Role of MRI in Evaluation of Primary and Secondary Bone Tumours

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ABSTRACT

Background

This study was conductedto assess bone tumours, including primary and secondary, using magnetic resonance imaging.

Methods

This was a hospital-based prospective observational study conducted among 100 patients to study the MRI characteristics of bone tumours at Padmashree Dr.D.Y. Patil Medical College and Hospital and Research Centre, Pimpri, Pune, over a period of two years from September 2020 to July2022 after obtaining clearance from the institutional ethics committee and written informed consent from the study participants.

Results

There were 49% women and 51% men among the patients. In our patients, 38% of the tumour locations were in the femur, and 8% were in the tibia. In 99 percent of the patients, margins were present. The majority of patients (50%) had margins that were well defined, with 10% having poorly defined margins. In 50% of the patients, the MRI revealed cortical involvement and a soft-tissue component in 30% of the cases. The most common outcomes of cortical involvement were cortical destruction (8%)and outgrowth-continuation of the cortex (14%). Both joint and neurovascular involvement were absent in all individuals. 7% of patients had tumour extensions detected on their MRIs. The MRI and x-ray results showed a significant degree of agreement with respect to the tumor's soft tissue component, cortical involvement, and extension. Osteidosteoma, chondrosarcoma, giant cell tumour, ewings sarcoma, SBC, ABC, skull osteoma, metastases, non-ossifying fibroma, malignant fibrous histocytoma, fibrroid dysplasia, and chordoma were found in 8%, 17%, 21%, 9%, 3%, 4%, 3%, 4%, 3%, 16%, 2%, 1%, 2%, and 3%, respectively, according to the MRI.

Conclusion

MRI had 100% sensitivityto diagnose the majority of bone tumors, while it had 100% specificity in diagnosing osteosarcoma, SBC and fibrous dysplasia.

Keywords: MRI, Evaluation, Primary, Secondary,BoneTumours.
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INTRODUCTION

When cells within a bone proliferate erratically, a lump or mass of aberrant tissue results.This condition is known as a bone tumour. Children and young adults have the most benign bone tumours. Most are found during imaging; however, some people suffer painor swelling.[1] Malignant bone tumours are less common than soft-tissue tumours and account for a modest part of most of the malignancies. (Weber) Most common and oftenindicate a bad prognosis are bone metastases. Rarely can cancer be cured after it has reached the bones, although it is frequently still treatable to limit its progression.[2]The timely and accurate diagnosis of bone cancer is of paramount importance, as it canimprovetheprognosisofthetumourbyinitiatingappropriateandearlytherapy.Histopathology is the gold standard for diagnosing bone tumours. Early detection of bone metastases is essential for staging, prognosis, and the use of preventive and therapeutic methods to decrease morbidity and death. Numerous radiographic modalities have been employed as non-invasive diagnostic methods for the diagnosis of primary and secondary bone malignancies. Bone metastases can be categorised as osteolytic, sclerotic (osteoblastic), or mixed based on imaging examinations.[3]Bonescintigraphyis very sensitive, despite having limited specificity. According to available data, 99Tcscintigraphy has a sensitivity between 62% and 89% and a false-positive rate of up to40%.[2] (macedo) Radiographs are a quick, low-cost, and convenient way to evaluatebone metastases. To find the source of bone pain, plain radiography is the first test that is done. Although plain radiography is quite specific, its sensitivity is only 44–50% because metastatic lesions may not initially appear on an x-ray.[2] The sensitivity of CT for identifying bone metastases ranges from 70% to 100%.[4] An MRI scan is still the gold standard for figuring out how big a local tumour is. Dynamic MRI is one of the modern techniques used to assess the response of cancer to therapy and enable better delineation of high-grade tumour areas.[5] MRI is used to examine the bone marrow for tumour involvement and to identify compression of the spinal cord. Sensitivity is 82-100% and specificity is 73-100%.[6] MRI is helpful even if radiographs are the main screening modality when radiographs are not clear or aggressive enough to detect a lesion or limit the differential. MRI's involvement in bone tumour diagnosis and prognosis is crucial; hence, it must be an effective evaluation method. However, we could not find any studies on the MRI findings of bone tumours in our settings. Additionally, the relationship between theradiographic findings and histopathology, which is considered the gold standard, also needs to be explored. Hence,thefollowingstudy was conducted.

