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Radiological Characterization Of Primary Malignant Bone Tumors In Patient

[1]*Dr.Asaad Mousa Joudah Al-Baaj, [2]Dr. Qassim Najem Abud Al Jenapi, [3]Dr. Thamer Yasir Hussein Alrikabi

Abstract:
Bone tumors are a commonly encountered diagnostic dilemma for radiologists. Benign and malignant neoplasms, metabolic abnormalities, and tumor like conditions (reactive focal abnormalities often related to developmental or inflammatory causes) all fall under the purview of bone tumors. Primary bone tumors are rare; tumor like conditions, metastasis, and lymphohematological malignancies outnumber primary bone tumors by far. Conventional radiography is recommended as the initial imaging modality for suspected bone tumors. Radiography provides excellent resolution and yields the most useful information about the morphologic characteristics of a lesion providing important diagnostic information regarding aggressive or nonaggressive characteristics of the lesion. The combination of radiographic imaging findings, clinical information such as the age of the patient, and in some cases histology, are all essential. Rather than discussing an in-depth analysis of every bone tumor, we will instead focus on a systematic approach to the radiographic analysis of bone tumors. The figures and tables in this article will help readers become familiar with specific radiographic appearances, location, and age predilection of common bone tumors and help to organize a differential diagnosis when analyzing a bone lesion.

Key words: *Benign and malignant tumor, primary bone tumors.*

Introduction:

Bone tumors are caused by either abnormal growth of bone-like tissue or soft tissue in the bones. Tumors are classified into benign or malignant and primary or secondary. Globally malignant bony lesions have two age incidences (between 10-20 years and 40-80 years). They also have gender predilection, with the incidence in males 1.5% more than in females [1]. A study conducted in the northern region of Pakistan found primary bone tumors accounted for 3.14% of all tumors [2].
The diagnostic evaluation of focal bone lesions involves information from the patient's medical history (age, gender, malignancies, history of pain, injuries), examination of the lesion, radiographic examination of the margins, degree of cortical expansion, periosteal reaction, and previous imaging. Primary bone tumors are overshadowed by metastatic cancers such as carcinoma and hematologic malignancies. MRI helps differentiate malignant bony lesions from benign lesions. In small lesions, MRI is helpful as small lesions can be picked up on a diffusion-weighted image (DWI) sequence, on which diffusion restriction indicates more toward malignancy. MRI is also helpful in imaging to follow up after treatment [3].
Radiological assessment of bone lesions is difficult if specialized centers are not available. Conventional radiography plays a major role in bone tumor diagnosis. X-rays play their specific role in imaging diagnostic workups. Bone tumor aggressiveness is calculated by interpretation of its bony matrix on the radiograph. For local staging, MRI is considered the most effective method [4].
n accurate diagnosis requires the patient's age, location of tumor, pattern of their destruction/margins, aggressiveness, growth speed, matrix formation, periosteal reaction (inside or outside), cortical involvement, size, number, and appearance on MR imaging [5,6,7]. Benign tumors are pathologies commonly encountered in daily practice and have various common characteristic appearances. Hence, it is essential for clinicians to evaluate their presentation, symptoms, and radiographic appearance to be safe from misdiagnosing.

Etiology:

The etiology and pathogenesis of most bone tumors are uncertain. Current hypotheses indicate that clonal chromosomal aberrations in mesenchymal stem cells develop, the mutations activate genes, and the gene expression profile determines the specific phenotype and biologic potential of the newly formed neoplasm. The specific molecular genetic changes and

[1]*Iraqi Ministry of Health, Diwaniyah Health Dirctorate, Diwaniyah, Iraq. M.B.Ch.B. \ C.A.B.M.S. \ (Radiology)
E-mail:- Assaad.mousa@yahoo.com.
[2]Iraqi Ministry of Health, Diwaniyah Health Dirctorate, Diwaniyah, Iraq. M.B.Ch.B. \ C.A.B.M.S. \ (Radiology)
[3]Iraqi Ministry of Health, Thi-Qar Health Office, Thi-Qar, Iraq. M.B.Ch.B. \ C.A.B.M.S. \ (Radiology)[3]

their related alterations in signaling pathways have resulted in a better understanding of the pathogenesis of some bone tumors and have helped identify diagnostic markers, prognostic factors, and new forms of targeted therapy. [8]

Classification:

