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Original Research

A prospective study on assessment of role of MRI in prediction of malignancy of musculoskeletal system

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ABSTRACT:
Background: The evaluation of musculoskeletal tumors requires a close interaction between the orthopedic oncologist, radiologist, and the pathologist. Successful outcome can be achieved in a considerable number of patients by following the appropriate diagnostic strategies and staging studies. The purpose of this study is to evaluate the role of MRI in musculoskeletal tumours, especially, in prediction of malignancy & to compare whether the diagnosis made on MRI correlates with the cytological/histopathological diagnosis. **Methods:** Seventy (70) patients with clinically suspected malignancy of musculoskeletal were included in the study. All the patients were made to undergo MRI examination using 1.5 Tesla MRI, manufactured by GE, SIGNA HDX MACHINE. The findings of MRI spine were assessed and analyzed. **Results:** Out of 70 patients included in the study; 39 were male (55.7%) and remaining 31 were female (44.3%). The preliminary examination showed the presence of edema, necrosis, hemorrhage, fascial penetration, bone changes and neurovascular involvement. A correct histological diagnosis is reached on the basis of imaging studies alone in 65% to 75% of cases. The sensitivity for a MRI diagnosis of malignant tumour was 95% and specificity was 84%. **Conclusion:** Thus we conclude that Spinal dysraphism were common in females, with commonest anomaly being vertebral anomaly. Magnetic resonance imaging is an accurate, noninvasive, safe and advanced modality for evaluation of the malignant tumor diagnosis and help in better management of these patients with prompt and accurate diagnosis. A systematic approach markedly improves diagnostic results.
Keywords: Peritumoral Edema, Musculoskeletal Tumour, Irregular Margin, Soft Tissue Edema, Dynamic Enhancement

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INTRODUCTION

Musculoskeletal tumors can originate in bone or soft tissues such as muscle and cartilage. If they are malignant, they are considered sarcomas (e.g., osteosarcoma, chondrosarcoma). Although tumors of the musculoskeletal system are uncommon, a major concern with bone tumors is the development of pathologic fractures. In many instances, when the tumor is in an extremity, complete tumor resection is necessary via either limb salvaging (limb-sparing) techniques or amputation[1,2].

Limb-sparing procedures typically have three phases: tumor resection, bone reconstruction, and soft-tissue reconstruction for wound closure. One example of a limb salvage procedure is the total femur replacement. Patients undergoing this procedure achieve good long-term prosthetic survival; 90% have limb survival. A major determining factor in outcome is the oncologic diagnosis and associated complications. Confounding factors affecting patient outcomes include the presence of metastases, chemotherapy, and radiation therapy. Refer to Chapter 11 for suggestions on physical therapy management of the patient with cancer[3-5].

The management of musculoskeletal tumorsrequires a multidisciplinary team from the time of diagnosis through medical treatment, recovery, and rehabilitation. Despite more sophisticated imaging

modalities, the diagnosis of many bone tumors can be made based on plain radiographs. Analysis of plain radiographs for periosteal reaction, junction of the lesion with the host bone, cortical disruption, matrix of the lesion and site, and the number of the lesion(s) in skeleton can further direct the diagnosis. Following the initial plain radiograph evaluation, further analysis can be done with computed tomography (CT) scans or magnetic resonance imaging (MRI), to delineate the extent of the tumor within the bone and also any extension into the soft tissue. The multiplanar imaging capabilities and superior anatomic resolution of MRI are very helpful in defining the size, contents, and relationship of the lesion to adjacent neurovascular structures, which are all necessary for planning the biopsy and tumor resection. MRI is highly reliable for planning limb salvage or an amputation, but the interaction between the orthopedic surgeon and the radiologist in reviewing the imaging studies is crucial prior to the procedure. An MRI of the whole length of the involved bone allows visualization of the entire length to detect skip metastases.

Magnetic resonance imaging has traditionally been utilized for staging of bone lesions and as such has been extremely valuable in planning management, but the advent of more advanced pulse sequences allows for some increased lesion characterization as well. Conventional MRI sequences do not usually allow for lesion characterization, as both benign and malignant processes show increased relaxation times on both T1 and T2 sequences. Main strengths of MRI in bone tumor imaging include the ability to assess extent of marrow involvement, to determine the presence of discontinuous, or ‘‘skip’’ lesions within the same bone, and to determine the extent of any soft tissue component extending beyond the cortex. For these reasons, continuous images extending from the joint above the lesion to the joint below are typically obtained. Additionally, MRI carries the advantage of absence of ionizing radiation. However, limitations of MRI include susceptibility artifact from metallic hardware, which is often placed in the surgical treatment of musculoskeletal tumors, and inability to safely image many patients with pacemakers or other metallic devices[6-9].

