

Figure 2. **(A)** Coronal inversion recovery magnetic resonance image demonstrating intramedullary and soft-tissue edema. There is irregularity at the medial aspect of the distal femur. **(B)** Sagittal T_2-weighted image demonstrating marrow space and soft-tissue edema. **(C)** Axial T_1-weighted image after gadolinium demonstrates enhancing marrow space and soft-tissue edema. **(D)** Axial T_2-weighted image with fat saturation demonstrating extensive edema within the marrow space as well as the surrounding

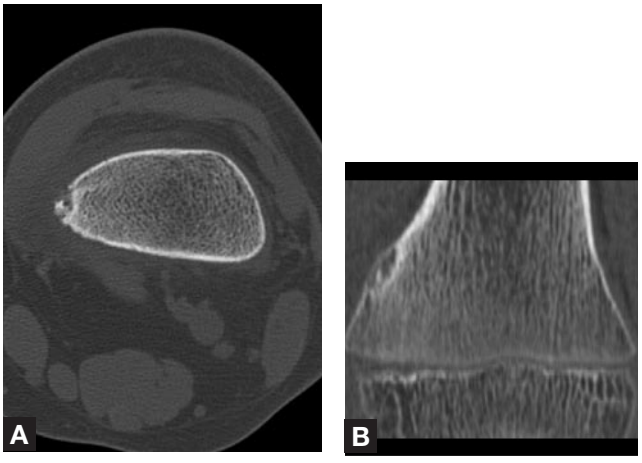

Figure 3. **(A)** Axial and **(B)** coronal computed tomography images reveal the dcrete site of the radiolucent nidus with the area of central calcification.

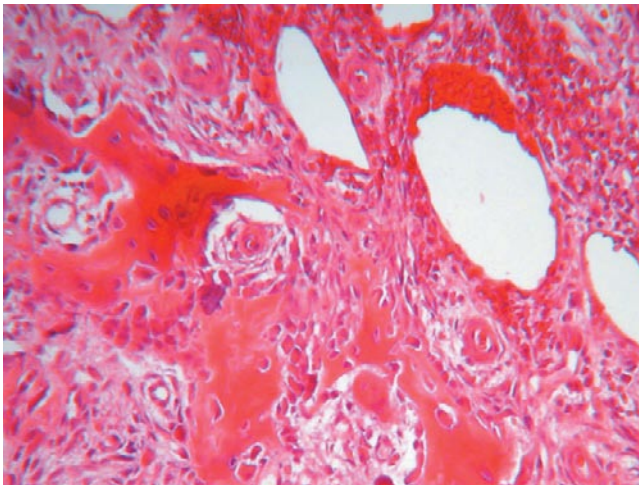

Figure 4. Intermediate-power photomicrograph of the frozen section obtained from excisional biopsy (stain, hematoxylin and eosin; magnification, x 100). It demonstrates the interlacing network of osseous trabeculae with varying levels of mineralization. The presence of dilated small vessels seen in the stroma is one of the characteristic histological features of osteoid osteoma.

Radiographic Interpretation

AP and lateral radiographs (Figure 1) demonstrate an area of cortical irregularity at the medial aspect of the distal femur. There is a more focal area of rounded lucency within the cortex. There is no clearly demonstrable cortical thickening on these images.

MRI demonstrates extensive bone marrow edema involving the distal femoral metaphysis and metadiaphysis with some involvement of the medial epiphysis (Figure 2). This is manifest as increased T_2 signal and enhancement on T1 images after gadolinium. There is a focal defect in the medial femoral cortex corresponding to the site of the lesion. No discrete soft-tissue mass is identified.

CT nicely reveals the discrete site of the radiolucent nidus (Figure 3) with the area of central calcification. Although there is no significant cortical thickening, the architecture of the surrounding bone is preserved.

- **Given the history, physical examination, imaging findings, and laboratory studies, the differential diagnoses are osteoid osteoma, osteoblastoma, chronic osteomyelitis (Brodie abscess), and possible malignant tumor.**

Histologic Interpretation

Excisional biopsy with frozen section was performed. Grossly, the specimen consisted of multiple gray-tan irregular fragments measuring 2.0 cm × 1.5 cm × 0.5 cm in aggregate. Hematoxylin- and eosin-stained sections (Figure 4) revealed a nidus containing irregular trabeculae of woven bone rimmed by osteoblasts and osteoclasts. The trabeculae are intertwined with vascularized stroma and numerous dilated capillaries.