The classification of bone tumors is based on the normal cell or tissue type that they recapitulate [9] . Most differentiate along the cell lines or tissue types that compose the skeletal system; a small number have consistent and distinctive clinicopathologic features but lack an identified normal tissue counterpart. Further subclassification of bone sarcomas is based on their specific histologic characteristics, their relationship to the underlying bone, their genetic aberration, and the presence of preexisting conditions. A variety of non-neoplastic conditions and diseases may present as a mass involving bone, and these must be distinguished from primary bone neoplasms to ensure appropriate treatment**.** [10]
When cells divide abnormally and uncontrollably, they can form a mass or lump of tissue. This lump is called a tumor. Bone tumors form in your bones. As the tumor grows, abnormal tissue can displace healthy tissue. Tumors can either be benign or malignant.
Benign tumors aren't cancerous. While benign bone tumors typically stay in place and are unlikely to be fatal, they're still abnormal cells and may require treatment. Benign tumors can grow and could compress your healthy bone tissue and cause future issues. [11]
Malignant tumors are cancerous. Malignant bone tumors can cause cancer to spread throughout the body.

Types of benign bone tumors:
Osteochondromas

Benign tumors are more common than malignant ones. According to the (AAOS), the most common type of benign bone tumor is an osteochondroma. This type accounts for between 35 and 40 percent of all benign bone tumors. Osteochondromas develop in adolescents and teenagers.
These tumors form near the actively growing ends of long bones, such as arm or leg bones. Specifically, these tumors tend to affect the lower end of the thighbone (femur), the upper end of the lower leg bone (tibia), and the upper end of the upper arm bone (humerus). [12]
These tumors are made of bone and cartilage. Osteochondromas have been considered to be an abnormality of growth. A child may develop a single osteochondroma or many of them.

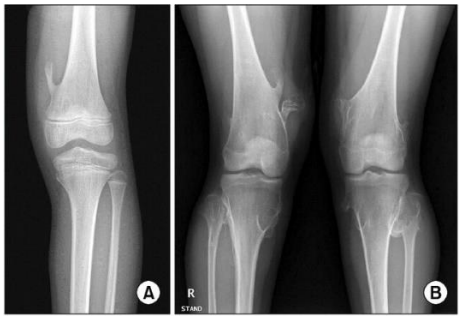

Figure 1. A pedunculated osteochondroma in the distal femur.

Nonossifying fibroma unicameral

Nonossifying fibroma unicameral is a simple solitary bone cyst. It's the only true cyst of bone. It's usually found in the leg and occurs most often in children and adolescents. [13]

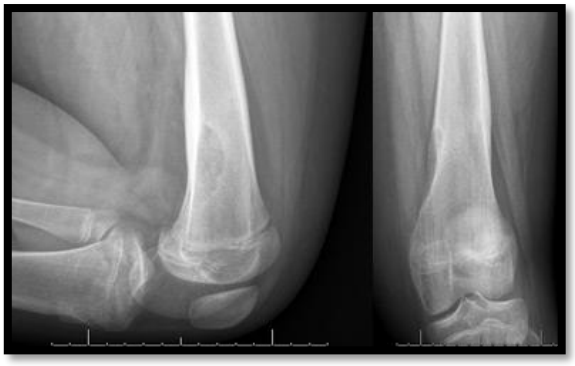

Figure 2 – The NOF is located on the edge of the distal femur (thigh bone).

Giant cell tumors

Giant cell tumors grow aggressively. They occur in adults. They're found in the rounded end of the bone and not in the growth plate. These are very rare tumors.

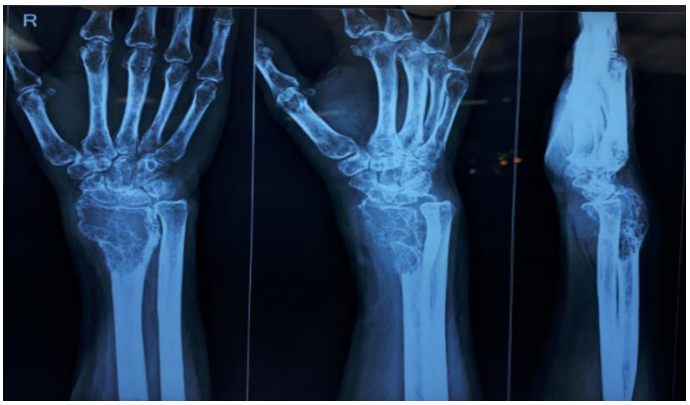

Figure 3: Pre-operative radiograph of right wrist showing locally aggressive giant cell tumor (GCT) of the right distal radius**.**

