



## MRI EVALUATION OF BONE TUMORS AND TUMORS LIKE CONDITION

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### ABSTRACT

**Background:** MRI plays an important role in diagnosis and treatment of bone tumor in current scenario. MRI can differentiate bone tumor as either benign or malignant and determine its stage thereby helping in making decisions for type/site of biopsy and in planning treatment. **Objective:** The objectives of our study were to assess the diagnostic accuracy of MRI in bone tumor and tumor like conditions with histopathological correlation and to describe their spectrum and MRI features. **Methods:** This was a hospital based study carried out on cross sectional basis in the Department of Radiology over a period of one year. 32 patients who underwent MRI and histopathological examination of bone tumor and tumor like conditions were selected for the study. The true positive, false positive, true negative and false negative cases were determined considering histopathology as a gold standard and diagnostic accuracy was calculated. **Result:** Among 32 patients, 16 (50%) cases were diagnosed as benign tumor, 9 (28%) were diagnosed as tumor like condition, 5 (15.6%) cases were diagnosed as primary malignant tumor and 2 (6.2%) as metastatic tumor. GCT was the most common benign tumor (4,12.5%) and osteosarcoma (3, 9.4%) was the most common malignant tumor. Most cases (29, 90.6%) were accurately diagnosed on MRI and confirmed on histopathology. Diagnostic accuracy of MRI was between 93.7 to 100%. **Conclusion:** MRI was found to be a valuable modality of imaging in diagnosing various tumor and tumor like conditions of bone.

**KEYWORDS:** Magnetic Resonance Imaging, Bone tumor and tumor like conditions, Histopathology.

### INTRODUCTION

Evaluation of bone tumors involves a multimodality approach. Conventional X-ray constitutes the initial imaging modality for characterizing bone tumors and tumor-like conditions. Computed tomography (CT) is valuable tool for evaluation of bone tumors because of its cross-sectional imaging capability. The inherent inability of ultrasound to penetrate the cortical bone limits its role in the assessment of bone tumors. Magnetic resonance imaging (MRI) is the investigation of choice for evaluation of bone tumors and tumor like conditions. MRI exquisitely assesses the extent of cortical, intramedullary, joint, soft tissue and neurovascular involvement by the neoplasm.<sup>[1]</sup> Important features such as fluid–fluid levels and tumor composition may lead to a more accurate diagnosis. Bone lesions often pose diagnostic challenges to surgical pathologists. Therefore, an integrated approach involving radiographic, histologic, and clinical data are necessary to form an accurate diagnosis and to determine the degree of activity and malignancy of each lesion. Advancement in

the imaging technologies have allowed diagnosis of bone tumor in early stage. It's now possible to determine the aggressiveness of the tumor and precisely stage the tumor using images. MRI is the most important among these imaging modalities which can diagnose the tumor, as either benign or malignant and determine its stage depending on whether it is intra or extra compartmental. This helps in making decisions for type/site of biopsy and in planning treatment, as most unicompartmental tumors are resectable with limb salvage while locally aggressive tumors may need radical excision and amputations. MRI plays an important role in diagnosis and treatment of bone tumor in current scenario.

### METHODS

The study was carried out in the Department of Radiodiagnosis & Imaging, B.P.Koirala Institute of Health Sciences, Dharan over a period of one year. Patients with clinical suspicion of bone tumor and tumor like conditions referred for MRI evaluation were included in the study. After taking informed consent the

detailed clinical history was taken and general, systemic and local examination was done as per structured pro forma. Plain radiograph of the region of interest was also analyzed and findings were recorded in structured pro forma. A total of 32 patients were enrolled in the study. All the patients were evaluated on 0.35 Tesla open magnet MAGNETOM C! SYNgo MR Scanner (Siemens). MRI was done using T1W, T2W, STIR sequences in axial, coronal and sagittal planes. Gadolinium-enhanced T1W sequence was obtained in all the cases. MRI features like signal intensity, contrast enhancement, presence of fluid-fluid level, bone marrow edema, cortical breach, joint involvement, soft tissue extension and neurovascular involvement were evaluated and recorded on a structured pro forma for data analysis. Histopathological analysis was done in all cases and finding was recorded on a structure pro forma for analysis of the data. The MRI diagnoses were correlated with histopathological diagnoses (gold standard). The true positive, true negative, false positive and false negative cases were determined to calculate the diagnostic accuracy of MRI for bone tumors and tumor like conditions of bone. The spectrum of the bone tumors and tumor like conditions was obtained on MRI and histopathology separately. The MRI features of histopathologically proven bone tumors and tumor like conditions of bone were described separately.