AIMS AND OBJECTIVES

- To investigate the use of magnetic resonance imaging in the diagnosis and treatment of primary and secondary bone tumours.
- To study the MRI characteristics of bone tumours.
- To characterize the bone tumours in terms of age, gender, location, margins, soft tissue component, cortical involvement, joint involvement, neurovascular involvement and extension of tumours.
- To correlate with x-ray and histopathological findings wherever possible.
- MRI contrast study where ever needed.

MATERIALS &METHODS

This was a hospital-based prospective observational study conducted among 100 patients to study the MRI characteristics of bone tumours at Padmashree Dr.D.Y. Patil

Medical College and Hospital and Research Centre, Pimpri Pune, over a period of two years from September 2020 to July2022 after obtaining clearance from the institutional ethics committee and written informed consent from the study participants.

Inclusion Criteria

- Tumors of all the bones, including the spine and skull.
- Metastatic tumours.
- Patients ofagemorethan5years.
- All individuals who are clinically suspected of having bone swelling.

Exclusion Criteria

- Postoperative cases and patients undergoing radiation therapy.
- Expectant mothers.

In addition to metallic foreign bodies, claustrophobia, in-situ biostimulators, in-situ neurostimulators, and deviant respiratory function tests, the patient also has an in-situ cochlear implant.

Statistical Methods

Data was entered in MS Excel and analyzed using SPSS software. Results were presented as tables.

RESULTS

Frequency		Percent
Broadbase-well defined	1	1.0
Eccentriclesionwithcorticalbase	1	1.0
Expansiledestructivelesion	1	1.0
Expansilelesion	1	1.0
Fairlydefined,lobulated	1	1.0
FairlyWell DefineExtra Axial	1	1.0
Fairlywelldefined	5	5.0
Illdefined	10	10.0
Irregularlymarginated	2	2.0
Lobulatedirregular	1	1.0
Nomargins	1	1.0
pedunculated-welldefined	21	21.0
Scleroticmarginwitheccentricmuralnodule	1	1.0
Sessile-Welldefined	3	3.0
Sessileandpedunculated	1	1.0
Sharplydefined	1	1.0
Solitaryexpansile	1	1.0
Wellcircumscribed	1	1.0
Welldefined	50	50.0
Welldefinedeccentric	3	3.0
Welldefinedlobulated	1	1.0
Well-DefinedSmooth	1	1.0
Total	100	100.0

Table1:DistributionofStudySubjectsAccordingtoMarginsofTumorsinMRI

MRI Characteristics of Tumors: Margins of Tumors

Marginswerefoundin99%of thepatients.The majority of the patients had well-defined margins (50%), followed by ill-defined margins in 10%.

Soft Tissue Component

30% of the patients had soft-tissue components in the MRI.

Cortical Involvement

Fifty percent of the patients had cortical involvement on their MRI. The most prevalent results for cortical involvement were outgrowth-continuation of cortex (14%) and cortical destruction (8%).

Neurovascular Findings were foundin 8% of the Patients

Frequency			**Percent**
	No	93	93.0
	Yes	7	7.0
	Total	100	100.0

Distribution of Study Subjects According to Extension of Tumours in MRI

Feature	**Kappa**	**p Value**
SoftTissuecomponent	0.579	<0.001
Corticalinvolvement	0.886	<0.001
Extensionof tumor	1	<0.001

Correlation between MRI and X-Ray Findings

Table 2

7% of Patients had an MRI and had a Tumour Expansion

X-rays were done on 40 patients.

