Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/zg5p3w16

DETERMINATION OF THE DIAGNOSTIC ACCURACY OF MAGNETIC RESONANCE IMAGING IN PREDICTION OF MALIGNANCY OF THE MUSCULOSKELETAL SYSTEM IN SUSPECTED CASES TAKING HISTOPATHOLOGY AS A GOLD STANDARD

Dr. Rabia Mahnoor Khan[1]*, Dr. Nauman Al Qamari[2], Dr. Ammarah Afaq[3], Dr. Anila Rahim[4], Dr. Muhammad Ahsan Khan[5]

[1*]Resident, Dow Institute of Radiology, DUHS, Karachi
[2]Assistant Professor, Dow Institute of Radiology, DUHS, Karachi
[3]Resident, Dow Institute of Radiology, DUHS, Karachi
[4]Assistant Professor, Dow Institute of Radiology, DUHS, Karachi
[5]Medical Officer, Dow University Hospital, DUHS, Karachi

***Corresponding Author**: Dr. Rabia Mahnoor Khan
*Resident, Dow Institute of Radiology, DUHS, Karachi Email: rabiamkhan@gmail.com

Abstract

Introduction: Magnetic resonance imaging (MRI) has become essential for the preoperative assessment and treatment monitoring of patients with musculoskeletal tumors.

Objective: To determine the diagnostic accuracy of magnetic resonance imaging in prediction of malignancy of the musculoskeletal system in suspected cases taking histopathology as a gold standard.

Methods: The study conducted a Cross-sectional study on patients who presented with suspected musculoskeletal tumors at the Department of Radiology, Ojha Campus, Dow University, Karachi, from April 2021 to October 2021. MRI scans were conducted using a 1.5 T Siemens superconducting system, capturing T1-weighted (T1W) and Short Tau Inversion Recovery (STIR) images in sagittal or coronal planes, followed by T2-weighted (T2W) and post-contrast T1W images in axial planes. Tumors were classified as malignant or non-malignant based on specific MRI characteristics. Sensitivity, specificity, positive and negative predictive values and diagnostic accuracy were calculated taking histopathological finings as gold standard. Data were compiled and analyzed using SPSS version 23.0.

Results: A total of 336 patients were studied. The mean age of patients was 42.69±15.72 years, average symptom duration was 2.89±1.14 weeks and mean tumor size was 1.57±0.77 cm. Of the participants, 173 (51.5%) were male, and 163 (48.5%) were female. The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were recorded as 90.5%, 90.4%, 94%, 84.9%, and 90.4%, respectively.

Conclusion: Magnetic resonance imaging was observed as a sensitive and uncomplicated imaging modality for the detection of musculoskeletal malignancy with acceptable accuracy.

Keywords: MRI, musculoskeletal system, bone tumour and malignancy

INTRODUCTION

Musculoskeletal tumors represent a rare and varied group of neoplasms. Bone and cartilage sarcomas account for only about 0.5% of all human cancers, with a significantly higher incidence in children compared to adults.[1] Several techniques are available for diagnosing tumors, but magnetic resonance imaging (MRI) is essential for preoperative evaluation and ongoing treatment monitoring in patients with musculoskeletal tumors.[2] Assessing the anatomical extent, characteristics, and histopathological features of bone and soft-tissue tumors requires a diagnostic approach, with MRI typically being the most effective imaging method for evaluation.[3] A study conducted by Alex Daniel Jr. III, Ekram Ullah, and Shagufta Wahab reported that MRI demonstrated a sensitivity of 95% and a specificity of 84% in diagnosing malignant tumors.[4] In contrast, other studies have reported that MRI has low specificity in distinguishing between benign and malignant masses, with most lesions presenting a nonspecific appearance.[5] In the most significant roles of magnetic resonance imaging (MRI) is to determine the complete extent of musculoskeletal tumors, particularly is required for accurate treatment planning and surgical preparations. The current study was done to investigate the diagnostic accuracy of MRI in discriminating between both musculoskeletal malignant and benign lesions. It is especially essential because many benign lesions, including non-ossifying fibroma, fibrous dysplasia, and osteoma, do not require a biopsy to be diagnosed. Furthermore, taking a biopsy on these lesions may result in misinterpretation and needless interventions, which further complicate the treatment of patients. Consequently, assessing the reliability of MRI in detecting malignancies is critical for preventing unnecessary interventions and assuring optimal strategies of the treatment.