## RESULT

A total of 32 cases with bone tumors and tumor like conditions meeting the inclusion criteria were evaluated in this study. Age of the patients ranged from 7 to 65 years with maximum number of patients (40.6%) in the age group of 10 to 19 years. Out of 32 patients, 17(53.1%) were male and 15 (46.9%) were female with male to female ratio of 1.2:1. Among 32 patients, most common presenting complain was pain and swelling in 16 (50%) cases followed by painless swelling in 11(34.4%) and pain in 5 (15.6%). Among 32 patients, 16(50%) cases were diagnosed as benign tumor, 9 (28%) were diagnosed as tumor like condition, 5(15.6%) cases were diagnosed as primary malignant tumor and 2(6.2%) as metastatic tumor on MRI. Among 32 cases, femur was the most common location (n=10, 31.2%), followed by tibia (n=6, 18.8%), cranial bone (n=5, 15.6%), humerus (n=4, 12.5 %) and fibula (n=2, 6.3%). Other bone involved were mandible (n=1, 3.1%), patella (n=1, 3.1%), clavicle (n=1, 3.1%), radius (n=1, 3.1%) and phalynx (n=1, 3.1%).

Out of 23 lesions which occurred in long bones of limb, most common location was meta-diaphysis (n=10,

43.4%) followed by meta-epiphysis (n=5, 21.7%) and diaphysis (n=4, 17.4%). The lesion was confined only to the metaphysis in 4 (17.4%) cases. Among 32 patients, GCT (n= 4, 12.5%) and ABC (n= 4, 12.5%) were the most common tumor and tumor like condition on MRI. Other tumor and tumor like conditions diagnosed on MRI were fibrous dysplasia (n=3, 9.4%), hemangioma (n=3, 9.4%), osteochondroma (n=3, 9.4%), chondrosarcoma (n=2, 6.3%), osteoid osteoma (n=2, 6.3%), enchondroma (n=2, 6.3%), metastasis (n = 2, 6.3%), osteosarcoma (n=2, 6.3%), ameloblastoma (n=1, 3.1 %), ewing's sarcoma (n=1, 3.1%), filled in NOF (n=1, 3.1%), osteoma (n=1, 3.1%) and simple bone cyst (n=1, 3.1%). In our study, all the patients underwent histopathological examination. True positive (TP), false positive (FP), true negative (TN) and false negative (FN) cases on MRI were calculated considering histopathological diagnosis as gold standard. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of GCT, ABC and FD were 100 %, 100 %, 100 %, 100%,100%; 100%, 96.5%, 75%, 100%, 96.8% and 66.7%, 96.6%, 66.6%, 96.5%, 93.7% respectively.

The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of hemangioma were 100%, 96.6%, 66.6%, 100% and 96.8% respectively. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of osteochondroma, enchondroma, chondrosarcoma, ewing's sarcoma, osteoid osteoma, osteoma and simple bone cyst were 100%. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of osteosarcoma were 66.6 %, 100%, 100 %, 96.6 % and 96.8 % respectively.

One case each of ameloblastoma and filled in NOF were falsely diagnosed on MRI leading to 0% sensitivity, 96.8% specificity, 0% PPV, 100% NPV and 96.8% accuracy. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of central giant cell granuloma, plasmacytoma, epithelioid hemangioendothelioma, JPsOF and intramedullary osteosclerosis were 0%, 100%, 0%, 96.8% and 96.8% respectively. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of metastasis were 0 %, 93.7 %, 0 %, 100 % and 93.7 % respectively.

**Table 1: Distribution of bone tumor and tumor like conditions of bone on MRI and histopathology.**

Tumors and tumor like conditions	MRI diagnosis (n=32)	Histopathological diagnosis (n=32)
Benign tumor	16 (50%)	14 (43.7%)
Tumor like condition	9 (28.1%)	10 (31.3%)
Primary malignant tumor	5 (15.6%)	8 (25%)
Metastasis	2 (6.2%)	0%

Table 2: Showing comparison of MRI diagnosis with histopathological diagnosis.