The determination of the anatomical extent, characteristics, and histopathological features of bone tumors and soft-tissue sarcomas involves a diagnostic strategy in which a biopsy is the final step. MRI, however, is usually the best imaging system for the evaluation of a soft-tissue mass or the extent of soft-tissue or bone-marrow involvement by a bone tumor. MRI demonstrates the depth, size, and local extent of tumours. Published opinions regarding the value of MR imaging in characterizing the pathologic nature of musculoskeletal masses and discriminating between benign and malignant lesions are divergent. There is a wide range of specificity values of MR imaging in differentiation of benign from malignant musculoskeletal lesions reported in the literature. Berquist et al. in 1990 and Moulton et al. in 1995 found a relatively high specificity of 76%-90%. Other researchers have reported that MR imaging has low specificity in differentiation between benign and malignant masses, and most lesions demonstrate a nonspecific appearance. Thus, the role of MRI in predicting malignancy has been inadequately studied in literature and here we venture to find out suitable imaging characteristics or a combination of them for prediction of malignancy and to compare whether the diagnosis made on MRI correlates with the histopathological/cytological diagnosis[10-12].

METHOD

Data was collected from patients clinically suspected and advised to undergo MRI spine at National institute of Medical Sciences and Research, Jaipur, from September 2018 to December 2020. The study included 70 patients that came from the department oncology. Patients had MRI spine examination at the department with 1.5 TESLA GE SIGNA HDX MACHINE MRI machine. Information was collected on standard data collection forms. Relevant information regarding age, sex, birth history, developmental history, presenting complaints and radiological findings were recorded. Various MR imaging characteristics of benign and malignant musculoskeletal tumours were identified and they were evaluated prospectively for their role in prediction of malignancy. These characterstics included size of tumour, shape and lobulation, margination, signal intensity on T1 and T2 weighted sequences, enhancement pattern, homogenous or heterogenous appearance, peritumoral edema, presence of necrosis and calcification, fluid-fluid level, neurovascular involvement etc.

INCLUSION CRITERIA

All cases of open spinal dysraphism

- Cases presenting with lumbosacral swelling
- Cases presenting with Dimple, tuft of hair, nevi
- Cases showing vertebral anomalies in Plain radiograph
- Cases presenting with bladder/bowel incontinence since childhood
- Cases presenting with motor or sensory deficit since childhood
- Cases presenting with congenital scoliosis/ kyphoscoliosis/ kyphosis etc.

EXCLUSION CRITERIA

- Treated cases
- Spinal tumors

ETHICAL APPROVAL

Approval of institute Human Ethics Committee was obtained. Informed written consent was obtained from

all the participants, after explaining the objectives of the study, risks and benefits involved. The personal details of the patients were kept confidential throughout the study.

STATISTICAL ANALYSIS

Various pulmonary function parameters were considered as primary outcome variables. Presence or absence of exposure to air pollution and duration of air pollution was the primary explanatory variable. Descriptive analysis of the data was done by using frequency and percentage for categorical variables, mean and standard deviation for quantitative variables. The mean values of the pulmonary function parameters were compared among various study groups. Analysis of variance (ANOVA) was used to assess the statistical significance of the association. P value 0.05 was considered as statistically significant. IBM SPSS version 21 was used for statistical analysis.

