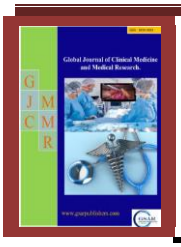

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Sonographic Evaluation of Primary Malignant Bone Tumor: Case Reports

By

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Abstract

Primary malignant bone tumors are rare but can be aggressive. Early detection is crucial for effective treatment. Plain radiography and CT scans remain the gold standards for diagnosing and characterizing bone tumors. Ultrasonogram (USG) is generally not effective for imaging bone tumors, as it cannot penetrate the bone's cortex. However, ultrasound is excellent for assessing soft tissues and can evaluate the superficial surfaces of bones. Musculoskeletal (MSK) ultrasound has advanced significantly and continues to improve, making it the first preferred imaging modality of choice for any palpable superficial mass to the physicians. So, it is important for the sonologist to be able to identify bone tumors during ultrasound examinations. This report presents two cases of primary malignant bone tumors where the initial evaluation was performed using sonography.

Keywords: *Musculoskeletal (MSK) ultrasound, primary bone tumor, Osteosarcoma, GCT (Giant Cell Tumor).*

INTRODUCTION

Primary malignant bone tumor account for 1-1.5% of all malignancy and 7% of pediatric tumor. Bone tumors have various pattern of growth, infiltration and internal architecture. Early detection is essential for successful treatment. Conventional radiography (X-ray) and computed tomography (CT) are regarded as the primary modalities to diagnose bone tumor and in advance cases magnetic resonance imaging (MRI) is used. Ultrasonogram (USG) is not included as a suitable tool in the diagnostic algorithm of bony tumor. But it is currently the preferred initial diagnostic tool for assessing MSK swelling and pain. So sonologists need to be familiar with sonographic presentation of bone tumor in the expanding era of MSK USG. Here we report two cases of primary malignant bone tumor diagnosed initially by USG, then correlated with other imaging modalities and confirmed by histopathology [(Madej et al, 2018, Wermeński et al, 2008)]

Case Reports

CASE-1: A 26-year-old male patient was referred to our center by outpatient department (OPD) for USG evaluation of left wrist swelling. He reported pain and swelling in distal forearm of left side for approximately six months, with no history of trauma. The pain worsened with activity and was initially relieved by medication. For the past month, the pain persisted despite medication and he experienced a mild, continuous ache. The swelling gradually increased, causing slight restriction of active wrist movement, which affected both his daily activities and professional life. The patient had no significant medical history. On local examination, diffuse swelling was observed over the left distal forearm. The swelling was firm, free from the overlying skin but fixed to the underlying bone.

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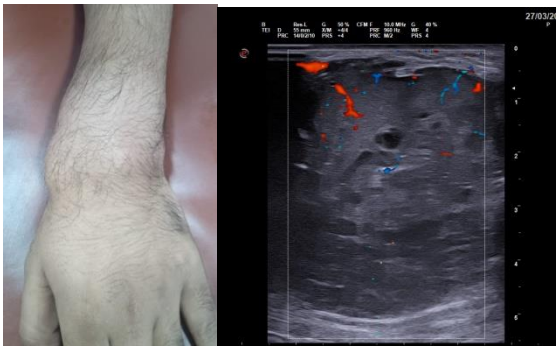

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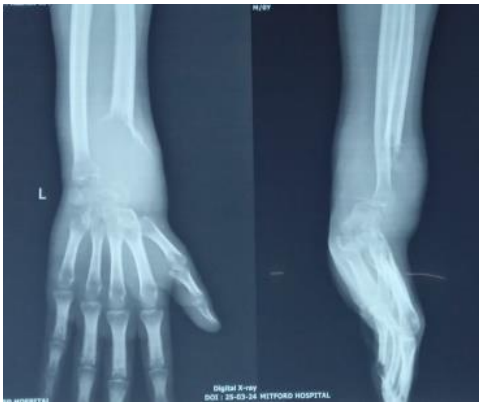
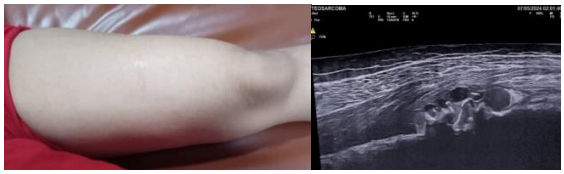


Fig: (a) A 26-years-old young male presented with left wrist swelling. (b) Ultrasound image revealed a fairly large heterogeneously hypoechoic soft tissue mass (*) having internal vascularity. (c) Plain X-rays revealed typical features of GCT (Giant Cell Tumor), presenting as a subarticular, expansile, lytic lesion with cortical destruction at the lower end of the radius.