- **Given the history, physical findings, radiographic studies, and histologic picture, what is the diagnosis, and how should this lesion be treated? The correct diagnosis is given on the next page, with a discussion.**

Correct Diagnosis, Discussion, and Treatment

Osteoid osteoma is the correct diagnosis.

Evidence from the history, physical examination, imaging studies, and histologic appearance confirmed the diagnosis of osteoid osteoma. The treatment course for this lesion included complete excision of the nidus using high-speed surgical burr and mechanical evacuation (Figure 5). Preoperative anatomic localization was aided by appropriate imaging studies, including CT, and fluoroscopy was used intraoperatively. After excision of the nidus, the bone defect was grafted. The patient did not require any local treatment for pain management. He used crutches for 2 weeks after the surgery with toe-touch weight-bearing of the affected extremity and then gradually progressed to full weight-bearing in the next 2 weeks. At 8-week follow-up, he was asymptomatic and was able to bear full weight on the affected extremity. His incision was healed without any signs of infection. Plain radiographs of the left leg at 3-year follow-up (Figure 6) showed healing of the bone lesion with little residua.

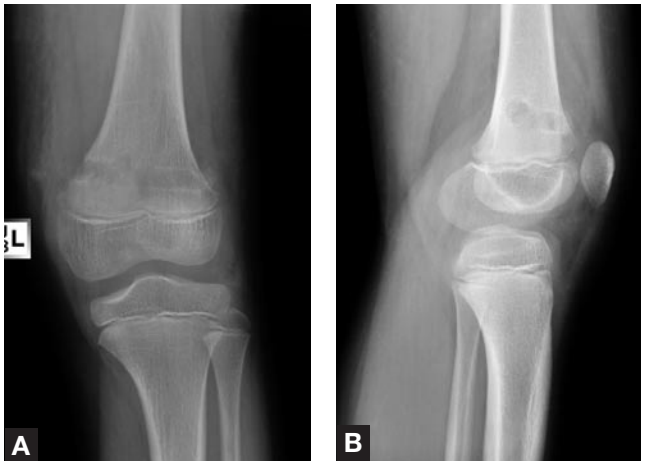

Figure 5. Post-procedure plain **(A)** anteroposterior and **(B)** lateral radiographs of the knee following complete excision of the nidus using high-speed surgical burr and mechanical evaluation.

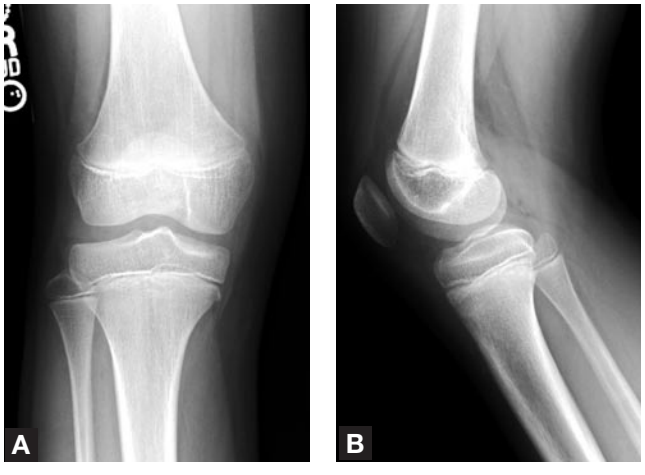

Figure 6. Plain **(A)** anteroposterior and **(B)** lateral films obtained at 3-year follow-up show healing of the bone lesion with little residua.

First described in 1935 by Jaffe,[1] osteoid osteoma is a benign, painful tumor of the bone. It is the third most common primary benign bone tumor, representing approximately 10% to 12% of benign bone tumors.[2-5] The lesion is classically located in the long bones, with a predilection for femur, tibia, humerus, and lumbar spine, but can develop in any bone.[6] Males are more often affected than females by a ratio of 3:1.[7] Lesion growth is curiously restricted, and rarely is the lesion found to be more than 1.5 cm in diameter.[7]

Pain that is more acute at night and resolves with acetylsalicylic acid is the cardinal symptom of osteoid osteoma. Typically, pain is very well localized and can be used to identify the location of the lesion. Kaweblum and colleagues[8] stated that pain is the most important diagnostic tool for patients younger than 5 years.