Bone tumor and Tumor like conditions	MRI	HP	TP	TN	FP	FN
Giant cell tumor	4	4	4	28	0	0
Aneurysmal bone cyst	4	3	3	28	1	0
Fibrous dysplasia	3	3	2	28	1	1
Osteochondroma	3	3	3	29	0	0
Hemangioma	3	2	2	29	1	0
Chondrosarcoma	2	2	2	30	0	0
Enchondroma	2	2	2	30	0	0
Osteosarcoma	2	3	2	29	0	1
Osteoid osteoma	2	2	2	30	0	0
Metastasis	2	0	0	30	2	0
Ewing's sarcoma	1	1	1	31	0	0
Osteoma	1	1	1	31	0	0
Simple bone cyst	1	1	1	31	0	0
Ameloblastoma	1	0	0	31	1	0
Filled in NOF	1	0	0	31	1	0
EHE	0	1	0	31	0	1
CGCG	0	1	0	31	0	1
Plasmacytoma	0	1	0	31	0	1
JPsof	0	1	0	31	0	1
Intramedullary osteosclerosis	0	1	0	31	0	1

## Illustration(Figures)



Figure. (1a)

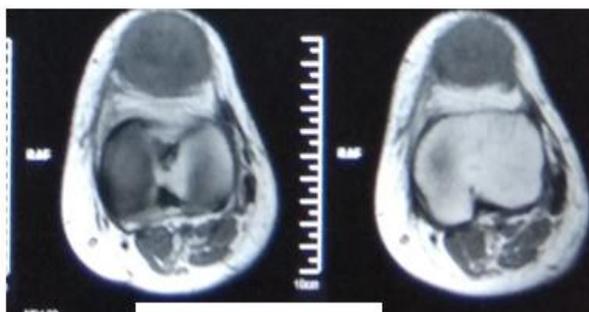


Figure: (1b)

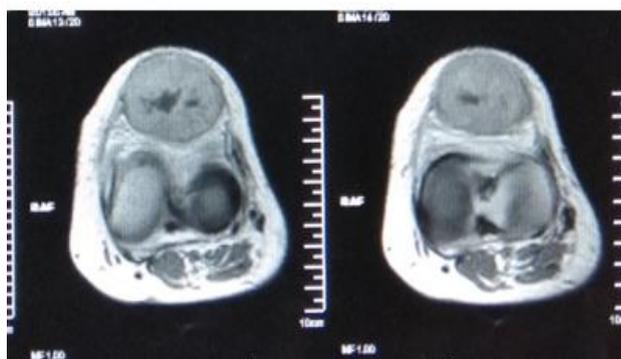


Figure. (1c)

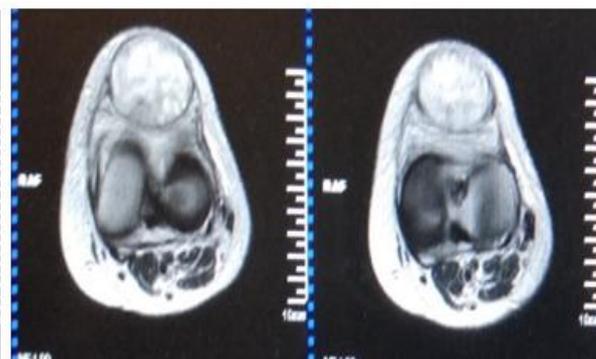


Figure. (1d)

Figure 1: Plain radiograph lateral view (1a), axial T1W (1b), post gadolinium axial T1W (1c) and axial T2W (1d) showing GCT of patella. It appears as expansile lytic lesion with thinning of cortex on plain radiograph. Tumor appears isointense to muscle on T1W and heterogeneously hyperintense on T2W sequences. The lesion shows mild to moderate enhancement on post contrast images with few small non-enhancing areas within it.



Figure 2(a)



Figure 2 (b)



Figure 2 (c)



Figure 2(d)

**Figure 2: Plain radiograph AP view (2a), coronal T1W (2b), post gadolinium coronal -T1W (2c) and sagittal T2W images (2d) showing distal femoral osteosarcoma. Plain radiography shows permeative type of bone destruction with ill-defined margin and wide zone of transition. Tumor appears intermediate on T1W image, hyperintense on T2W image and shows mild heterogeneous enhancement on post gadolinium enhanced-T1W images. Tumor shows cortical breach with soft tissue involvement. Tumor is also involving articular cartilage of knee joint.**