There was a concordance between the MRI and thex-ray findings.

The MRI and X-ray results showed a significant degree of agreement with respect to the tumor's soft tissue component, cortical involvement, and extension (p0.05).

	Sensitivity	**Specificity**	**Positive PredictiveValue**	**Negative PredictiveValue**
Osteoidosteoma	100	95.7	66.7	100
Enchondroma	100	89.1	50	100
Osteochondroma	77.8	88.1	58.3	94.9
Osteosarcoma	80	100	100	97.9
Chondrosarcoma	100	98	50	100
GCT	100	98	66.7	100
Ewing'ssarcoma	100	97.9	66.7	100
SBC	100	100	100	100
Metastases	100	97.8	85.7	100
Fibrousdysplasia	100	100	100	100

DiagnosticValidityofMRIforEachBoneTumors(InComparisonwithHistopathology)

Frequency		**Percent**
yes	23	23.0
no	77	77.0
Total	100	100.0

Table3:DistributionofStudyScanAccordingtoContrastScansDone

Fibroid dysplasia and chordom a were 8%,17%,21%,9%,3%,4%, 3%,3 %,4%, 3%, 16%, 2%, 1%, 2% and 3%, respectively. A contrast scan was done on 23%of thepatients.

DISCUSSION

The present study looked at how MRI affected 100 individuals' bone tumours. In 92 bone tumours, Azad H. et al.[7] linked imaging methods with histology. A study by Salazar C. et al.[8] looked at imaging in 64 patients with bone cancers. Gerber E. et al.[9]studied 88 patients similarly. The mean patient age was 34.6 ± 20.6 years. In Azad H. et al.and Salazar C. et al., the mean age was 31.3 ± 9.61 years and 33.5 ± 27 years. 45% of thestudy's participants were under 30 years old,

according to Gerber et al. S. Parlak etal.[10] examined MRI's role in distinguishing Ewing sarcoma from osteosarcoma. The meanage was 11.8 ± 5.76 years. Males (51%) and females (49%) in this study were about equal. 53.3% of participants in a study by Azad H. et al. were female. Men were somewhat higher at 73.1%, 64.1%, 57%, and 52% in the studies by Bernard SA. et al., Salazar C, et al., Kinnunen AR. et al.[11] and Gerber E. et al.

The most common tumour locations were the humerus (10%) and femur (39%), respectively. Sixty-eight percent were in the long bones (femur, humerus, tibia, and fibula) in the current study. Long bones are the most prevalent site for Ewings sarcoma and osteosarcoma (69.2% and 86.4%, respectively). Kinnunen AR et al. revealed similar findings for the femur, showing that 23% of the long bones exhibited fibrous dysplasia. In 17% of the patients on MRI in the current investigation, the spine was affected. In the study by Kinnunen A-R et al. on fibrous dysplasia, 18% had spine involvement. In the current study, 7% of the participants had pelvis involvement. In the study by Kinnunen A-R et al. on fibrousdysplasia,6% had pelvis involvement.The ribs were involved in only 2% of thepresent study. In the study by Kinnunen AR, et al. on fibrous dysplasia, 4% had ribinvolvement.The metacarpalswere involved inonly 4% of the present study. In the study by Kinnunen A-Retal. On fibrous dysplasia, 0.7% had meta carpal involvement. In the current study, craniofacial involvement was seen in 3% of the participants. In the study by Kinnunen A-R et al. and Cappabianca S. et al.[12]on the role of fibrous dysplasia, the cranio facial site was the most common region involved.