An estimated one third of osteoid osteoma cases do not present with the classic physical and radiographic findings.[9] Reported misdiagnoses in cases of osteoid osteoma include osteomyelitis, neuromuscular disease, osteoarthrosis, fractures, Legg-Calvé-Perthes disease, and tuberculosis.[10-14] Enneking[9] postulated that, in approximately one third of all osteoid osteomas, the nidus is radiologically occult, and if clinical findings are absent, the lesion may remain undetected.

Characteristic radiographic findings consist of a well-delineated, smooth, regular, round to oval small radiolucency within the cortex of the affected bone. The affected bone may appear calcified, surrounded with dense homogeneous sclerotic bone.[11] On plain radiograph, the appearance of osteoid osteoma is of dense reactive bone. The lesion is radiolucent but may not materialize on plain radiograph because of the density of the reactive surrounding bone. The nidus often can be found within the cortex of the bone and is best localized with a thinly cut CT scan.[15]

Various authors have reported that MRI may be misinterpreted or misleading in the diagnosis of osteoid osteoma.[16-22] The falsely aggressive appearance of the lesion on MRI (especially when MRI has been the sole investigation) may not only lead to a missed diagnosis but may result in inappropriate and unnecessary surgery.[23] On the other hand, CT has proved to be of value in accurately demonstrating location, nidus, and other characteristic diagnostic radiographic features of osteoid osteoma in various studies.[24-26]

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In a recently concluded prospective blind study of the diagnostic accuracy of MRI versus CT for osteoid osteoma in children, Hosalkar and colleagues[23] noted that CT reliably and accurately identified the lesions of osteoid osteoma as both benign-latent (15/21 cases, ie, 71%) and correctly as osteoid osteoma (14/21 cases) more frequently than MRI (7/36 cases, ie, 19%) ($P \leq .0001$ for each). Hosalkar and colleagues wrote that, if a child presents with clinical findings consistent with osteoid osteoma (night pain, marked relief with anti-inflammatory drugs, findings on plain radiographs), and the clinician suspects osteoid osteoma (and knows where the anatomic lesion is), CT should be the advanced imaging modality of choice. If the location of the osteoid osteoma is unclear, then a bone scan should be performed to localize the lesion before proceeding to CT (osteoid osteomas, which are difficult to localize, are termed needle-in-haystack tumors). MRI (especially without clinical or CT correlation) may not be reliable, could be easily misinterpreted, and can lead to misdiagnosis.

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When secondary sclerosis is not present, an osteoid osteoma may be more or less dense than adjacent bone, or even invisible. Accordingly, symptoms can precede plain radiograph findings; in these instances, bone scans may be helpful in diagnosis, as osteoid osteoma almost always gives a positive signal.[7] Radiographs following the natural course of an osteoid osteoma show increased density reaction and modest isotope uptake for several years after ossification, even after the patient has become asymptomatic.[9]

Histologically, the nidus is made up of woven osteoid and bony trabeculae of various sizes clearly surrounded by bone, which may be densely sclerotic.[7,27] Within these trabeculae, vascular fibrous connective tissue and benign giant cells may be observed. At the center of the nidus, it is not unusual to find bone because it is the densest site of mineralization.

Grossly, osteoid osteoma is embedded in a region of cortical sclerosis. Redder than the surrounding sclerotic bone, the nidus is usually clearly prominent. The texture varies from soft and granular to densely sclerotic, with no apparent correlation between degree of sclerosis and composition of lesion.[7]

Other Conditions in the Differential Diagnosis

Fibrous cortical defect is an uncommon, spontaneously resolving defect of the metaphysis that almost always occurs in the long bones. Generally clinically quiet, this defect is usually inadvertently found when a radiograph is ordered for another complaint in some patients who present with pain, swelling, and/or fracture. Radiographs commonly show a lucency originating at the metaphysis and migrating to the cortex accompanied by a thin or prominent line of sclerosis and incomplete trabeculae, giving a multilocular appearance. Fibrous cortical defect on histologic examination is a loose storiform arrangement of spindle cell proliferation.[7]

Brodie abscess, a unique form of osteomyelitis, has a radiographic appearance that mimics the present case. The large zone of sclerosis seen on radiograph is typical of Brodie abscess.[7] Physical findings for osteomyelitis include fever and local erythema, neither of which was described in this case. A histologic section of osteomyelitis varies according to infectious organism; however, typical findings show granulation tissue amid a network of proliferating capillaries and polymorphonuclear leukocytes, plasma cells, and lymphocytes.[7]

