ORIGINAL ARTICLE

Role of magnetic resonance imaging in the evaluation of painful shoulder

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Abstract

Background: The shoulder pain etiology is diverse and many disorders present with similar symptoms and signs. Magnetic Resonance Imaging (MRI) provides good multiplanar delineation even without contrast and absence of radiation hazards. *Aim and Objectives:* To evaluate the role of MRI in diagnosing causes of shoulder pain and their limitations and pitfalls, if any. *Material and Methods:* A descriptive cross-sectional study was undertaken in a tertiary care centre from January 2023 to December 2023 with study population of 100 patients referred to the Department of Radiology at our institute with complaints of shoulder pain. *Results:* Most patients in the study in our study were in the age group of 41-60 years (44%) with mean age of patients being 45.34 ± 16.10 years. In the present study, most patients were male (72%) and common pathologies observed were joint effusion (64%), rotator cuff tear (50%), tendinopathy (46%), degenerative diseases (42%), and bursitis (34%). Hill Sachs's lesion was observed in 20% of patients, while Bankart's was in 24%. A malignant tumor was present in only one patient. *Conclusion:* MRI showed high sensitivity and specificity for detecting rotator cuff pathologies. It is also highly sensitive for shoulder injuries arising from soft tissues particularly in cases without known trauma. These findings underscore the clinical relevance of MRI in managing shoulder pain, emphasizing its potential to enhance patient outcomes and optimize treatment strategies.

Keywords: Diagnosis, Rotator Cuff Disease, Imaging Modalities, Shoulder Pathology

Introduction

The shoulder joint is an intricate structure that has the highest range of motion among all other joints, yet it remains stable under most circumstances. The joint stability is maintained by various structures, including the osseous glenoid, the joint capsule, the fibrous labrum, the glenohumeral ligaments, and several muscles surrounding the shoulder [1]. Shoulder pain and disability can significantly impact the patient's daily activities and work productivity, leading to a considerable socioeconomic burden. While primary healthcare can manage most cases effectively, some patients may require surgery depending on the severity of their symptoms and diagnosis. Shoulder pain has numerous causes; many disorders present with similar symptoms and signs. Most shoulder pain worsen with arm elevation or overhead activities. The diagnosis of shoulder pain is complex and may require a broad differential diagnosis. Imaging studies may be challenging to interpret, and mixed findings on clinical and imaging evaluations are shared [2].

Shoulder sonography was initially developed as a non-invasive means to detect conditions causing painful shoulders. However, with the advent of high-resolution surface coils and advancements in Magnetic Resonance Imaging (MRI), it has become the reference standard for imaging shoulder disorders [3]. MRI provides detailed information about bone, labral cartilage, deep parts of various ligaments, capsules, and areas obscured by bone. It also includes information about adjacent structures, muscle atrophy, muscle size, cross-sectional area, and fatty degeneration, all of which have implications for the physiologic and mechanical status of the rotator cuff. Artefacts generated by respiratory and cardiac motion are not a problem in MRI of the joints as they are in MR scanning of the body. Rotator cuff disease is one of the most common causes of shoulder pain. MRI can provide valuable information about rotator cuff tears (Figures 1, 3), such as tear dimensions, depth or thickness, shape, adjacent structures' involvement, and muscle atrophy. MRI can also provide information about the coraco-acromial arch and impingement related to rotator cuff tears [4-5]. Therefore, this study aimed to assess the role of MRI in diagnosing the causes of shoulder pains and to assess the limitations of MRI in diagnosing the pathology which can be attributed to symptom of the patient.

Material and Methods

Study design: The present study was a descriptive cross-sectional study undertaken to evaluate the role of MRI in diagnosing causes of shoulder pain in a tertiary care centre.

Study period: The present study period was from January 2023 to December 2023.

Study population: The study population included indoor and outdoor patients referred with complaints of shoulder pain to the Department of Radiology at our institute.

Sample size: A total sample size of 106 patients with complaints of shoulder pain referred to the Department of Radiology in our hospital was included in the study population.

Sample size estimation: According to basics of research methodology [6], $n = Z2 \times p \times (1\text{-p})/d2$

Where n is the minimum sample size, Z is a function of specified error (alpha and beta), and the type of hypothesis= 1.96, p is the prevalence of shoulder pain = 0.7, and d is absolute precision = 0.1. With the above values, we get the minimum sample size of 80. So, the sample size was taken as 106 patients with shoulder pain.

Inclusion criteria: Patients with pain in shoulder joint, trauma to the shoulder joint and clinically suspected to have either a rotator cuff injury (total thickness or partial thickness tears), biceps tendon injury, calcific tendinitis, fractures or any other condition causing shoulder pain were included in the study.