1% of the MRIs in the study showed sclerosis and demineralization. In the Azad H. et al. investigation, sclerotic MRI lesions were present in 37% of the patients. In a research by Parlak et al., sclerosing lesions were seen in 31% of patients with Ewing sarcoma and 42.8% of patients with osteosarcoma. The current study's MRI data revealed no evidence of joint involvement. According to Schima et al., MRI can accurately detect joint involvement.[13]

The most frequent cortical involvements were cortical destruction (8%) and outgrowth-continuation of the cortex (14%).BloemJLet al.[14] found that T2-weighted images canreveal cortical involvement. On MRI, 7% of tumours extended overall and 1% extendedepiphysis and metaphysis. 72.8% metaphyseal or epiphyseal involvement in Azad H. etal. research. E wings sarcomaan dosteosarcoma had meta physeal-diaphy seal involvement at 55.4% and 57.9%, respectively. Miwa S.et al.[15] found that corticaldestructionorperiostealreactions indicate malignancyon x-rays andCT.

The most recent report said that there was a significant agreement between the MRI and x-ray data regarding the extent, cortical involvement, and soft tissue component of the tumour. In terms of diagnostic accuracy (90% vs. 95.1%), sensitivity (92.9% vs. 94.4%), specificity (87.5% vs. 95.7%), positive predictive value (86.7% vs. 94.4%), and negative predictive value (93.3% vs. 95.7%), Salazar C. et al. claim that X-rays performed worse than MRI. Furthermore, MRI has been demonstrated to be superior to CT in determining soft tissue involvement and characterising tissue, according to Cappabianca S. et al. According to reports by Kang Y. et al.[16] and Murphey MD et al.[17] soft-tissue mass was found in 25–81% of chondrosarcomas.

According to the current study, 30% of the patients had soft tissue involvement in their bone tumours. Consistent with the present discoveries, Miwa S. et al. also documented that contrast agents improved the capacity of MRI to distinguish between the soft tissue and vascular relationships of the bone tumour. BloemJLet al., concluded that therelationship of tumors with large vessels is slightly better demonstrated on MRI than onCT. But in the case of soft tissue invasion, MRI was not able to define the relationship with vessels. Bloem JLetal., also mentioned that angiography did not reveal any information additional to the MRIfindings.

In 8% of the patients in the current research, MRIs revealed neurovascular involvement of the tumours. Additionally, Hogeboom WR et al.[18] noted that when it

came to differentiating bone tumours from neurovascular systems, soft tissues, and joint involvement, MRI performed better than CT. The MRI results from the current investigation, however, did not indicate significant joint involvement. 50% of the participants in the current research demonstrated cortical involvement, according to MRI. However, according to Hogeboom WR et al., CT provides a more accurate assessment of cortical bone involvement.

Margins of the tumor were detected on MRI in 99% of the patients in the current study.This could help in describing benign and malignant tumors. Lodwick GS et al.[19] alsomentioned thatimagingtechniques candifferentiate benignfrom malignantconditionsby studying the margins. In supportof this, a radiographic classification of tumorsbased on margins has also been developed. Miwa S. et al. had described thatbone scintigraphy could not be superior to MRI in differentiating between benign andmalignant tumors.

In the current investigation, MRIs showed osteochondroma in 21% of the patients. Salazar C. et al. found that the equivalent frequency was about 20.3%. In the current study, 9% of patients had an MRI that showed osteosarcoma.SalazarC. etal., also reported that 4.6% had osteosarcoma. Gerber E, etal. Diagnosed osteosarcoma based on histological findings and reported a higher prevalence of about12.5%. In the current study, chondroblastoma was negative in all patients. In the study by Gerber E.etal.,on histologicexamination,3.4%werediagnosedwit hchondroblastoma. In the study by Parlak S. et al., 9.1% of the osteosarcomas were chondroblastomas. In the current study, chondrosarcoma was detected on MRI in 3% oftheparticipants.GerberE. etal. Reported a higher prevalence of about 9% on histological examination. Kang Y.et al.reported that soft tissue mass and acetabularcartilage involvement were detected on MRI in all cases of high-grade chondrosarcoma. Douis H. et al.[20] also reported findings similar to Kang Y. et al.regarding MRI findings of high-grade chondrosarcoma.

