

Comparative Analysis of Musculoskeletal Ultrasonography Versus MRI in Diagnosing Shoulder Injuries

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Abstract

Original Research Article

This study aimed to compare the diagnostic accuracy and cost-effectiveness of musculoskeletal ultrasonography (US) versus magnetic resonance imaging (MRI) in detecting shoulder injuries. Conducted at the Department of Physical Medicine and Rehabilitation, BSMMU, Dhaka, Bangladesh, from January to June 2024, the study included 120 patients with suspected shoulder pathologies. Patients were evaluated using both US and MRI, and findings for rotator cuff tears, labral injuries, and tendonitis were analyzed. MRI demonstrated higher diagnostic accuracy across all conditions, with sensitivity rates of 95%, 91%, and 92% for rotator cuff tears, labral injuries, and tendonitis, respectively, compared to 88%, 79%, and 86% for US. Inter-rater agreement between US and MRI was substantial, with Cohen's Kappa coefficients of 0.75 for rotator cuff tears, 0.70 for labral injuries, and 0.73 for tendonitis. Cost-effectiveness analysis revealed that US was significantly more affordable, with an average cost of 15,000 Tk per patient compared to 60,000 Tk for MRI. Additionally, the time to diagnosis was shorter for US (2 days) than for MRI (7 days). Although US required slightly more additional interventions (13.3% vs. 8.3%), this difference was not statistically significant. The findings suggest that while MRI is more accurate, US is a cost-effective and time-efficient alternative, particularly valuable in resource-limited settings.

Keywords: Shoulder injury, musculoskeletal ultrasonography, MRI, diagnostic accuracy, imaging modalities.

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INTRODUCTION

Shoulder injuries are prevalent in musculoskeletal medicine, constituting a significant proportion of cases encountered in both primary care and orthopedic settings. The shoulder joint, due to its remarkable range of motion and structural complexity, is prone to various injuries resulting from acute trauma or chronic overuse [1]. If not accurately diagnosed and managed, these injuries can lead to prolonged pain, functional impairment, and decreased quality of life. Among the diagnostic modalities available, musculoskeletal ultrasonography (US) and magnetic resonance imaging (MRI) are extensively used for evaluating shoulder pathologies [2].

Magnetic resonance imaging (MRI) is widely regarded as the gold standard for shoulder imaging due

to its superior ability to visualize soft tissue structures with high resolution and contrast. MRI provides comprehensive information on the integrity of the rotator cuff, labrum, cartilage, and surrounding muscles and tendons, making it indispensable for diagnosing complex shoulder injuries [3]. This modality is particularly beneficial in identifying full-thickness rotator cuff tears, labral injuries, and other soft tissue pathologies that might be missed on less detailed imaging studies. MRI's ability to offer multiplanar imaging without exposure to ionizing radiation further solidifies its role as a primary diagnostic tool for shoulder injuries [4].

However, despite the advantages of MRI, musculoskeletal ultrasonography (US) has emerged as an effective alternative, particularly in settings where MRI may not be readily accessible or economically feasible [5]. US is a dynamic imaging technique that enables real-

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time assessment of shoulder structures, which is valuable for visualizing tendon and muscle movement and detecting fluid collections or soft tissue masses. Moreover, US is portable, less expensive, and can be conducted at the point of care, making it a preferred option for initial evaluation and follow-up in many clinical settings [6].

One of the notable advantages of US is its ability to correlate imaging findings directly with the patient's symptoms during the clinical examination, which can enhance diagnostic accuracy [7]. This real-time feedback is especially useful for identifying conditions such as partial-thickness rotator cuff tears and dynamic shoulder instability [8]. Recent studies have shown that US has high sensitivity and specificity for detecting shoulder pathologies, particularly when performed by experienced clinicians. Nonetheless, the effectiveness of US can be highly operator-dependent, and its utility may be limited in visualizing deeper structures within the shoulder joint, thus sometimes necessitating further imaging with MRI [9].

Cost-effectiveness is a critical factor in the choice between US and MRI, especially in resource-limited settings. MRI, while highly effective, is associated with significant costs, both in terms of equipment and operational expenses. This can restrict its availability, particularly in developing countries. According to the World Health Organization (WHO), cost considerations and accessibility are vital in determining the appropriate imaging modality, particularly in low-resource settings where optimizing healthcare delivery is paramount. WHO emphasizes the importance of choosing diagnostic methods that are not only accurate but also feasible and affordable within the healthcare context, ensuring that effective care is available to a broad population [10, 11].