Enchondroma

An enchondroma is a cartilage cyst that grows inside the bone marrow. When they occur, they begin in children and persist as adults. They tend to be part of syndromes called Ollier's and Mafucci's syndrome. Enchondromas occur in the hands and feet as well as the long bones of the arm and thigh. [14]

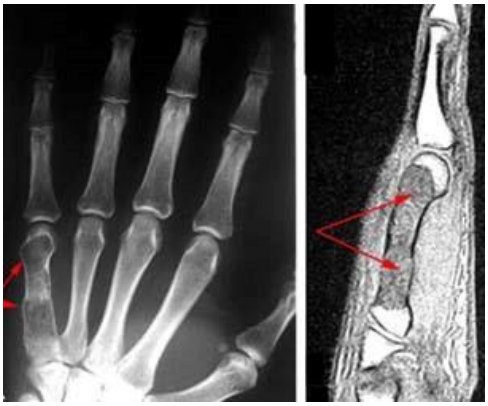

Figure 4. X-ray (left) and MRI scan (right) showing a large enchondroma of the fifth metacarpal of the hand.
Fibrous dysplasia

Fibrous dysplasia is a gene mutation that makes bones fibrous and vulnerable to fracture.

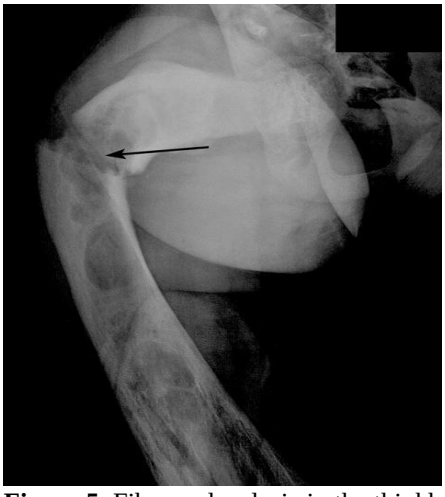

Figure 5. Fibrous dysplasia in the thighbone. This X-ray shows a fracture at the tip of the arrow.

Aneurysmal bone cyst

An aneurysmal bone cyst is an abnormality of blood vessels that begins in the bone marrow. It can grow rapidly and can be particularly destructive because it affects growth plates. [15]

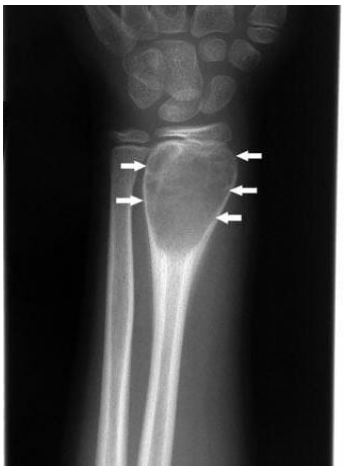

Figure 6. Show the characteristic of an aneurysmal bone cyst. X-ray shows a ballooning periosteal new bone formation around the expansile lesion (arrows),

Types of malignant bone tumors

There are also several types of cancer that produce malignant bone tumors. Primary bone cancer means that the cancer originated in the bones. According to the National Cancer Institute (NCI)Trusted Source, primary bone cancer accounts for less than 1 percent of all types of cancer. [16]
The three most common forms of primary bone cancers are osteosarcoma, Ewing sarcoma family of tumors, and chondrosarcoma.

Osteosarcoma

Osteosarcoma, which occurs mostly in children and adolescents, is the second most common type of bone cancer. This usually develops around the hip, shoulder, or knee. This tumor grows rapidly and tends to spread to other parts of the body.

The most common sites for this tumor to spread are areas where the bones are most actively growing (growth plates), the lower end of the thighbone, and the upper end of the lower leg bone. Osteosarcoma is also sometimes known as osteogenic sarcoma. Here's how it's treated and the outlook for people diagnosed with osteosarcoma. [17]

Ewing sarcoma family of tumors (ESFTs)

Ewing sarcoma family of tumors (ESFTs) strikes adolescents and young adults, but these tumors can sometimes affect children as young as 5 years old. This type of bone cancer usually shows up in the legs (long bones), pelvis, backbone, ribs, upper arms, and the skull.