In the current study, GCT was positive in4% of participants on MRI. Gerber E.etal. reported as lightly higher prevalence of about 5.6% on histological examination. Parlak, S. et al. also reportedthat about 4.5% of the osteosarcomas were GCT. In the current study, Ewing sarcoma was positive on MRI in 3% of the patients. Salazar C. et al., reported a very high prevalence of Ewings sarcoma of about 9.3% on MRI, and Gerber E. et al. onhistologicalexaminationalsoreported9%. In the current study, on MRI,16% had meta stases. In the study by Azad H. et al. and Gerber E. et al.meta states were slightly lower at3.3%and 5.6%respectively.

According to the research conducted by Azad H. et al., MRI has a positive predictivevalue of 97.3%, a negative predictive value of54.5%, and a diagnostic accuracy of 87.0% when it comes to identifying bone tumours. For bone tumours asawhole, Salazar C. et al., also observed increased sensitivity (94.4%), specificity (95.7%), diagnostic accuracy (95.1%), positive predictive value(94.4%), and negative predictive value (95.7%). Sensitivity was reported to be 95% by Gerber E. etal., while specificitywas64%.

MRI can be used to identify fibrous dysplasia with complete sensitivity and specificity. Consistent with the current findings, MRI can detect fibrous dysplasia, according to Cappabianca S. et al. and Shah ZK et al.[21] According to Cappabianca S. et al. and Tokano H. et al.[22] a biopsy is necessary to diagnose fibrous dysplasia because an accurate diagnosis of dysplastic disease cannot be made with a CT scan or an MRI alone. Clinical reports state that intralesional cystic degeneration and its associated oedematous components can be identified by MRI.

In the current study, MRI has a sensitivity and specificity of 100% and 98%, respectively, for diagnosing chondrosarcoma. Like the present finding, Bernard SA etal.[23] found that MRI for chondrosarcoma had a sensitivity of 100% and a specificity of 98%. While CT had the same sensitivity, the same study found that its specificity wasonly95%.

The current investigation found that MRI could detect metastases with a sensitivity

of100% and a specificity of 97.8%. Multiple studies, including those by Eustace et al.[24] Ste in bornetal.[25] LauensteinTCetal.[26]and Engelhard etal. [27] have demonstrated that magnetic resonance imaging (MRI) is more sensitive and specific thanbone scintigraphy for detecting bony metastases. Whole-body MRI had a high sensitivityof 89% and a high specificity of 91% in the study by Wu L-M et al.[28]

The study by KirchhhoffSB etal. Foundthat MRI was more sensitive (98.5%vs.66%) in detecting spinal metastases. It was previously reported by Cappabianca S. et al. thatcontrast-enhanced MRI could distinguish between dysplastic and malignant neoplasticbone lesions.

Bloem JL. et al. have discovered that when it comes to detecting the depth of bone marrow extension, MRI is more accurate than CT. Additionally, Hogeboom WR, et al. have demonstrated that MRI is a more effective bone cancer detection method than CT. But the study also pointed out that MRI could not be used to measure exact duration since breathing movements differed. According to Berquist TH. et al.[29] the main use of MRI in bone malignancies is staging; it is not helpful in differentiating between tumours with distinct histological subtypes. The study also discovered that, for the purpose of detecting bone cancer, contrast-enhanced MRIs perform better than regular MRIs.

CONCLUSION

All things considered, the features of the primary and secondary bone tumours were evidently visible on MRI. Osteochondroma was the most common MRI diagnosis. Of the patients with margins, almost 80% had well-defined margins. It was shown that 50% of the patients had cortical involvement. There were neurovascular findings in 8% of the individuals. An MRI revealed tumour growth in 7% of the patients. The findings from the MRI and x-ray showed a significant degree of concordance with respect to the soft tissue component, cortical involvement, and tumour extension. MRI showed 100% specificity and 100% sensitivity for the majority of bone tumours when it comes to diagnosing osteosarcoma, SBC, and fibrous dysplasia. In twenty-three patients, a CT scan was performed.

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