MATERIAL AND METHODS

A Cross-sectional study conducted in which 336 patients were included who came from the Department of Radiology, Ojha Campus, Dow University, Karachi, during a period of six Months April 2021 to October 2021. Individuals presented with suspected musculoskeletal tumors of either age and genders were included in the study. Cases with superficial lesions, renal failure, musculoskeletal cancer, contrast allergy, metallic implant and cardiac pacemakers were excluded from the study. Study was done after obtaining the Ethical approval from the ethical review committee, and written informed consent was collected from all patients prior to their participation in the study. MRI scans were performed using a 1.5 T superconducting system (Siemens). T1-weighted (T1W) and Short Tau Inversion Recovery (STIR) images were acquired in sagittal or coronal planes to accurately assess the tumor's longitudinal extent. Subsequently, T2-weighted (T2W) and post-contrast T1W images were taken in axial planes. Additional sequences, such as Gradient Echo (GRE), were utilized when necessary. Variables such as age, gender, duration of symptoms, height, weight, size of the tumour, location of the tumor, malignancy on MRI and histopathology was noted. On MRI musculoskeletal tumour was classified as malignant positive tumour on the basis of fascia penetration, neurovascular involvement, peritumoral edema, peritumoral necrosis and infiltrative margins. Moreover, on MRI musculoskeletal tumour was classified as malignant negative on the basis of Smooth and well defined margins, rounded or lobulated shape, fluid levels and peritumoral fat. Data was compiled and analyzed through SPPS version 23.0.

RESULTS

Out of 336 patients minimum age of the patient was 15 while maximum age of the patients was 65 years. The mean age was 42.69±15.72 years, with mean symptom duration of 2.89±1.14 weeks and an average tumor size of 1.57±0.77 cm. Of the participants, 173 (51.5%) were male and 163 (48.5%) were female. A total of 183 patients (54.5%) had symptoms lasting ≤ 1 week, while 153 (45.5%) had symptoms for more than 1 week. Regarding tumor location, 28 patients (8.3%) had tumors in the diaphysis, 110 (32.7%) in the metaphysis, 149 (44.3%) in the epiphysis, and 49 (14.6%) in the metadiaphysis. **Table. 1**

Frequency distribution of malignancy on histopathology showed that out of 336 patients, 211 (62.8%) and 125 (37.2%) had and did not have malignant bone tumour whereas on MRI frequency showed that 203 (60.4%) and 133 (39.6%) patients had and did not have malignant bone tumour respectively. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of magnetic resonance imaging in prediction of malignancy of musculoskeletal system in suspected cases taking histopathology as gold standard was found to be 90.5%, 90.4%, 94%, 84.9% and 90.4% respectively. **Table: 2**

Table: 1. Demographic and clinical characterizes of the patients n=336

Variable		Statistics
Age (mean ±SD)		42.69±15.72 years
Duration Of Symptoms (mean ±sd)		2.89±1.14 weeks
Size Of Tumour (mean ±sd)		1.57±0.77 cm
Gender	Male (N/(%)	173(51.49%)
	Female (N/(%)	163(48.51%)
Location of tumour	Diaphysis	28(8.33%)
	Metaphysis	110(32.74%)
	Epiphysis	149(44.35%)
	Metadiaphysis	49(14.58%)

Table: 2. Diagnostic accuracy of MRI in prediction of malignancy of musculoskeletal system in suspected cases taking histopathology as gold standard n=336

MRI	**Histopathology**		**Total**
	Positive	**Negative**	
Positive	191(TP)	12(FP)	203(60.42%)
Negative	20(FN)	113(TN)	133(39.58%)
Total	211(62.80%)	125(37.20%)	336(100.0%)
Sensitivity (TP/TP+FN x 100) =			**90.5%**
Specificity (TN/TN+FP x 100) =			**90.4%**
Positive Predictive Value (TP/TP+FP x 100) =			**94%**
Negative Predictive Value (TN/FN+TN x 100) =			**84.9%**
Diagnostic Accuracy (TP + TN/Total patients x 100) =			**90.4%**