It begins in the cavities of the bones where the bone marrow is produced (the medullary cavities). In addition to thriving in bone, ESFTs can also grow in soft tissue, such as fat, muscle, and blood vessels. According to the NCITrusted Source, African-American children very rarely develop ESFTs. Males are more likely to develop ESFTs than females. ESFTs grow and spread rapidly. [18]

Chondrosarcoma

Middle-aged people and older adults are more likely than other age groups to develop chondrosarcoma. This type of bone cancer usually develops in the hips, shoulders, and pelvis. [19]

Secondary bone cancer

The term "secondary bone cancer" means that the cancer started somewhere else in the body and then spread to the bone. It usually affects older adults. The types of cancer most likely to spread to your bones are: [20]

Multiple myeloma

The most common type of secondary bone cancer is called multiple myeloma. This bone cancer shows up as tumors in the bone marrow. Multiple myeloma most commonly affects older adults.

Symptoms

Most patients with a bone tumor will experience pain in the area of the tumor. The pain is generally described as dull and achy. It may or may not get worse with activity. The pain often awakens the patient at night. Although tumors are not caused by trauma, occasionally injury can cause a tumor to start hurting. Injury can cause a bone weakened by tumor to break, which often leads to severe pain. Some tumors can also cause fevers and night sweats. Many patients will not experience any symptoms, but will instead note a painless mass. [21]

Medical history and physical exam:

This includes any medications you take, details about any previous tumors or cancers that you or your family members may have had, and symptoms you are experiencing. Your doctor will physically examine you. The focus is on the tumor mass, tenderness in bone and any impact on joints and/or range of motion. In some cases, the doctor may want to examine other parts of your body to rule out cancers that can spread to bone.

Imaging and tests:

Different types of tumors exhibit different characteristics on X-ray. Some dissolve bone or make a hole in the bone. Some cause extra formation of bone. Some can result in a mixture of these findings[22,23]

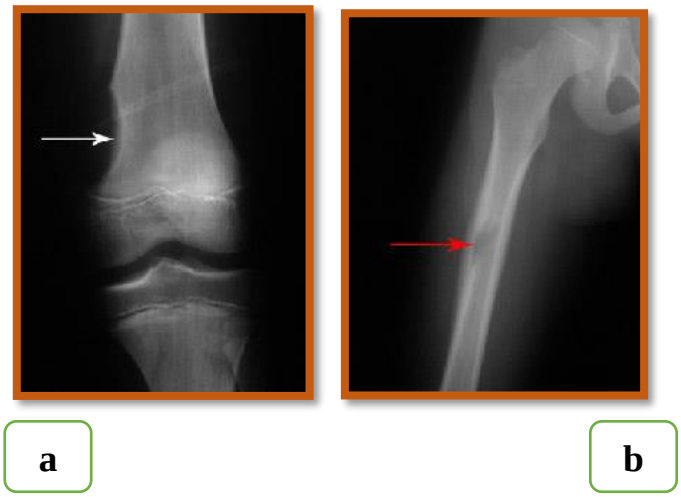

Figure 1 a: Shows a tumor causing a saucer-like erosion in the end of the thighbone.
Figure 1 b: Shows a bone tumor in the middle of the femur exhibiting a combination of characteristics.

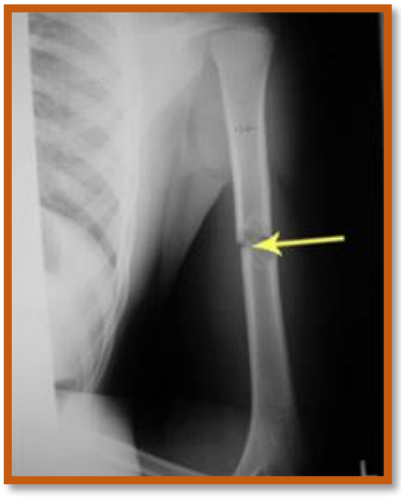

Figure 2: Shows a fracture through a tumor in the middle of the upper arm bone.

Some tumors have characteristic findings on X-rays. In other cases, it may be hard to tell what kind of tumor is involved. You may need more imaging studies to further evaluate some tumors. These may include MRI (magnetic resonance imaging) or CT (computed tomography). [24]

