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Case Series

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A Case Series on Distinguishing Osteomyelitis from Malignant Bone Tumors in the Pediatric Population

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Abstract

Distinguishing osteomyelitis from malignant etiologies poses significant challenges due to similarity in clinical presentations and imaging findings. This is even more difficult in the pediatric population, in which reliance on patient history may be limited. Prompt and accurate diagnosis is essential to avoid delays in treatment that could impact outcomes. This case series presents four instances in which initially both infectious and malignant pathologies were considered in the diagnoses. The aim is to highlight specific characteristics that may aid in the diagnosis. Institutional review board waiver of consent was obtained.

Keywords

Osteomyelitis, Bone tumors, Osteosarcoma, Penumbra, Pediatric

Introduction

Hematogenous osteomyelitis can be difficult to distinguish from bone tumors given similar clinical presentations and/or radiographic findings [1]. Imaging characteristics such as osteolytic lesions, cortical destruction, sclerosis, pathological fractures, and periosteal reactions can be seen in both infectious and malignant processes, which further blur the lines between benign and malignant processes [2]. The penumbra sign, which refers to the slightly hyperintense T1-weighted appearance of the lining of an abscess, is thought to be due to granulation tissue [3]. This is one of the few characteristics that may help differentiate subacute osteomyelitis from a bone tumor. Accurate differentiation is crucial to prevent unnecessary interventions and alleviate the distress associated with misdiagnosis.

Case Presentations

Case 1: A six-year-old female with a past medical history of eczema and autism presented with right wrist pain and swelling for five days. C-reactive protein (CRP), Erythrocyte sedimentation rate (ESR), and IgG were elevated, but the patient was afebrile and white blood cell count was within normal limits. Wrist radiographs suggested an infectious process (Figure 1), but further characterization with magnetic resonance imaging (MRI) was recommended. T1 weighted non-contrast MRI of the right wrist (Figure 2) revealed a soft tissue mass surrounding the right distal radial metaphysis. Post-contrast T1 MRI showed necrosis within the soft tissue mass with a periosteal reaction of the radius and, to a lesser extent, of the ulna (Figure 3). An aggressive process, such as metastatic disease from neuroblastoma was initially suspected based on the MRI. Abdominal ultrasound was recommended to exclude neuroblastoma, which was unremarkable. Computed tomography (CT) guided biopsy resulted in findings

Figure 1: Frontal radiograph of the right wrist revealed multiple lucencies within the distal radial metaphysis.

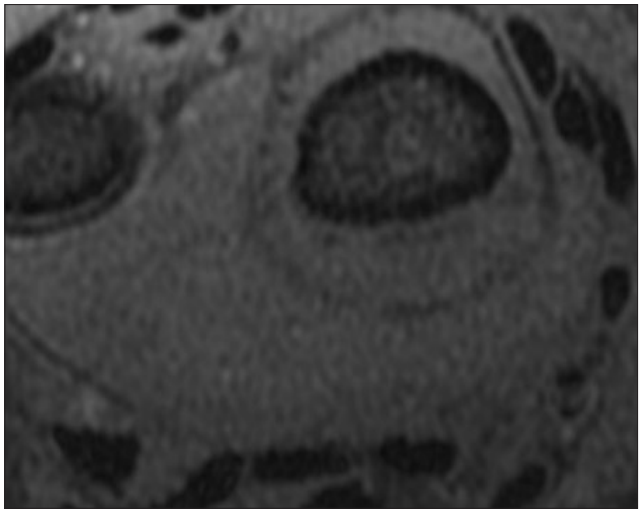

Figure 2: T1 weighted non-contrast MRI of the right wrist showed a soft tissue mass of the distal radial metaphysis.

consistent with acute osteomyelitis. A pediatric infectious disease physician, orthopedic surgeon, and rheumatologist were all involved in the care of the patient. Biopsy culture was positive for methicillin-susceptible staphylococcus aureus (MSSA) and the patient was prescribed Bactrim twice daily. The patient took Bactrim inconsistently over five weeks before being transitioned to Levofloxacin given that it was once daily instead. The patient's wrist swelling and pain resolved, and CRP normalized after completing the treatment.

