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Diagnostic Accuracy of Magnetic Resonance Imaging in Diagnosing Malignant Musculoskeletal Tumours, Taking Histopathology as Gold Standard

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ABSTRACT

Objective: The rationale of this study is to determine the capability of MRI in diagnosing malignant musculoskeletal tumours, by measuring the sensitivity and specificity of MRI for musculoskeletal tumours. **Study design:** Cross-sectional (validation) study. **Settings:** Department of Radiology Madinah Teaching Hospital, Faisalabad. **Duration of study:** 1st January 2024 to 30th June 2024. **Methodology:** The study comprised 120 patients aged 20 to 70 years presenting suspected musculoskeletal tumors of duration >4 weeks. Patients taking chemotherapy for any type of lesions, liver cirrhosis, undergone orthopedic surgery, claustrophobic patients and with cardiac pacemakers were excluded. Next, a 3.0 T MRI machine was used for magnetic resonance imaging. Axial and coronal T1WI and axial and sagittal fat-suppressed T2WI were among the traditional MRI procedures. The consultant radiologist assessed the MRI results for malignant musculoskeletal tumors (present or absent) based on the following criteria: big diameter (>6 cm), heterogeneous signal intensity on T1-weighted MRI, high signal intensity on T2-weighted MRI, and peritumoral edema. Following a biopsy, the histology report and the MRI results were compared for each patient. **Results:** MRI sensitivity was (93.85%), specificity (87.27%), PPV (89.71%), NPV (92.31%), and diagnostic accuracy (90.83%) in the diagnosis of malignant musculoskeletal tumours. **Conclusion:** According to the study's findings, MRI is an extremely sensitive and precise imaging technique for diagnosis of malignant musculoskeletal tumours.

INTRODUCTION

Either aberrant growth of bone-like tissue or soft tissue within the bones is the source of bone tumors. Primary and secondary tumors are categorized as either benign or malignant. There are two age ranges for globally malignant bone lesions: 10–20 years and 40–80 years. Additionally, they exhibit gender partiality, with males experiencing a 1.5% higher prevalence than females.[1] Information from the patient's medical history (age, gender, cancers, pain history, injuries), lesion examination, radiographic assessment of the margins, degree of cortical expansion, periosteal reaction, and prior imaging are all used in the diagnostic evaluation of focal bone lesions. Hematologic malignancies and metastatic cancers like carcinoma eclipse primary bone tumors.[2,3]

Because of its broad range of applications, high sensitivity, nonionizing radiation, and affordability, ultrasound (US) is the first test used to evaluate soft tissue masses.[4] US can easily differentiate between solid and cystic lesions and offer information on the size and anatomical location of the lesions.[5] Additionally, US can show the hemodynamic alterations within the lesions by using color Doppler. MRI is regarded as the preferred first test for locating, characterizing, and staging large, deep lesions. Its strong intrinsic contrast resolution makes it ideal for determining the anatomic extent of STTs and evaluating local staging.[6,7] In a study, the prevalence of malignant musculoskeletal tumours was found to be 48.9% and the sensitivity and specificity of MRI in diagnosing malignant musculoskeletal tumours were 89.23% and 88.57% respectively.[8] Another study has shown the MRI in differentiating malignant and benign musculoskeletal tumours as 94.12% and 90.0%.[9]

The rationale of this study is to determine the capability of MRI in diagnosing malignant musculoskeletal tumours, by measuring the sensitivity and specificity of MRI for musculoskeletal tumours, presenting in department of Radiology Madinah Teaching Hospital, Faisalabad. As the disease frequency is expected to be different in this region so the diagnostic accuracy is expected to differ also the available data and local literature regarding this diagnostic parameter for this disease is limited in last five years. This study will aid the utilization of non-invasive method in early diagnosis for treatment of various musculoskeletal tumours and help reduce the burden (both on patient and labs) also reduce

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the time wastage involved and high risk of seeding that can be caused during diagnostic biopsies.