Stratification for different parameters with respect to sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of magnetic resonance imaging in prediction of malignancy of musculoskeletal system in suspected cases taking histopathology as gold standard was found to be for age groups of 90.6%, 87.8%, 93.6%, 82.8% and 89.7% respectively for age group of 12-40 years, whereas found to be 90.2%, 93.2%, 94.8%, 87.3% and 91.4% for age group of 41-65 years. **Table. 3**

In this study on assessing the diagnostic accuracy of MRI against histopathology as the gold standard, a total of 336 patients were analyzed based on gender. Among the male participants, 109 had positive MRI results, which included 101 true positives (TP) and 8 false positives (FP). This group exhibited a sensitivity of 89.3%, specificity of 86.6%, positive predictive value (PPV) of 92.6%, negative predictive value (NPV) of 81.2%, and overall diagnostic accuracy (DA) of 88.4%. In contrast, among the female participants, 94 had positive MRI results, comprising 90 true positives and 4 false positives. The female group demonstrated higher sensitivity at 91.8%, specificity of 93.8%, PPV of 95.7%, NPV of 88.4%, and an overall diagnostic accuracy of 92.6%. These results indicate that MRI shows a strong diagnostic performance, particularly in females, when compared to histopathological findings. **Table. 4**

Table-3: Diagnostic accuracy of MRI taking histopathology as gold standard according to Age n=336

Age Groups	MRI	Histopathology		TOTAL	
		Positive	Negative		
12-40	Positive	117(TP)	08(FP)	125	Sensitivity= **90.6%** Specificity = **87.8%** **PPV = 93.6%** **NPV = 82.8%** **DA = 89.7%**
	Negative	12(FN)	58(TN)	70	
	Total	129	66	195	
41-65	Positive	74(TP)	04(FP)	78	Sensitivity= **90.2%** Specificity = **93.2%** **PPV = 94.8%** **NPV = 87.3%** **DA =91.4%**
	Negative	08(FN)	55(TN)	63	
	Total	82	59	141	

Table-5: Diagnostic Accuracy of MRI Taking Histopathology as Gold Standard according to gender n=336

Gender	MRI	Histopathology		Total	
		Positive	Negative		
Male	**Positive**	**101(TP)**	**08(FP)**	**109**	Sensitivity=**89.3%** Specificity = **86.6%** **PPV = 92.6%** **NPV = 81.2%** **DA = 88.4%**
	Negative	**12(FN)**	**52(TN)**	**64**	
	Total	**113**	**60**	**173**	
Female	**Positive**	**90(TP)**	**04(FP)**	**94**	Sensitivity= **91.8%** Specificity = **93.8%** **PPV = 95.7%** **NPV = 88.4%** **DA = 92.6%**
	Negative	**08(FN)**	**61(TN)**	**69**	
	Total	**98**	**65**	**163**	

DISCUSSION

Assessing the anatomical extent, characteristics, and histopathological characteristics of bone tumors and soft-tissue sarcomas typically follows a diagnostic approach where biopsy serves as the final step.[6] However, MRI is generally regarded as the most effective imaging technique for evaluating soft-tissue masses and determining the extent of soft-tissue or bone marrow involvement in bone tumors.[6,7] MRI provides detailed information about the depth, size, and local spread of tumors. There is a spectrum of opinions in the literature regarding the effectiveness of MRI in characterizing the pathological nature of musculoskeletal masses and differentiating between benign and malignant lesions. Additionally, reported specificity values for MRI in distinguishing benign from malignant musculoskeletal lesions vary widely.[6] This study included a total of 336 patients who met the inclusion and exclusion criteria. The demographic characteristics revealed a mean age of 42.69±15.72 years, indicating that the study encompassed a wide age range, which is pertinent for understanding the prevalence of musculoskeletal tumors across different age groups. 173 (51.5%) were male and 163 (48.5%) were female. The average duration of symptoms among participants was 2.89±1.14 weeks, suggesting that many patients presented with relatively recent onset of symptoms, which may impact the stage and characteristics of the tumors assessed. Regarding tumor size, the mean measurement was 1.57±0.77 cm. In the comparison of this study ALI S et al[8] reported that the average age of the patients was 42.59±10.16 years, with gender ration as (0.68:1= male to female) and in their study average duration of disease was 2.95±1.42 months.