## DISCUSSION

A total of 32 patients with bone tumor and tumor like conditions on MRI were studied. In our study, age of patients ranged from 7 to 65 years, with maximum number of cases 13 (40.6%) in 2<sup>nd</sup> decade. In a study done by Rafique and Bari, among 30 patients with bone tumors, age of the patients ranged from 5 to 75 years.<sup>[2]</sup> In a similar study done by Baweja *et al.*, age of the patients ranged from 10- 57 years with most of them in the age group of 10-20 years.<sup>[3]</sup> In a study by Naegash *et al.*, out of 205 bone tumors, majority of bone tumors (n=87, 42.4%) were in the age range of 10 to 19 years.<sup>[4]</sup>

In our study, male predominance of bone tumor and tumor like conditions was noted, as 17 (53.1 %) cases were males and 15 (46.9 %) cases were females with male to female ratio of 1.2:1. In a study by Rao *et al.*, in 523 cases of primary bone tumor and tumor like conditions, male preponderance was noted.<sup>[5]</sup> Male preponderance was also noted in study by Solooki *et al.*, in which there were 170 women (39.9%) and 256 men

(60.1%) with male to female ratio of 1.5:1.<sup>[6]</sup> In a similar study done by Rhusto *et al.*, 34 patients (55%) were males and 28 (45%) patient were females with male to female ratio of 1.2:1.<sup>[7]</sup>

In our study, there were 8 cases (25%) of malignant tumors and 24 cases (75%) of benign tumor & tumor like conditions. Similarly, in a study done by del Carmen Baena-Ocampo *et al.*, out of 566 bone tumors, benign bone tumors accounted for 405 (71.6%) and malignant bone tumors for 161 (28.4%) of cases.<sup>[8]</sup> In a study done by Rao *et al.*, among 523 cases of primary bone tumor and tumor like conditions, 39% were malignant tumors and 61 % were benign tumor and tumor like condition.<sup>[5]</sup>

In our study, among 24 cases of benign tumors and tumor like conditions of bone, the most common benign tumor and tumor like conditions was GCT (n=4, 14.2%) followed by osteochondroma (n=3, 12.5%), FD (n=3, 12.5%) and ABC (n=3, 12.5%). There were 2 (8.3 %) cases each of enchondroma, osteoid osteoma and

hemangioma. There were one (4.1%) case each of ossifying fibroma, osteoma, plasmacytoma, simple bone cyst, central giant cell granuloma and intramedullary osteosclerosis. In a study by del Carmen Baena-Ocampo *et al.*, the most common benign bone tumors were osteochondroma (43.7%; 177 cases) followed by giant cell tumor of bone (14.6%; 59 cases), enchondroma (10.1%; 41 cases), fibrous dysplasia (8.4%; 34 cases), non-ossifying fibroma (7%; 27 cases), aneurysmal bone cyst (6%; 24 cases) and chondroblastoma (3.5%; 14 cases).<sup>[8]</sup> In a study by Rao *et al.*, out of 319 cases of benign bone tumor and tumor like conditions, osteochondroma was the most frequent benign tumor (30.3%).<sup>[5]</sup> In our study, there were less number of cases of osteochondroma which might be because many osteochondroma cases diagnosed on imaging were not operated (asymptomatic cases) and histopathological examination was not done in those cases and thus were excluded from the present study.

In our study, out of 8 malignant cases, most common tumor was osteosarcoma (n=2, 37.5%) followed chondrosarcoma (n=2, 25%). There were one case (12.5%) each of plasmacytoma, ewing's sarcoma and epithelioid hemangioendothelioma. In a study by Rao *et al.*, out of 204 malignant tumors the highest incidence was of osteosarcoma (45.7%) followed by Ewing's sarcoma (19.4%).<sup>[5]</sup> In a study by del Carmen Baena-Ocampo *et al.*, most common type of malignant bone tumor was osteosarcoma (46.6%; 75 cases), followed by chondrosarcoma (9%; 14 cases), multiple myeloma (8%; 13 cases), plasmocytoma (6.8%; 11 cases), lymphoma (5.6%; 9 cases) and Ewing's sarcoma (2.5%; 4 cases).<sup>[8]</sup>