METHODOLOGY

This descriptive, cross-sectional study was conducted on 120 patients aged 20 to 70 years presenting to the Department of Radiology, Madinah Teaching Hospital, Faisalabad, and who had suspected musculoskeletal tumors (musculoskeletal mass of >5 cm in size in any region of body, non-transilluminating and adheres to underlying structures) of duration >4 weeks. Sample size of 120 cases has been calculated with 95% confidence level, prevalence of prevalence of malignant musculoskeletal tumours as 48.9%8 and 8% desired precision for the sensitivity and specificity of MRI in diagnosing malignant musculoskeletal tumours as 89.23% and 88.57% respectively.[8] Using a non-random consecutive sampling strategy, patients were chosen. Patients taking chemotherapy for any type of lesions, liver cirrhosis, undergone orthopedic surgery, claustrophobic patients and with cardiac pacemakers were excluded.

The institutional ethical review board gave its clearance for this investigation to be carried out. Prior to their assignment to the trial, all patients gave their informed consent. Age, sex, length of illness, and mass size were recorded. Next, a 3.0 T MRI machine was used for magnetic resonance imaging. Axial and coronal T1WI and axial and sagittal fat-suppressed T2WI were among the traditional MRI procedures. The consultant radiologist assessed the MRI results for malignant musculoskeletal tumors (present or absent) based on the following criteria: big diameter (>6 cm), heterogeneous signal intensity on T1-weighted MRI, high signal intensity on T2-weighted MRI, and peritumoral edema. After that, each patient had a biopsy, and the results of the histopathology report—which states that the presence of hyperplastic blood vessels and tiny patches of necrotizing tissue encircled by anaplastic cells will be considered a positive result for malignant tumors—were compared to the MRI results. A custom created proforma was used to record all of the data, including the demographic data.

SPSS version 25.0 was used for the analysis of the data that was gathered. The data's normality was examined using the Shapiro-Wilk test. For age, disease duration, and mass size, the mean and SD or median (IQR) were computed. Gender, malignant musculoskeletal tumors on MRI, and histology (present or absent) were used to compute the frequency and percentage. The sensitivity, specificity, NPV, PPV, and diagnostic accuracy of MRI in identifying malignant musculoskeletal tumors, using histopathology as the gold standard, were computed using a 2x2 contingency table. By using stratifications and post-stratification, effect modifiers such as age, gender, length of illness, and mass size were managed. Diagnostic accuracy were computed using a 2x2 contingency table.

Table

		Malignant on histopathology	
		Present	Absent
Malignant on MRI	Present	**True Positive**	**False Positive**
	Absent	**False Negative**	**True negative**

RESULTS

The study's age range was 18–70 years old, with a mean age of 48.77 ± 10.02 years. According to Table I, the majority of the patients—66, or 55.0%—were in the 46–70 age range. Out of these 120 patients, 72 (60.0%) were males and 48 (40.0%) were females with male to female ratio of 1.5:1. The illness lasted 4.97 ± 2.15 months on average. Table I displays the distribution of patients with different variables.

Of the patients who tested positive for malignant musculoskeletal tumours on MRI, 61 (True Positive) had malignant musculoskeletal tumours, while 07 (False Positive) had no malignant musculoskeletal tumours on histopathology findings. Of the 52 patients who tested negative for MRI, 04 (False Negative) had malignant musculoskeletal tumours on histopathology, but 48 (True Negative) did not (p=0.0001), as Table II demonstrates. MRI sensitivity was (93.85%), specificity (87.27%), PPV (89.71%), NPV (92.31%), and diagnostic accuracy (90.83%) in the diagnosis of malignant musculoskeletal tumours. Table III displays the diagnosis accuracy stratification by age, gender, duration, and size of mass.

Table I

Distribution of patients with other confounding variables (n=120)

Confounding variables		Frequency	%age
Age (years)	20-45	54	45.0
	46-70	66	55.0
Gender	Male	72	60.0
	Female	48	40.0
Duration of disease (months)	≤6	61	50.83
	>6	59	49.17
Size of mass (cm)	≤5	70	58.33
	>5	50	41.67

Table II

Diagnostic accuracy of magnetic resonance imaging in diagnosing malignant musculoskeletal tumours, taking histopathology as gold standard.