This study primarily focused on the the diagnostic performance of magnetic resonance imaging (MRI) in predicting malignancy in the musculoskeletal system, taking histopathology as the gold

standard. Findings of this study demonstrated a sensitivity of 90.5%, which indicates that MRI is highly effective in correctly identifying patients with malignant tumors. The specificity of 90.4% further suggests that MRI is also reliable in correctly identifying patients without malignancy, minimizing false-positive results. Furthermore, the positive predictive value (PPV) of 94% indicates that a high percentage of patients who tested positive on MRI indeed had malignancy confirmed by histopathology. Although, the negative predictive value (NPV) of 84.9% suggests that while MRI is reliable in ruling out malignancy, there remain a small percentage of cases where malignancy might still be present despite negative MRI findings. Ultimately, the diagnosis accuracy of 90.4% highlights the importance of MRI in the detection of suspected musculoskeletal malignancies. Our findings are consistent with previous research, demonstrating the relevance of MRI not just in identifying cancer but also in guiding treatment planning and management for patients with musculoskeletal malignancies. In the comparison of this study ALI S et al[8] reported the diagnostic values of MRI for detecting musculoskeletal tumours were sensitivity: 89.23%, specificity: 88.57%, PPV: 87.88%, NPV: 89.86% and diagnostic Accuracy: 88.89%, with histopathology taking as the gold standard. In contrast, another study focused on the diagnostic performance of MR mammography for malignant breast lesions found a higher sensitivity of 93.9%, although the specificity was lower at 73.5%. This modality possesses an overall diagnostic accuracy of 89.3%, with 92.3% positive predictive value (PPV) and 78.1% negative predictive value (NPV). Such data indicating that while MR mammography is useful for breast lesions, it has a distinct profile of diagnostic reliability than musculoskeletal MRI.[9] Additionally Shirin M et al[11] demonstrated that the diffusion-weighted MRI (DW-MRI) showed a sensitivity of 96.4% and a specificity of 71.4% in detecting malignant musculoskeletal tumors and overall diagnostic accuracy for this imaging technique was found to be 91.4%. In another study by Boruah DK et al[12] conducted to assess the diagnostic efficacy of diffusion-weighted imaging in conjunction with conventional MRI sequences for distinguishing between musculoskeletal benign and malignant lesions and they reported that this approach achieved a sensitivity of 83.3% and a specificity of 87.5%. Overall accuracy of the diagnostic method was found to be 84.6%, indicating its effectiveness in differentiating between benign and malignant soft tissue tumors.[12] Findings of this study were also supported by Tabassum S et al[13], where they reported that the average age of participants was 59.75±8.57 years, with male predominance and among the 125 patients evaluated, diffusion-weighted MRI (DW MRI) demonstrated impressive diagnostic performance for identifying malignant focal liver lesions, using histopathology as the gold standard. The sensitivity was 92.3%, and the specificity was 93.6%. Additionally, the positive predictive value (PPV) was 96%, while the negative predictive value (NPV) stood at 88%. Overall, the diagnostic accuracy of DW MRI was found to be 92.8%, highlighting its effectiveness in this clinical context.[13] Few other studies also were in correlation of our findings.[14,15] Consistently, research by Daniel et al found that MRI sensitivity for predicting malignancy in the musculoskeletal system reached 95%, with a precision of 84%. They emphasized that MRI is instrumental in developing a well-structured differential diagnosis based on factors such as tumor occurrence, patient age, and the tumor anatomical location. Furthermore, a separate study highlighted the high diagnostic accuracy of MRI, which was found to be 88.97% when compared to histopathology.[16] The good diagnostic performance emphasizes the importance of introducing MRI into ordinary clinical practice for the evaluation of these difficult situations. Future studies required to investigate into the specific MRI features that lead to this accuracy, as well as how these imaging findings associated to the prognosis.

CONCLUSION

Study revealed that MRI scans exhibit high diagnostic accuracy, especially in differentiating between benign and malignant focal bone lesions. This level of accuracy can significantly decrease the reliance on invasive histopathological procedures, thereby reducing patient risk and discomfort while streamlining the diagnostic process. With additional large-scale studies aimed at enhancing

the reliability of this diagnostic tool, healthcare providers will be better equipped to make informed decisions regarding patient management, ultimately improving overall care and efficiency.