In our study, femur was most commonly affected bone (n=10, 31.2%), followed by tibia (n=6, 18.8%), cranial bone (n=5, 15.6%), humerus (n=4, 12.5 %) and fibula (n=2, 6.3%). Other bone involved were mandible (n=1, 3.1%), patella (n=1, 3.1%), clavicle (n=1, 3.1%), radius (n=1, 3.1%) and phalynx (n=1, 3.1%). In a study by Rao *et al.*, the most commonly affected bones were femur followed by tibia and humerus.<sup>[5]</sup> Findings similar to our study were also noted in a study by del Carmen Baena-Ocampo *et al.* in which most common anatomical distribution of the tumors was femur (40%; 226 cases), tibia (18%; 100 cases), humerus (12%; 67 cases), hand (8.5%; 48 cases), vertebrae (6.4%; 36 cases), pelvic ring (3.2%; 18 cases), fibula (2.3%; 13 cases), forearm (2%; 10 cases), foot and ankle (2%; 10 cases), and scapula (1.6%; 9 cases).<sup>[8]</sup> Similar finding was also noted in a study by Solooki *et al.*, in which 426 cases were analyzed and found that femur was the most commonly involved bone, followed by the humerus (19.3%; 34) and tibia (14.2%, 25) in malignant bone tumors while tibia (27.6%; 59) and hand bones (12.7%; 27) were the common bones involved in benign tumors.<sup>[6]</sup>

In our study out of 23 lesions which occurred in long bones of limb, most common location was meta-epiphysis (n=10, 43.4%) followed by meta-epiphysis

(n=5, 21.7%) and diaphysis (n=4, 17.4%). Tumor was confined only to the metaphysis in 4 (17.4%) cases. In a study by Ghadiali *et al.*, out of 30 cases of bone tumors, 9 (30%) cases involved meta-epiphysis, 8 (26.6%) cases involved diaphysis, 8(26.6%) cases involved metaphysis and 4 (13.3%) cases involved meta-diaphysis.<sup>[9]</sup>

In our study, MRI diagnosis was compared with histopathological diagnosis to calculate the diagnostic accuracy of MRI for bone tumors and tumor like conditions of bone. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of GCT, ABC and FD were 100 %, 100 %, 100 %, 100%,100%; 100%, 96.5%, 75%, 100%,96.8% and 66.7%, 96.5%, 66.6%,96.5%, 93.7% respectively. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of hemangioma were 100%, 96.6 %, and 66.6 %, 100% and 96.8% respectively. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of osteochondroma, enchondroma, chondrosarcoma, ewing's sarcoma, osteoid osteoma, osteoma and simple bone cyst were 100%. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of osteosarcoma were 66.6 %, 100%, and 100 %, 96.6 % and 96.8 % respectively. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of metastasis were 0 %, 93.7 %, 0 %, 100 % and 93.7 % respectively. The sensitivity, specificity, PPV, NPV and accuracy of MRI for diagnosis of central giant cell granuloma, hemangioendothelioma, plasmacytoma, JPsOF and intramedullary osteosclerosis were 0%, 100%, 0%, 96.8% and 96.8% respectively. For Ameloblastoma and filled in NOF, MRI showed 0% sensitivity, 96.8% specificity, 0% PPV, 100 % NPV and 96.8 % accuracy. In a study by Bhuyan *et al.*, out of 50 patients with musculoskeletal tumors, the overall sensitivity of MRI in diagnosis of bone tumor was 100%, specificity of 94.7% and diagnostic accuracy of 98%.<sup>[10]</sup> In a study by Mahnken *et al.*, among 34 patients with a suspected aneurysmal bone cyst, MRI demonstrated a sensitivity of 77.8% and specificity of 66.7% for diagnosis of aneurysmal bone cyst.<sup>[11]</sup> In a study by Klontzas *et al.*, among 30 patients, MRI was 94.7% specific and 100% sensitive for the detection of osteoid osteoma, with positive and negative predictive values of 91.7% and 100%, respectively.<sup>[12]</sup>

## CONCLUSION

In conclusion, MRI was found to be a valuable modality of imaging in diagnosing various tumor and tumor like conditions of bone with accuracy between 93.7 to 100%. In our study, giant cell tumor was the most common tumor followed by ABC, osteosarcoma, osteochondroma, fibrous dysplasia, hemangioma, chondrosarcoma, osteoid osteoma, enchondroma, plasmacytoma, central giant cell granuloma, intramedullary osteosclerosis, osteoma, juvenile psammomatoid ossifying fibroma, epithelioid hemangioendothelioma, ewing's sarcoma and simple

bone cyst. MRI can be a helpful imaging tool to diagnose various tumor and tumor like conditions of bone.

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