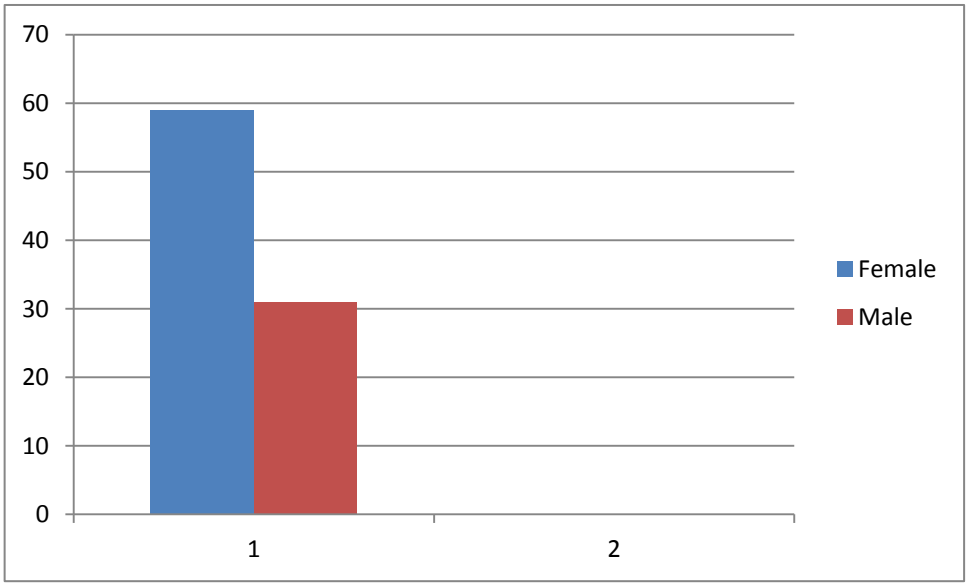
RESULT

Out of 70 patients included in the study; 39 were male (55.7%) and remaining 31 were female (44.3%). Their mean age was 57 years (range 16–74 years). DWI was performed on 73 (81.6%) patients. The distribution of findings is shown in Figure 1. The patients were divided into seven groups on the basis of ages: 10-19, 20–29, 30–39, 40–49, 50–59, 60–69, and 70-79 years and are designated as group I - VII. The demographic characteristics of the patients were studied: gender, age, and comorbidities results are shown in table 1.

Table1: Demographic data of patients

Age (Years)	Benign	Malignant	Total
10-19	8	8	16
20-29	6	8	14
30-39	5	7	12
40-49	5	5	10
50-59	3	5	8
60-69	1	5	6
70-79	-	4	4
Total	28	42	70

Figure1: Demographic data of patients



The proportion of benign and malignant tumours confirmed on histopathological evaluation was 60% (42) and 40% (28) respectively. Of these tumours seemed to be arising from bone in 45 (65%) and from soft tissue in 25 (35%) cases. Malignant tumours were seen in 19 out of 32 male patients (59%) and 5 out of 18 female patients (28%). The MR imaging characteristics included in this study with their respective sensitivity and specificity are tabulated in Table 2. A number of features were associated with a benign diagnosis, including size less than 8 cm, sharp margination, homogeneous T2 signal, absence of edema, and absence of necrosis or calcification and fluid-fluid levels (FFLs). Similarly, malignant tumours are commonly associated with size more than 8 cm, irregular margins, inhomogeneous signal, and presence of edema, necrosis, hemorrhage, fascial penetration, bone changes and neurovascular involvement. MRI diagnosis of the tumor as benign or malignant was made

subjectively based on a combination of MRI features, tumor prevalence and location of tumor as well as patient's age and sex. Three senior radiologists made the diagnosis and in cases of contradiction, the diagnosis was made based on majority decision. A correct diagnosis is reached on the basis of imaging studies alone in 65% to 75% of cases. The MRI diagnosis & final diagnosis were compared and the results are tabulated in Table 2. he sensitivity for a MRI diagnosis of malignant tumour was 95% and specificity was 84%.

Table 2: Different feature measured through MRI

Investigation Area	Sensitivity	Specificity	PPV	NPV
Size > 8cm	0.69	0.89	0.79	0.79
Shape	0.91	0.84	0.91	0.93
Margin	0.89	0.99	0.81	0.94
Isointensity	0.81	0.82	0.89	0.78
Edema	0.90	0.79	0.94	0.69
Intratumoral Nacrosis	0.78	0.85	0.74	0.96
Fascial Penetration	0.83	0.77	0.92	0.97
Bone Changes	0.91	0.94	0.99	0.85
Neuromascular Involvement	0.80	0.92	0.91	0.81
Enhancement Pattern	0.87	0.78	0.64	0.91