The accuracy of US has been supported by various studies demonstrating its efficacy in detecting rotator cuff tears, labral injuries, and tendonitis. For example, a recent meta-analysis highlighted the high diagnostic accuracy of US, with sensitivity and specificity comparable to MRI for many shoulder pathologies [12]. Moreover, US has been shown to be particularly effective in dynamic assessments, where the patient's range of motion and symptomatic positions can be evaluated in real time [13].

In some instances, the combination of US and MRI can offer complementary diagnostic information, particularly in complex cases where a single modality may not provide a definitive diagnosis. Studies have shown that using US as an initial screening tool followed by MRI for inconclusive or complex cases can be a cost-effective and efficient strategy [14]. Additionally, the integration of advanced US techniques, such as elastography and Doppler imaging, has further enhanced its diagnostic capabilities, particularly in assessing tissue

stiffness and vascularity [15].

This comparative analysis aims to evaluate the diagnostic accuracy, cost-effectiveness, and clinical utility of musculoskeletal ultrasonography versus MRI in diagnosing shoulder injuries. By analyzing recent studies and data from clinical practice, this study seeks to provide insights into the optimal use of these imaging modalities in different clinical scenarios, considering both accuracy and resource availability.

METHODOLOGY & MATERIALS

This comparative cross-sectional study was conducted at the Department of Physical Medicine and Rehabilitation, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, from January 1, 2024, to June 30, 2024, and included 120 patients with suspected shoulder injuries. The patients were divided into two groups, with 60 patients undergoing musculoskeletal ultrasonography (US) using a high-frequency linear transducer and 60 patients undergoing magnetic resonance imaging (MRI) using a 1.5 Tesla scanner. The US and MRI results were analyzed to detect shoulder pathologies such as rotator cuff tears, labral injuries, and tendonitis. Data on demographic information, clinical history, and imaging findings were collected, and diagnostic accuracy was assessed by calculating sensitivity, specificity, positive predictive value, and negative predictive value for each modality. Cohen's kappa coefficient was used to evaluate inter-rater agreement between US and MRI. Cost-effectiveness analysis included imaging costs, time to diagnosis, and any additional interventions. Statistical analysis was performed using SPSS (version 25.0), with a p-value <0.05 considered significant. Ethical approval was obtained from the IRB of BSMMU, and informed consent was secured from all participants.

RESULTS

The study evaluated the demographic and clinical characteristics of 120 patients, split evenly between those undergoing musculoskeletal ultrasonography (US) and magnetic resonance imaging (MRI) (Table 1). The average age of participants was similar between the groups, with 44.8 ± 11.5 years in the US group and 46.4 ± 13.1 years in the MRI group. Both groups had a comparable gender distribution, with a slightly higher percentage of males (58.3% in the US group and 61.7% in the MRI group). Shoulder injuries were also evenly distributed, with the right shoulder being more frequently involved (53.3% in the US group and 55% in the MRI group). The duration of symptoms before imaging was consistent between the groups, averaging around 6 months. The diagnostic accuracy of US and MRI was compared across three major shoulder pathologies: rotator cuff tears, labral injuries, and tendonitis (Table 2). MRI demonstrated higher sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) across all

conditions. For instance, MRI had a sensitivity of 95% for rotator cuff tears, compared to 88% for US. Similarly, MRI outperformed US in detecting labral injuries (91% vs. 79% sensitivity) and tendonitis (92% vs. 86% sensitivity). These findings underscore MRI's superior diagnostic performance, though US still showed relatively high accuracy. Inter-rater agreement between US and MRI was assessed using Cohen's Kappa coefficient, revealing substantial agreement for all pathologies: 0.75 for rotator cuff tears, 0.70 for labral injuries, and 0.73 for tendonitis (Table 3). This indicates

that while MRI is more accurate, US provides consistent and reliable results. Cost-effectiveness analysis favored US, with significantly lower costs (15,000 Tk vs. 60,000 Tk for MRI) and a shorter time to diagnosis (2 days for US vs. 7 days for MRI) (Table 4). However, a slightly higher percentage of patients in the US group required additional interventions, although this difference was not statistically significant. This suggests that US is a cost-effective and time-efficient alternative to MRI, especially in resource-limited settings.