Ultrasonogram was done using both linear and curvilinear transducer. USG showed a fairly large heterogeneously hypoechoic soft tissue mass (measuring >5.5 cm in length, AP diameter 4.8 cm) replacing the lower end of radius. The mass was expansile causing cortical thinning and destruction. On doppler study, low resistant internal vascularity noted. The involvement of the lower radius, patient's young age and presence of hypoechoic soft tissue mass with cortical destruction suggested an aggressive giant cell tumor (GCT). Radiological correlation was advised and plain X-ray revealed a subarticular, expansile, lytic lesion with cortical destruction at the lower end of the radius affecting both the epiphysis and metaphysis. No periosteal reaction noted. After surgical intervention histopathology showed malignant GCT.

CASE-2: A 15-year-old girl was referred by the outpatient department (OPD) for ultrasound evaluation of left thigh due to dull aching pain for several weeks, mild swelling at mid-thigh and difficulty in walking for one week. She didn't give any history of trauma. On local examination, mild soft tissue asymmetry was noted on the anterolateral aspect of the left mid-thigh. The overlying skin appeared normal and had a normal temperature.



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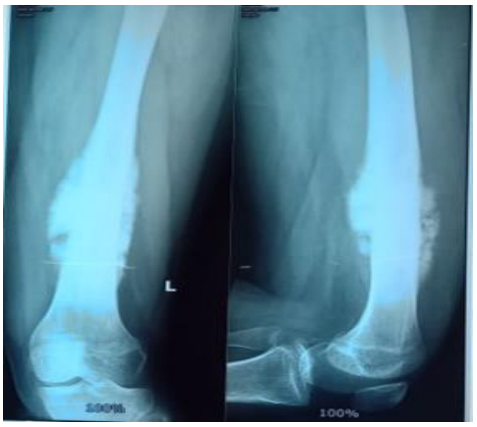

Fig: (a) Femoral lesion in a 15-year-old girl who presented with left thigh swelling and pain. (b) Longitudinal gray-scale ultrasound image of the left femur demonstrates a saucerized cortical defect (arrow head), peripheral periosteal reaction (arrow), and hypoechoic soft tissue mass (*). (c) Plain x ray revealed typical features of osteosarcoma as mixed sclerotic & lytic lesion in the femoral shaft with sunburst periosteal reaction.

Ultrasound scanning of the swollen area revealed a cortical defect in the femur filled with hypoechoic tissue that protruded into the surrounding soft tissue. The exact size could not be determined due to the lesion extending beyond the transducer's field of view. The adjacent periosteum appeared edematous with periosteal elevation and subperiosteal fluid collection. The soft tissue mass exhibited parallel linear hyperechoic lines resembling a "sun ray" appearance. These sonographic features were suggestive of a malignant bone tumor. Subsequent X-rays showed a mixed sclerotic and lytic lesion in the diaphysis of the femur accompanied by a "sunburst" periosteal reaction, characteristic of osteosarcoma. Serum alkaline phosphatase level was elevated and histopathology (core biopsy) confirmed the diagnosis of osteosarcoma of left femur.

Discussion

Bone tumors are the second most common cause of cancer-related death in children. The incidence of bone tumors increases with age, peaking in the second decade of life. Plain X-rays, CT scans, and MRI are the primary imaging modalities used for diagnostic and staging evaluation of bone tumors. When interpreting bone tumors, factors such as age, sex, and clinical history must be considered. Age is particularly significant as most bone tumors occur in specific age groups. While sex has limited diagnostic value, clinical history may also be less informative as many lesions present with nonspecific symptoms such as pain, swelling, or pathological fractures. Several factors should be considered

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including the number of lesions (solitary or multiple), the type of involved bone (flat, axial, or tubular), the specific part of the bone affected (shaft or bony end) and the involvement of bony components (cortex, medulla, or both). Zone of transition, periosteal or soft tissue involvement, presence of calcification, and cortical destruction are essential for differentiating malignant from benign lesions. These criteria are integral to the imaging algorithm for bone tumors.

For many years, plain X-ray was the only imaging modality available and remains the primary tool for diagnosing bone tumors. With the advent of CT, it has become an excellent option for providing detailed images of bony structures and tumor-related changes. MRI is utilized to evaluate local progression, marrow infiltration and potential complications. Scintigraphy (bone scan) is important for detecting skeletal metastasis. Recent advancements in fusion technology such as PET-CT offer new possibilities for imaging musculoskeletal tumors.

Ultrasonography is not typically considered a primary modality for imaging bone tumors, as it is not specifically designed to assess osseous tissue. With the advancements of musculoskeletal ultrasound, it is increasingly being utilized by the physicians as a first-line imaging tool for MSK pathology. USG is excellent for visualizing soft tissue and can also effectively evaluate superficial osseous, cartilaginous and articular structures. Most malignant tumors tend to destroy the cortical bone, leading to periosteal reactions and the formation of soft tissue masses. USG can detect tumors when there is cortical involvement or when they are located subperiosteally. Due to cortical destruction or thinning, ultrasound can penetrate the bone and reveal the internal architecture of the tumor. However, the exact size of a lesion may be difficult to measure if it extends beyond the transducer's field of view which could lead to missed detections.