REFERENCES

1. Bergovec M, Kubat O, Smerdelj M, Seiwerth S, Bonevski A, Orlic D. Epidemiology of musculoskeletal tumours in a national referral orthopaedic department. A study of 3482 cases.Cancer Epidemiol. 2015;39(3):298-302.
2. Lange MB, Nielsen ML, Andersen JD, Lilholt HJ, Vyberg M, Petersen LJ.Diagnostic accuracy of imaging methods for the diagnosis of skeletal malignancies: A retrospective analysis against a pathology-proven reference.Eur J Radiol. 2016;85(1):61-67.
3. Bhuyan MH, Bhuyan RK. How accurate is MRI in the prediction of musculoskeletal tumours-A prospective evaluation. Int J Biomed Res. 2015:942-6.
4. Daniel A, Ullah E, Wahab S, Kumar V. Relevance of MRI in the prediction of malignancy of musculoskeletal system-a prospective evaluation. BMC musculoskeletal disorders. 2009;10(1):125.
5. Sen J, Agarwal S, Singh S, Sen R, Goel S. Benign vs malignant soft tissue neoplasms: Limitations of magnetic resonance imaging. Indian J Cancer 2010;47:280-6.
6. Daniel A, Ullah E, Wahab S, Kumar V. Relevance of MRI in prediction of malignancy of musculoskeletal system-A prospective evaluation. BMC musculoskeletal disorders. 2009 Dec;10:1-7.
7. Baweja S, Arora R, Singh S, Sharma A, Narang P, Ghuman S, Kapoor SK, Puri S. Evaluation of bone tumors with magnetic resonance imaging and correlation with surgical and gross pathological findings. Indian J Radiol Imaging. 2008;16:611–8
8. ALI S, MAQSOOD S, AKHTAR S, HAMEED N, GHAFFAR SA, HUSSAIN M. Diagnostic Accuracy of Magnetic Resonance Imaging in Predicting Malignancy in Musculoskeletal Tumors Taking Histopathology as Gold Standard. Age (years).;42:10-6.
9. Fatima S, Waheed S, Khan MI. Diagnostic accuracy of MR mammography in diagnosing malignant breast lesions taking histopathology as gold standard. Journal of the College of Physicians and Surgeons Pakistan. 2019 Jan 1;29(1):16-8.
10. Daniel A, Ullah E, Wahab S, Kumar V. Relevance of MRI in prediction of malignancy of musculoskeletal system-A prospective evaluation. BMC musculoskeletal disorders 2009;10(1):125.
11. Shirin M, Rahman S, Chowdhury P, Showkat MS, Karki BP, Al Azad MS. Accuracy of diffusion-weighted magnetic resonance imaging in diagnosing malignant musculoskeletal tumours. Bangabandhu Sheikh Mujib Medical University Journal. 2024 Jun 29;17(2):e72248-.
12. Boruah DK, Gogoi B, Patni RS, Sarma K, Hazarika K. Added value of diffusion-weighted magnetic resonance imaging in differentiating musculoskeletal tumors using sensitivity and specificity: A retrospective study and review of literature. Cureus. 2021 Jan;13(1).
13. Tabassum S, Haider S. Diagnostic accuracy of diffusion weighted MRI in differentiating malignant from benign liver lesions taking histopathology as gold standard. Pakistan Journal of Medical Sciences. 2024 Mar;40(4):669.
14. Ankita G, Mannan N, Jaipal U. Diagnostic accuracy of contrast-enhanced magnetic resonance imaging in bone tumors and its association with surgical findings assuming histopathological findings as gold standard. Int J Sci Res. 2018;6(1).
15. Hazarika M, Bhuyan RK, Bhuyan R. How accurate is MRI in prediction of musculoskeletal tumors: a prospective evaluation. Int J Biomed Res. 2015;6(12):942-6.
16. Hassan S, Khan MT, Ghafoor M, Raman R, Aslam N, Mumtaz A, Manzoor H. Diagnostic Accuracy of Magnetic Resonance Imaging in Detecting Parametrial Invasion in Cervical Cancer Patients, Taking Histopathology as the Gold Standard. Journal of The Society of Obstetricians and Gynaecologists of Pakistan. 2024 May 28;14(2).