The histologic and radiologic similarities of **osteoblastoma** and osteoid osteoma make diagnosis difficult, and thus one must turn to lesion size and clinical presentation for the correct diagnosis.[6,7,28] As previously stated, osteoid osteoma is uniquely small, no more than 1.5 cm in diameter, whereas osteoblastoma can range from 2 to 10 cm in diameter. Radiographically, osteoblastoma occasionally presents with secondary sclerosis.[6,7] Clinically, patients with osteoblastoma present with pain; however, this pain differs from the pain that is characteristic of osteoid osteoma in that relief comes with aspirin. In the case presented, the patient responded variably to pain with use of aspirin, yet the size of the lesion definitively proved the diagnosis of osteoid osteoma.

Radiographs of **periosteal chondroma**, a very rare, benign tumor of mature hyaline cartilage, characteristically show sclerotic bone surrounding a cup- or saucer-shaped alteration of the cortex. Histologically, lesions are very dense with chondrocytes.[28] Despite the consistency of the radiographic presentation with that of periosteal chondroma, the histologic findings of this lesion ruled out the diagnosis of periosteal chondroma.

Langerhans cell histiocytosis (LCH), known as the Great Imitator, varies greatly in presentation and requires biopsy for diagnosis. Characteristically, pain is the presenting complaint. On radiographs, the appearance of LCH varies widely, and there are single to numerous lesions; typically, lesions are lytic with well-defined margins, but surrounding sclerosis may occur with time. Histologically, proliferating histiocytic elements with admixtures of acute and chronic inflammatory cells, predominately eosinophils, are fairly distinctive.[9]

Treatments for Osteoid Osteoma

Surgical en bloc resection, curettage, and radiofrequency thermoablation of the lesion are preferred treatment modalities.[29,30] Sluga and colleagues[30] showed that the risks for postprocedural complications, such as fracture and recurrence, are almost equivalent for en bloc and curettage techniques. Tetracycline-fluorescence can sometimes be useful in locating the nidus intraoperatively.[31-33] Beyond en bloc and curettage techniques, other surgical approaches include preoperative CT with a pin guide. This procedure can decrease the risk for missing the nidus while subsequently avoiding larger resections—which decreases postprocedural fracture.[34] Radiofrequency thermoablation has been described as a highly effective, minimally invasive, and safe technique for treating osteoid osteoma.[35,36] In their series of 126 patients treated with CT-guided thermoablation with 2 years of follow-up, Rosenthal and colleagues[36] reported complete relief of symptoms after the procedure in 89% of patients (112/126) and resolution after treatment for 91% (107/117) of cases in which radioablation was the primary treatment. However, in this series, for patients with recurrent lesions, radioablation success was significantly lower: 6 of 10 recurrent lesions were treated unsuccessfully.

Outcomes

Complications following resection of the lesion include recurrence and pathologic fracture. It is recommended that care be taken when removing the lesion from the bone because, if the mass is indiscriminately chiseled or damaged, a pathologic diagnosis will be impossible.[7] If the lesion is haphazardly removed, and the pathology service is unable to make the diagnosis, postoperative radiographs should be obtained to ensure complete tumor removal.

Complete removal of the nidus is usually associated with pain relief immediately following surgery. Reported recurrence rates range from 2% to 22%,[7,37] and recurrence can be resolved with lesion reresection. In their series of 70 patients with osteoid osteoma, Pfeiffer and colleagues[38] found the local recurrence rate to be 7% after curettage compared with no recurrences after en bloc resection. However, pathologic fractures were observed following both treatment strategies in this series. Similarly, Sluga and colleagues[30] reported 12% recurrence in the group treated with curettage versus 4.5% in the group treated with en bloc resection. Postoperative fractures were seen in 2% of the curettage treatment group and in 4.5% of the en bloc resection treatment group.

Osteoid osteoma eventually resolves if not removed surgically. It matures in a few years and reaches a stage 1 latent process. Pain typically decreases over 2 to 4 years and eventually disappears.[9] Thus, conservative treatment is sometimes an option if pain is manageable with analgesics.

Authors' Disclosure Statement and Acknowlegements

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