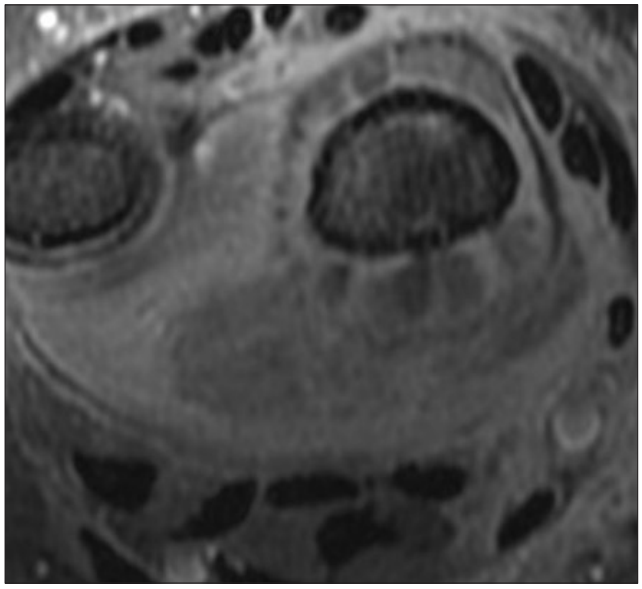

Figure 3: Post-contrast T1 MRI showed hypointense foci within the soft tissue mass, likely consistent with necrosis.

Case 2: A 5-year-old male with no significant past medical history presented with two and a half weeks of left wrist pain and edema. The symptoms began after the patient was bitten by a mosquito. He was initially diagnosed at an outside institution with an allergic reaction and given Benadryl without alleviation of his symptoms. He was afebrile with ESR, CRP and complete blood count (CBC) within normal limits. Wrist radiographs demonstrated a localized inflammatory process with a periosteal reaction in addition to a focal lytic lesion in the ulnar metaphysis with a central sclerotic sequestrum (Figure 4). The differential diagnoses based on the radiographs included brodie's abscess and eosinophilic granuloma. MRI was recommended for further evaluation, which showed a homogeneously enhancing lesion in the distal ulnar metaphysis with bone marrow and soft tissue edema, as well as a periosteal reaction (Figure 5, figure 6 and figure 7). Differential diagnoses after the MRI included osteomyelitis, abscess, Langerhans histiocytosis, and osteoid osteoma. Pathology was consistent with chronic osteomyelitis. The patient did well after debridement, antibiotic cement, and IV antibiotics.

Case 3: A 14-year-old male with no significant past medical history presented with six months of atraumatic pain and swelling around the left heel and ankle. Initial radiographs demonstrated a large sclerotic lesion with adjacent heterotopic ossifications and displacement of local soft tissues, fat planes and the achilles tendon, raising concern for an underlying malignancy, such as osteogenic sarcoma, but differential diagnoses also included ewing sarcoma and chronic osteomyelitis (Figure 8). MRI was recommended for further evaluation, which showed replacement of normal fatty bone marrow of the calcaneus with heterogeneous enhancement and a complex fluid collection displacing the tendons (Figures 9 and figure 10). Differential diagnoses based on the MRI included osteosarcoma or an infected fluid collection. Biopsy was consistent with chondroblastic osteosarcoma. The patient received chemotherapy and had to undergo a below the knee amputation.

Figure 4: Frontal radiograph of the wrist showed an expansile lytic lesion within the ulnar metaphysis with a central sclerotic sequestrum.