DISCUSSION

Overall prevalence of malignant musculoskeletal tumours is estimated between 5.1 and 15.5% of all sarcomas. In our study the relatively high number (n = 24, 48%) of malignant lesions was due to a selection bias caused by the referral policy including only patients who had an MR examination, excluding a large number of (superficial) lesions treated without imaging and of typically benign "do not touch" lesions. The low overall prevalence rate of musculoskeletal tumours is probably due to the fact that the referring centres are requested to send all musculoskeletal tumours (benign and malignant) to the national registry. In our study, among the morphological characteristics, size criteria of >6 cm and >8 cm yielded a sensitivity of 95% and 75% respectively. However, size criteria of >8 cm had a specificity of 76% while >6 cm had a specificity of 57%. Irregular and lobulated shapes of the tumors had a sensitivity and specificity of 83% and 76% respectively. Irregular and infiltrative margins had a sensitivity and specificity of 91% and 65% respectively. Berquist et al in 1990 conducted a study on 95 consecutive patients with soft tissue mass lesions and observed that 87% of malignant tumours were larger than 5 cm. 85% of malignant tumours had irregular margins. Moulton et al in 1995 showed that size criteria of >5 cm had a sensitivity of 85% and irregular margins had a sensitivity of 74%. So these morphologic characteristics have varied sensitivities in various studies and cannot be reliably used for differentiating benign from malignant tumours[13-17]. Benign lesions tend to have well defined margins, and some benign masses have characteristic appearances that aid in their differentiation from malignant processes. In our study, 'Heterogeneous appearance' of the tumour had a sensitivity and specificity of 100% and 50% respectively. 'Presence of peritumoral edema' had a sensitivity and specificity of 95% and 50% respectively. These characteristics are highly sensitive, but the specificity is too low to be considered reliable differentiating factors. De Schepper et al in 1992 noted inhomogeneous signal in 88% of malignant tumours. He had reported highest sensitivity for "absence of low signal intensity on T2" (100%). Pang et al, in 2003 demonstrated that statistically significant imaging features favouring a diagnosis of malignancy included inhomogeneity on T2-weighted images (p = 0.002) and a change in pattern from homogeneity on T1-weighted images to inhomogeneity on T2-weighted images (p = 0.003). Previous studies on the similar evaluations evaluated the incidence, quantity, and presentation of intra- and extraosseous edema accompanying benign and malignant primary bone lesions. The mere presence and quantity of marrow and soft tissue edema are unreliable indicators of the biologic potential of a lesion[18,19]. A similar study observed the MR morphologic appearance of primary bone tumors correlated with pathologic examinations and observed that peritumoral soft tissue edema was found by STIR sequence only in malignant tumors. Crim et al. in 1992 and Griffiths et al. in 1993 also studied the morphologic characteristics of tumours and observed that the majority of both benign and malignant masses had inhomogeneous signal intensity and at least partially irregular borders and MR imaging can be used to evaluate the extent of soft-tissue masses, but most masses will require biopsy to determine if they are benign or malignant[20-22].

CONCLUSION

Evaluation of bone tumors involves a multimodality approach and whereas cross-sectional imaging has extraordinarily improved the ability to characterize tumors ,the differential diagnosis of primary osseous neoplasm remains based on their radiographic appearance. Radiographs provide critical information

regarding lesion location, margin, matrix mineralization, cortical involvement and adjacent periosteal reaction. But MRI is the best modality for focal extent and local staging. The excellent contrast resolution and multiplanar capabilities of MRI lead to improved evaluation of both intra compartmental and extracompartmental extent of bone This is particularly true with regards to invasion of muscle, neurovascular structures and adjacent fat planes and degree of marrow involvement. MRI has also been shown to be superior in assessing intraarticular extension and the presence of intratumoral necrosis and haemorrhage. MRI is the best technique to detect skip lesions (small metastasis separated from primary tumor by healthy tissue) which are often missed by other imaging means. MRI also plays an important role in evaluation of effectiveness and follow up of treatment .. In these days of managed care cross sectional imaging is limited to one modality and most centres will chose MRI in this

No single characteristic consistently allowed distinction of benign from malignant tumors. Malignancy is predicted with the highest sensitivity when lesions have high signal intensity on T2-weighted images, larger than 6 cm diameter, have heterogeneous signal intensity on T1-weighted images and have peritumoral edema. The highest specificity is noted when lesions show tumor necrosis, bone or neurovascular involvement and mean diameter of more than 8 cm. When a lesion has a non-specific MR imaging appearance, it is useful to formulate a suitably ordered differential diagnosis based on tumour prevalence, patient age, and anatomic location. A systematic approach markedly improves diagnostic results.

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