	Histopathology findings (+ive)	Histopathology findings (-ive)	P-value
MRI (+ive)	61 (True positive)	07 (False Positive)	0.0001
MRI (-ive)	04 (False negative)	48 (True Negative)	

Sensitivity: 93.85%
Specificity: 87.27%
Positive Predictive Value (PPV): 89.71%
Negative Predictive Value (NPV): 92.31%
Diagnostic Accuracy: 90.83%

Figure 1

Area under the curve = 0.605

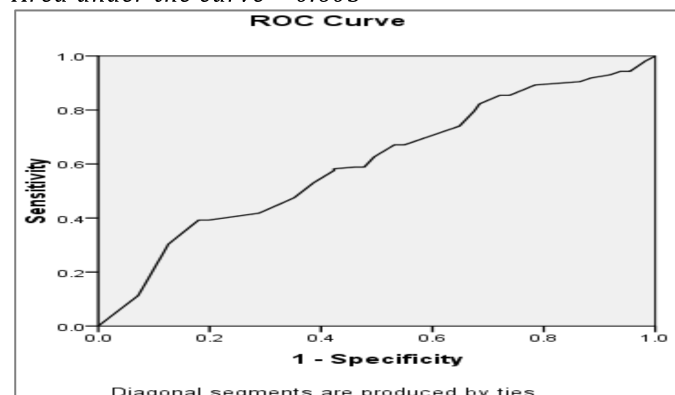

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Table III
Stratification of diagnostic accuracy with respect to age, gender, duration of disease and size of mass.

		Sensitivity	Specificity	PPV	NPV	DA	
Age (years)	20-45	88.14%	88.89%	91.23%	85.11%	88.46%	**0.001**
	46-70	97.25%	80.43%	92.17%	92.50%	92.26%	**0.001**
Gender	Male	91.84%	87.50%	91.84%	87.50%	90.12%	**0.001**
	Female	97.14%	83.78%	91.89%	93.94%	92.52%	**0.001**
Duration (months)	≤6	92.91%	88.10%	92.19%	89.16%	90.99%	**0.001**
	>6	97.56%	76.47%	90.91%	92.86%	91.38%	**0.001**
Size of mass (cm)	≤5	92.78%	90.48%	93.75%	89.06%	91.88%	**0.001**
	>5	95.77%	78.95%	89.47%	90.91%	89.91%	**0.001**

DISCUSSION

A biopsy is usually the last stage in a diagnostic process that evaluates the anatomical extent, features, and histological features of bone tumors and soft-tissue sarcomas.[10] MRI, on the other hand, is widely considered the best imaging method for assessing soft-tissue masses and figuring out how much bone marrow or soft-tissue involvement there is in bone cancers.[10,11] MRI offers comprehensive details regarding the size, local spread, and depth of tumors. The literature contains a range of views on how well MRI can distinguish between benign and malignant lesions and describe the pathogenic nature of musculoskeletal masses. Furthermore, there is a broad range in the reported specificity values for MRI in differentiating between benign and malignant musculoskeletal lesions.[6] A total of 120 patients who satisfied the inclusion and exclusion criteria were included in this study. With a mean age of 48.77 ± 10.02 years, the demographic data showed that the study covered a broad age range, which is important for figuring out how often musculoskeletal tumors are in various age groups. There were 48 (40.0%) females and 72 (60.0%) males. Participants' average symptom duration was 4.97 ± 2.15 months, indicating that many patients had very recent onset of symptoms, which could have affected the tumors' stage and features. Tumor size was measured at an average of 1.57±0.77 cm. The patients in this study had an average age of 42.59±10.16 years and a male to female ratio of 0.68:1. According to ALI S et al.[6], the condition lasted an average of 2.95±1.42 months.