Case 4: A 14-year-old male presented with acute on chronic atraumatic left thigh pain. He was initially diagnosed with migratory arthritis at an outside institution. The pain was almost exclusively at night and resolved with ibuprofen. Prior radiographs were unremarkable, but initial radiographs at our institution showed a periosteal reaction extending from the femoral diaphysis to the distal metaphysis, which were concerning for an infiltrative process (Figure 11). MRI showed a T1 isointense and a T2 hyperintense (with respect to skeletal muscle) focus extending from the distal femoral diaphysis into the metaphysis (Figure 12, figure 13 and figure 14). Differential diagnoses at this point included lymphoma/leukemia, Ewing's sarcoma, or chronic osteomyelitis. A nidus was not visualized, but osteoid osteoma could not be excluded entirely. Further workup with PET/CT showed minimal uptake in the distal femur without cortical destruction or periosteal thickening. Tissue biopsy was recommended, however the clinicians instead opted for a CT one month later, which showed a thick periosteal reaction of the femoral diaphysis with a lucency which could have represented an atypical appearing nidus (Figure 15). A radiograph six months after the initial presentation showed signs of healing with complete sclerosis of the previously seen periosteal reaction (Figure 16 and figure 17). Clinicians believed that the lesion represented a stress fracture from overuse while playing basketball.

Figure 5: Coronal T1 non-contrast MRI of the wrist showed an isointense lesion within the ulnar metaphysis.

Discussion

Amongst our four patients, only one had elevated inflammatory markers, while all the patients presented with pain and swelling, ambiguous symptoms that do not help in the differentiation between osteomyelitis and bone tumors. In a study involving ten patients initially thought to have bone tumors but ultimately diagnosed with osteomyelitis, nocturnal pain was reported by 70% of patients and all of them had elevated CRP levels [2]. CRP is a nonspecific marker of inflammation and can definitively be elevated in the setting of soft-tissue infections. Furthermore, in a study done with 238 patients, it was found that imaging failed to distinguish between a bone tumor and infection in 59.7% of osteomyelitis cases and in 81.5% of soft-tissue infection cases [4]. The overlap in clinical and radiological presentation makes differentiating entities a challenging feat for clinicians.

The slightly T1 hyperintense appearance of the wall of an abscess, coined with the penumbra sign, can be seen in subacute osteomyelitis. It has been suggested that the lining of an abscess is made from granulation tissue, which is proteinaceous and highly vascular, which is why it appears hyperintense on T1-weighted imaging and avidly enhances. Histologically there is a lack of hemorrhage to explain the hyperintense

Figure 6: Coronal T1 post-contrast images showed avid homogeneous enhancement of the lesion.

Figure 7: Coronal T2 fat saturated sequence showed bone marrow and soft tissue edema with a smooth solid periosteal reaction.

Figure 8: Lateral ankle radiograph showed a sclerotic lesion within the calcaneus with a soft tissue mass displacing the fat planes.

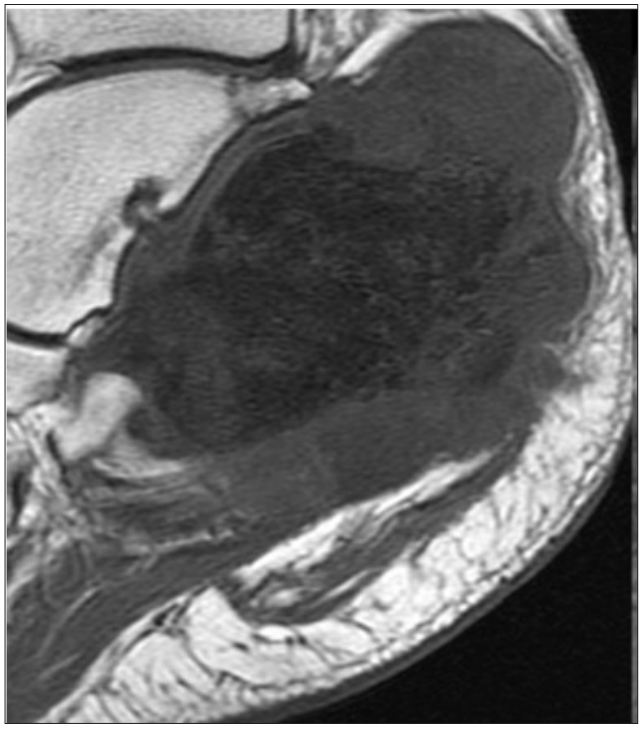

Figure 9: Sagittal T1 MRI showed the replacement of fatty marrow of the calcaneus with an intermediate signal rind.