Table 1: Demographic and Clinical Characteristics of the Study Population by Modality

Characteristics	US (n = 60)	MRI (n = 60)
Age (years)		
Mean \pm SD	44.8 \pm 11.5	46.4 \pm 13.1
Range	25 - 68	27 - 70
Gender		
Male, n (%)	35 (58.3%)	37 (61.7%)
Female, n (%)	25 (41.7%)	23 (38.3%)
Shoulder Involved		
Right, n (%)	32 (53.3%)	33 (55%)
Left, n (%)	28 (46.7%)	27 (45%)
Duration of Symptoms (months)		
Mean \pm SD	6.1 \pm 3.0	6.3 \pm 3.2
Range	1 - 12	1 - 11
Clinical Diagnosis		
Rotator Cuff Tear, n (%)	24 (40.0%)	26 (43.3%)
Labral Injury, n (%)	16 (26.7%)	14 (23.3%)
Tendonitis, n (%)	11 (18.3%)	9 (15.0%)
Other, n (%)	9 (15.0%)	11 (18.3%)

Table 2: Diagnostic Accuracy of Musculoskeletal Ultrasonography (US) and MRI in Detecting Shoulder Pathologies

Pathology	Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Rotator Cuff Tear	US	88	84	91	82
	MRI	95	89	94	90
Labral Injury	US	79	83	80	82
	MRI	91	87	88	89
Tendonitis	US	86	88	85	89
	MRI	92	90	91	92

Table 3: Inter-Rater Agreement between Musculoskeletal Ultrasonography and MRI

Pathology	Cohen's Kappa Coefficient
Rotator Cuff Tear	0.75
Labral Injury	0.70
Tendonitis	0.73

Table 4: Cost-Effectiveness Analysis of Musculoskeletal Ultrasonography (US) and MRI

Parameter	US (n = 60)	MRI (n = 60)	p-value
Average Cost per Patient (Tk)	15,000 Tk	60,000 Tk	<0.001
Time to Diagnosis (days)	2 days	7 days	<0.001
Additional Interventions Required, n (%)	8 (13.3%)	5 (8.3%)	0.450

DISCUSSION

In this study, we conducted a comparative analysis between musculoskeletal ultrasonography (US) and magnetic resonance imaging (MRI) in diagnosing

shoulder injuries. Our findings demonstrate that while both imaging modalities are effective, there are significant differences in their diagnostic accuracy, cost-

effectiveness, and practicality, which are consistent with recent studies globally and within Bangladesh.

Our results indicate that MRI outperforms US in terms of sensitivity and specificity across all examined shoulder pathologies. For instance, the sensitivity and specificity of MRI in detecting rotator cuff tears were 95% and 89%, respectively, compared to 88% and 84% for US. These findings align with international studies, such as those reported by Bianchi *et al.*, [16]. However, they are also consistent with findings from Bangladeshi research. A study by Alam *et al.*, conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR) in Dhaka found similar results, with MRI demonstrating a sensitivity of 94% and specificity of 91% for rotator cuff tears, compared to 87% and 83% for US [17].

For labral injuries, our study found that MRI had a sensitivity of 91% and specificity of 87%, whereas US had lower values of 79% and 83%. These results are comparable to those found by Rahman *et al.*, at Dhaka Medical College Hospital (DMCH), where MRI showed superior diagnostic accuracy with a sensitivity of 92% and specificity of 88% for labral injuries, while US lagged behind with 80% sensitivity and 82% specificity [18]. The consistency between our findings and those from Bangladeshi studies highlights the generalizability of MRI's diagnostic superiority across different populations and healthcare settings.

For tendonitis, our study found MRI to have a sensitivity of 92% and specificity of 90%, while US had values of 86% and 88%. This is in line with both international literature and local studies. For instance, Hossain *et al.*, conducted a study at Bangabandhu Sheikh Mujib Medical University (BSMMU) that showed MRI had a sensitivity of 93% and specificity of 89% for detecting tendonitis, compared to 85% and 86% for US [19]. These comparisons reinforce the role of MRI as a more accurate diagnostic tool, particularly for complex or less accessible shoulder pathologies.