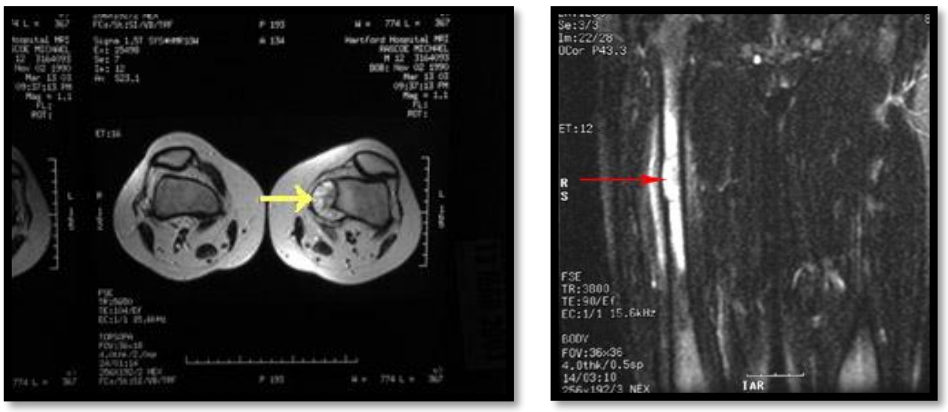

Figure 3: Shows the cross-sectional MRI appearance of the tumor

Results:

A total of 45 cases were included in this study. There was only slight preponderance of male compare to female. The minimum age was 15 years and the oldest patient was 61 years with the mean age 29.01 years.

In the present study, there were only a few more male patients than female patients, with an approximate ratio of 1:1.The mean ages at onset of Ewing sarcoma, osteosarcoma and chondrosarcoma were 15, 17 and 19 years, respectively. Osteosarcoma was the most common primary malignant bone tumor (71%), followed by Ewing sarcoma (16%), chondrosarcoma (7%) and lymphoma (2%). The most common site of the osteosarcomas, Ewing sarcomas and chondrosarcomas was the long bones. Overall, ~76% originated near the knee joint (distal femur and proximal tibia), which is consistent with the results of previous studies. The most common presenting symptom was pain, or an enlarging soft-tissue mass and pathological fractures. However, pathological fracture is one of the factors contributing to a poor prognosis and is indicative of aggressive tumors. The most common sites of metastasis were the lungs and other bones, while the lymph nodes and internal organs were rarely involved. Skip metastases have been reported in 2–7.5% of osteosarcoma and 4–7% of Ewing sarcoma patients . Skip lesions occurred in 6% of the osteosarcoma patients in the present study, which is a slightly higher rate than that reported in the literature. None of the patients with Ewing sarcoma developed skip lesions.

Bone scintigraphy is a method with high sensitivity, but low specificity. Due to osteogenetic activity or the increase in blood flow to benign and malignant bone tumors, the uptake of radionuclide in the lesions is increased. Therefore, in the majority of cases, Bone scintigraphy cannot differentiate benign from malignant tumors; however, it can be used to exclude benign tumors without radionuclide uptake. In addition, Bone scintigraphy is effective for detecting metastases of the skeletal system . CT is more effective than conventional radiography at revealing subtle destruction of the bone cortex, the type of tumor matrix and periosteal reactions. Three-dimensional CT is the best option for bone tumors in the pelvis, scapula and other complex or overlapping bones. Additionally, CT is useful for finding pulmonary metastases.
MRI is superior for evaluating the extent of intramedullary and soft-tissue masses. MRI is also markedly more efficient at detecting skip lesions.

Discussion:

Radiographs remain the most appropriate imaging modality for screening and initial characterization of primary bone tumors. Radiographs provide an accurate means by which to evaluate primary bone tumors. Radiographs effectively provide information in regard to tumor location, size, and shape, as well as evidence of tumor biological activity [24]. Tumor margin and periosteal reaction provide a reliable index of biological potential of the tumor, whereas matrix, if identified, is a key to the underlying of x-ray [25-26]. Although the utility of radiographs in stratifying bone lesions by biological activity is well established, there is sparse literature documenting concrete values on accuracy. A prospective study evaluating 200 consecutive bone tumors of the hand showed that subjective grading of tumors based on radiographic features provided a correct categorization of tumor grade (benign versus malignant) in 71.5% of cases [27]. In a retrospective study applying a modified chondrosarcoma to categorize 7% bone tumors, [28] found that a low radiographic grade assignment correlates with benignity and that increasing grade correlates with an increasing risk of malignancy. It should be noted that accurate radiographic characterization of some primary bone tumors (such as low-

grade cartilage lesions) is inherently difficult because of overlapping radiographic features of some benign and malignant chondroid lesions.

Conclusions

Bone tumors can be diagnosed with high diagnostic accuracy using X-rays and MRIs, which are reliable and noninvasive imaging methods. On X-rays by evaluating bone and soft-tissue calcification, and on MRI local invasion, soft-tissue characterization, perilesional changes, and diffusion restriction rule out malignancy and minimize errors and need for fine-needle aspiration cytology (FNAC) or biopsy with high diagnostic accuracy.

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