Similar to X-rays, the presence of a periosteal reaction on USG raises suspicion for malignancy. Normally the periosteum is not distinguishable from the bony cortex on USG. However, periosteal reactions may appear as separation of newly formed subperiosteal bone (referred to as Codman's triangle on X-ray) or as mineralization and calcification perpendicular to the long axis of the bone (resembling a "sunburst" pattern on X-ray) or there may be edematous, irregular periosteum.

It is important to carefully assess the transitional zone between the tumor and healthy bone. A wide transitional zone suggests malignancy. Ultrasound can help delineate tumor margins where an infiltrative growth pattern indicates malignancy but an expansile pattern is more suggestive of a benign lesion. Osteolytic areas are identified as heterogeneous and hypoechoic on USG while calcifications appear as echogenic structures. Additionally, USG can precisely locate tumors in relation to nearby joints, muscles, vessels, and growth cartilage. For detecting soft tissue masses, USG is a readily available, cost-effective and non-invasive tool that can be performed at the bedside or in the operating room. In these case reports, both demonstrated cortical defects and soft tissue swelling on USG, although periosteal reactions were noted only in the osteosarcoma case. The combination of color Doppler and power Doppler imaging is particularly useful for assessing tumor vascularity and US can also be utilized for guided biopsies. However, USG has limitations, including operator dependency and variability in image quality based on the patient's physical condition and equipment used. It is unable to assess marrow infiltration, an area where MRI excels.

Giant cell tumor (GCT) is an osteolytic lesion that represents about 3-5% of all primary bone tumor. Age of patients are mostly between 20-40 years with a female to male ratio of about 1.5:1. GCT typically involves the metaphysis of long bone and can extend up to epiphyseal plate with common sites including distal femur (50-55%), proximal tibia followed by distal end of radius. GCT is considered as benign usually but can be locally aggressive and malignant (2-9%). Patients commonly present with pain and swelling while asymptomatic individuals may show up with pathological fractures. Plain X-ray for GCT shows subarticular, eccentric, expansile lytic lesion without periosteal reaction. Aggressive tumors may display a wide zone of transition, markedly thin cortex and soft tissue involvement. On ultrasound, GCT may appear as a heterogeneous mass with cortical thinning or irregularity; however, USG findings alone are insufficient for a definitive diagnosis, needs to correlate with further imaging and histological studies. In our patient, the age was within the typical range. Malignant transformation occurs more frequently in females, which does not correlate with our patient’s demographic. The most reported complications include recurrence (15-50%), pulmonary metastasis (5-10%), and malignant transformation (<10%). MRI is sensitive for detection of soft tissue changes, intra articular extension and marrow changes [Kabg et al, 2006].

Osteosarcoma is the most common primary bone malignancy predominantly affecting adolescent and young adults aged 10 to 15 years with a 2nd peak found in elderly. It typically arises in the metaphysis of the growing long bones with the distal femur and proximal tibia as the most common sites followed by the proximal humerus. Males are more commonly affected than female with a ratio of about 1.6:1. Tall people are more affected compared to short people. Patients usually present with progressive pain in the affected limb, which intensifies as the tumor expands the bony cortex and stretches the periosteum. Swelling and tenderness occur in later course. An estimated 5-10% of patients remain asymptomatic until a pathological fracture reveals the underlying tumor. Serum alkaline phosphatase levels are markedly elevated in this condition. On radiograph, osteosarcoma has a characteristic mottled appearance comprising sclerotic and lytic lesion in the bone and soft tissue. USG appearance of osteoid are hyperechoic. Periosteal elevation or sunburst type of reaction are common periosteal changes on USG. Soft tissue of osteosarcoma is mixed echogenic, predominantly hypoechoic area with a variety of hyperechoic foci. According to Kabg et al, sensitivity of USG and radiography in the detection of soft tissue mass of osteosarcoma was 100% and 71.4%

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respectively. In our case, periosteal separation, edematous hyperechoic reflection seen with cortical irregularity. Age and sex of the patient were typical for osteosarcoma. X-ray image of our patient revealed typical mottled appearance of long bone with sun burst periosteal reaction and soft tissue swelling [Cobby et al, 2003,Álvarez López et al, 2023]

USG is a complimentary tool in the diagnosis of MSK tumor especially in child and adolescent. It provides dynamic images with high resolution of soft tissue as well as superficial bony surface. However, appropriate additional imaging should be performed to evaluate and confirm bony pathology.

Conclusion

Nowadays ultrasonography is the initial imaging modality to evaluate any musculoskeletal swelling. Besides identifying soft tissue pathology, it is important for the radiologists to be able to recognize the bony pathology on USG.

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