Using histopathology as the gold standard, this study mainly examined how well magnetic resonance imaging (MRI) performs diagnostically in identifying musculoskeletal cancer. According to the study's findings, MRI is quite successful at accurately identifying patients with malignant tumors, with a sensitivity of 93.85%. Additionally, the 87.27% specificity indicates that MRI is dependable in accurately identifying people who do not have cancer, reducing false-positive results. Additionally, a large proportion of patients who tested positive on MRI really had malignancy confirmed by histopathology, as indicated by the positive predictive value (PPV) of 89.71%. Despite MRI's ability to reliably rule out malignancy, a tiny proportion of instances may still have malignancy present despite negative MRI results, as indicated by the negative predictive value (NPV) of 92.31%. In the end, the 90.83% diagnosis accuracy emphasizes how crucial MRI is for identifying possible musculoskeletal cancers.

Our results are in line with earlier studies, showing the value of MRI in managing patients with musculoskeletal cancers and in assisting with treatment planning in addition to detecting cancer. According to ALI S et al.[6] assessment of this study, histology was the gold standard for diagnosing musculoskeletal tumors, while MRI's diagnostic values were 89.23% sensitivity, 88.57% specificity, 87.88% PPV, 89.86% NPV, and 88.89% diagnostic accuracy.

However, a different study that examined the diagnostic performance of MR mammography for malignant breast lesions discovered that while the specificity was lower at 73.5%, the sensitivity was higher at 93.9%. With a positive predictive value (PPV) of 92.3% and a negative predictive value (NPV) of 78.1%, this modality has an overall diagnostic accuracy of 89.3%. These findings suggest that although MR mammography can be helpful in detecting breast lesions, its diagnostic reliability profile differs from that of musculoskeletal MRI.[12]

Furthermore, it was shown by Shirin M et al.[13] that the MRI had a 91.4% overall diagnostic accuracy and a 96.4% sensitivity and 71.4% specificity in identifying malignant musculoskeletal tumors. Another study by Boruah DK et al[12] evaluated the diagnostic effectiveness of diffusion-weighted imaging in combination with traditional MRI sequences for differentiating between benign and malignant lesions in the musculoskeletal region. They found that this method had an 87.5% specificity and an 83.3% sensitivity. The diagnostic method's overall accuracy of 84.6% demonstrated its efficacy in distinguishing between benign and malignant soft tissue tumors.[14]

The study's findings were corroborated by Tabassum S et al.[15], who used histopathology as the gold standard. They reported that the average age of the participants was 59.75±8.57 years, with a male predominance, and that MRI demonstrated remarkable diagnostic performance for identifying malignant focal liver lesions among the 125 patients assessed. There was a 92.3% sensitivity and a 93.6% specificity. Furthermore, 88% was the negative predictive value (NPV) and 96% was the positive predictive value (PPV). MRI's overall diagnosis accuracy of 92.8% demonstrated how useful it is in this clinical setting.[13] A small number of other investigations also supported our findings.[16,17]

Daniel et al.'s study consistently showed that MRI had a 95% sensitivity and an 84% accuracy rate in identifying musculoskeletal cancer. They underlined that MRI plays a crucial role in creating a well-organized differential diagnosis based on variables such the anatomical location of the tumor, patient age, and tumor incidence. Additionally, a different study demonstrated that MRI has a high diagnosis accuracy of 88.97% when compared to

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histology.[18] The positive diagnostic results highlight how crucial it is to incorporate MRI into routine clinical practice in order to assess these challenging cases. Future research is necessary to examine the precise MRI characteristics that contribute to this accuracy and the relationship between these imaging results and prognosis.

The current study has several drawbacks. First, only primary cases were taken into consideration, and second, scans are expensive. Recurrent or previously operated instances where scar tissue or fibrosis distorts the anatomy and presents an uncommon challenge are not applicable to our investigation.

CONCLUSION

According to a study, MRI scans have a high diagnostic accuracy, particularly when it comes to distinguishing between benign and malignant localized bone lesions. This degree of precision can greatly reduce the need for invasive histopathology techniques, which lowers patient risk and pain while expediting the diagnostic procedure. More extensive research focused at strengthening this diagnostic tool's dependability would enable medical professionals to make more informed judgments about patient treatment, which will ultimately improve overall care and efficiency.

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