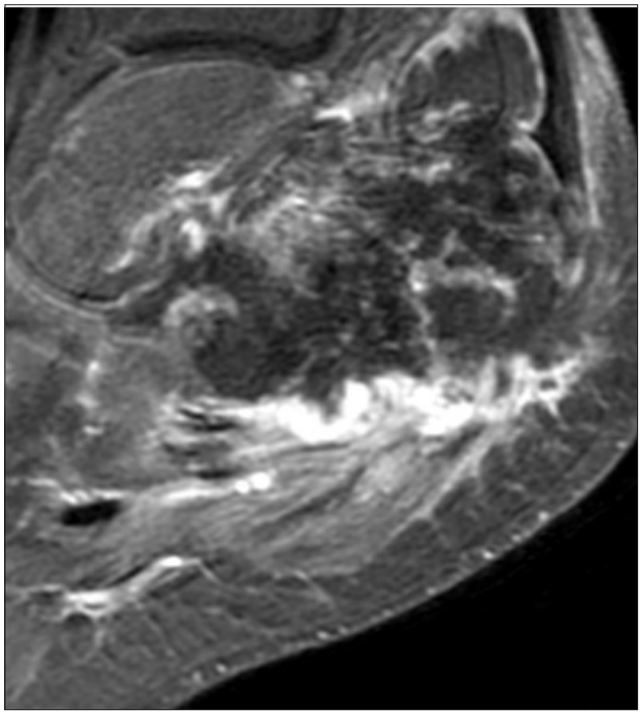

Figure 10: Sagittal T1 post-contrast imaging showed peripheral patchy enhancement extending into the retrocalcaneal bursa.

appearance on T1-weighted imaging [5]. In a study with 183 patients, the penumbra sign was thought to have a high specificity for infection at 96%, however the sensitivity was only 27%, proving that relying on this imaging characteristic is not sufficient for diagnosis [6]. The poor sensitivity of the penumbra sign is demonstrated by our first and second cases, in which the diagnoses were osteomyelitis, however there was no evidence of a T1 hyperintense rim. The lack of laboratory and imaging findings to fully differentiate between benign and malignant diseases indicates that a multidisciplinary approach is paramount.

Our cases demonstrate the need for ongoing awareness amongst providers regarding the nuanced presentation of osteomyelitis and bone tumors. As demonstrated by our fourth case, the initial diagnosis of migratory arthritis demonstrates how easily symptoms can be misinterpreted, especially if the patient is a poor historian. In the study with ten patients, one of the patients had nocturnal thigh pain for fourth months. Imaging revealed nonspecific finding such as an osteolytic lesion, a pathologic fracture, and a laminated periosteal reaction. The patient underwent multiple debridement surgeries and open reduction and internal fixation over two years before a bone cement with antibiotics was placed [2].

Conclusion

This case illustrates the importance of early differentiation between infectious processes and bone tumors to ensure timely intervention. Misdiagnosis can lead to unnecessary surgeries and delayed recovery. A thorough clinical assessment and multidisciplinary approach is needed to differentiate osteomyelitis from a more malignant process to ultimately improve patient outcomes. If imaging is equivocal for a

Figure 11: Lateral radiograph of the knee showed a periosteal reaction along the femoral diaphysis extending to the distal metaphysis.

diagnosis, surgical intervention may be needed, as was needed in most cases. A team-based approach not only enhances diagnostic accuracy but also ensures there is timely intervention.

Acknowledgments

This case series was presented as an educational exhibit at the 2024 annual American College of Osteopathic Radiology Conference.

Conflicts of Interest

None.