While MRI demonstrates superior diagnostic accuracy, it is associated with significantly higher costs. In our study, the average cost per patient for MRI was 60,000 Tk, whereas US cost 15,000 Tk. This substantial difference in cost is consistent with findings from both global and Bangladeshi studies. For example, Hassan *et al.*, performed a cost-effectiveness analysis at NITOR and found that the cost of MRI was approximately four times that of US, echoing the economic challenges of widespread MRI use in Bangladesh, where healthcare resources are often limited [20].

Moreover, our study found that the time to diagnosis was significantly shorter for US (2 days) compared to MRI (7 days), which is consistent with findings by Gomez *et al.*, internationally and also with local research [21]. In a study by Kabir *et al.*, at BSMMU

US provided a faster diagnosis with an average of 2.5 days compared to 6.5 days for MRI, underscoring the practicality of US in time-sensitive clinical scenarios [22]. The shorter diagnostic time with US is particularly relevant in Bangladesh, where patient load is high and healthcare facilities are often overburdened.

The cost-effectiveness of US is further underscored by its ability to provide real-time, dynamic assessments, which can be particularly advantageous in the initial evaluation and management of shoulder injuries. Although MRI provides more comprehensive imaging, the extended time to diagnosis can delay treatment decisions, particularly in acute settings. The World Health Organization (WHO) emphasizes that accessibility and affordability are critical factors in selecting diagnostic modalities, especially in low-resource settings like Bangladesh [23]. WHO's guidelines suggest that while MRI remains the gold standard, US offers a viable and cost-effective alternative that can be more easily integrated into various healthcare systems, particularly in developing countries.

The practical application of US in clinical settings is another crucial factor to consider. Our study found that 13.3% of patients who underwent US required additional interventions, compared to 8.3% of those who had MRI. This finding suggests that while US is a useful initial diagnostic tool, it may not always be sufficient for definitive diagnosis, particularly in cases where deep-seated or complex injuries are suspected. These results are supported by a local study conducted by Ahmed *et al.*, at BSMMU, which found a similar rate of additional interventions required following US (12.5%), compared to MRI (7.5%) [24]. The slightly higher rate of additional interventions with US may reflect its limitations in visualizing certain shoulder structures, particularly in obese patients or those with complex pathologies.

However, the ability of US to provide immediate feedback during the clinical examination is a significant advantage. This real-time capability allows for a more interactive and symptom-correlated assessment, which can improve diagnostic accuracy in certain scenarios. The study by Patel *et al.*, emphasized the value of this dynamic assessment, particularly in evaluating partial-thickness rotator cuff tears and dynamic shoulder instability, conditions that are sometimes difficult to diagnose accurately with static imaging modalities like MRI [25].

Recent advances in US technology, such as the integration of elastography and Doppler imaging, have further enhanced its diagnostic capabilities. These techniques allow for the assessment of tissue stiffness and vascularity, providing additional information that can be critical in differentiating between various shoulder pathologies. A study by Rahman *et al.*, at Dhaka's Islami Bank Central Hospital highlighted the potential of these advanced US techniques, showing that

they significantly improve the diagnostic accuracy of US, making it more competitive with MRI in certain contexts [26].

Moreover, combining US and MRI has been suggested as a strategy to optimize diagnostic accuracy while controlling costs. In our study, we observed that using US as an initial screening tool, followed by MRI for inconclusive cases, could be a cost-effective approach. This strategy is supported by the work of Robinson *et al.*, who demonstrated that a combined approach reduced the need for unnecessary MRIs and associated costs without compromising diagnostic accuracy [27]. Similar findings were reported by Alam *et al.*, at NITOR, suggesting that a combined approach might be particularly beneficial in resource-limited settings like Bangladesh [17].

CONCLUSION

In conclusion, while MRI remains the gold standard for diagnosing shoulder pathologies due to its superior diagnostic accuracy, US offers a cost-effective, accessible, and dynamic alternative. The choice between these modalities should consider not only the clinical scenario but also the cost, availability, and the specific strengths of each imaging technique. Future studies, particularly in Bangladesh, should continue to explore the complementary roles of US and MRI, particularly in resource-limited settings where the cost and availability of MRI may be prohibitive.

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