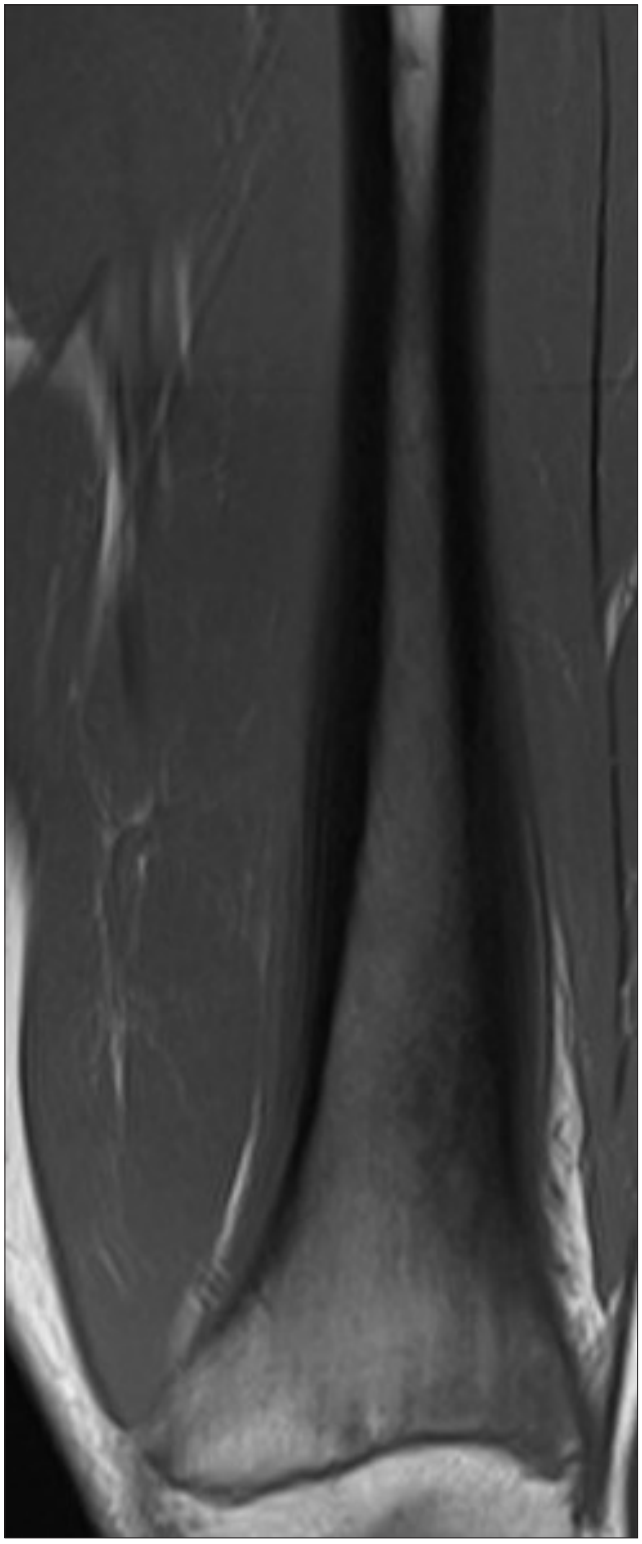

Figure 12: Coronal T1 sequence showed a T1 isointense abnormality in the distal femoral diaphysis.

Figure 13: Sagittal T2 fat saturated sequence displayed a hyperintense abnormality of the femoral diaphysis and metaphysis.

Figure 14: Coronal STIR sequence showed bone marrow edema and periosteal thickening in the distal aspect of the femur.

Figure 15: CT 1 month after presentation showed a thick periosteal reaction with an ovoid lucency in the medial cortex.

Figure 16: Knee radiograph 2 months after presentation showed a periosteal change of the distal diaphysis with cortical thickening.

Figure 17: Knee radiograph 6 months after presentation showed that the previously seen periosteal reaction had sclerosed**.**

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