Exclusion criteria: Patients with aneurysmal clips, metallic implants, cardiac pacemakers, and cochlear implants, claustrophobia, and those who were unwilling for imaging were excluded from the study.

Data collection: All patients with acute or chronic shoulder pain were selected and informed consent was taken from the patients. The selected subjects were visited, and the questionnaire was administered which consisted of two parts. The first part included a demographic profile and the second part consisted of the clinical examination and MRI findings. The questionnaire was validated by translation into the local language and reviewed by experts. Imaging was done with a Philips Ingenia-Elition × 3.0 Tesla MRI machine with a dedicated shoulder coil. A routine protocol was used to acquire all images (Table 1). All studies were evaluated together on Med synapse PACS on BARCO CoronisUniti (MDMC-12133) by 2 experienced musculoskeletal radiologists with more than 10 years of experience. The results were compiled using Microsoft Office Excel.

Table 1: Routine protocol for shoulder imaging

Sequence	TR (ms)	TE (ms)	Slice thickness (mm)	FOV (mm)	Matrix
Axial PD FS	3000	30	3.0	130	320 × 288
Coronal oblique T1	1000	10	3.0	130	288 × 256
Coronal oblique T2 FS	3500	70	3.0	130	320 × 288
Sagittal oblique T1	600	10	3.0	130	288 × 256
Sagittal oblique T2 FS	3500	70	3.0	130	320 × 288

FOV – field of view, FS – fat-suppressed, PD – proton density, TE – echo time, TR – repetition time

Statistical analysis

The data was compiled in an excel sheet, and a master chart was prepared. Patients in whom no pathology could be diagnosed on MRI study were excluded (i.e. 6 patients) from calculations of the rest of the statistics. All data analyses were done using IBM SPSS (version 22) for Windows. A chi-square test was applied to check the association between two attributes. Z-test (Standard Normal Deviate) was used to test the significant difference between two proportions. t-test was used to compare the means. The value of $p < 0.05$ was considered to be statistically significant.

Results

Table 2 displays the age distribution of patients, with the majority falling in the 41-60 age range (44%) and also shows the gender distribution among patients. The co-morbidities in the present study were hypertension (13%), followed by diabetes mellitus (10%), cardio-vascular disease (5%) and cerebro-vascular accident (2%). Maximum patients had their right side involved (60%). A history of trauma was present in 9 (9%) patients. Joint effusion was the most common lesion, observed in 64% of patients, followed by rotator cuff tears (50%) and tendinopathy (46%). Hill Sachs lesion was present in 20% of patients, while Bankart's lesion and its variants were present in 24% (Figure 2). One patient had a malignant tumor (Figure 4). One patient had osteomyelitis (Figure 5). The biceps tendon had the highest rate of tendinopathy lesions (50%). Most rotator cuff tears were observed in supraspinatus as partial tears (70%). Most cysts were observed as humeral cysts(75%). Twenty-one patients presented with co-morbidity in our study, among which the most common pathology was found to be that of rotator cuff tear and joint effusion, whereas the next most common pathology was that of degenerative disease followed by tendinopathy and bursitis. The table 2 shows the relation of rotator cuff tears by MRI findings and age among patients. Most rotator cuff tears were observed in those >30 years old, with statistical significance in only Supraspinatus-Partial tears ($p < 0.05$). Table 2 shows the relation of Bankarts/Variants by MRI findings and age among patients. Most Bankarts lesions were observed in age < 30 years among patients with statistical significance ($p < 0.05$). Accuracy of MRI in diagnosing patients with symptoms i.e. pain was assessed; in 6 patients, the MRI study was normal, and the cause of pain could not be determined. However, on symptomatic treatment with pain killers, the pain subsided in these patients. Thus the percentage accuracy of MRI was calculated to be 94.34% in our study.

Table 2: Clinical and demographic profile of patients

Age		
Age group (years)		**Number (Percentage)**
0-20		05 (05%)
21-40		31 (31%)
41-60		44 (44%)
61-80		20 (20%)
Total		100 (100%)
Sex	**Male**	72 (72%)
	Female	28 (28%)
Co-morbidities		
Co-morbidities		**Number (Percentage)**
Hypertension		13 (13%)
Diabetes Mellitus		10 (10%)
Cardio-vascular disease		05 (05%)
Cerebro-vascular accident		02 (02%)
Side affected		
Side		**Number (Percentage)**
Right		60 (60%)
Left		40 (40%)
Total		100 (100%)

Continued...

History of trauma	
Trauma	**Number (Percentage)**
Present	09 (09%)
Absent	91 (91%)
Total	100 (100%)
Lesions by MRI findings	
Pathology	**Number (Percentage)**
Adhesive Capsulitis	05 (05%)
Tendinopathy	46 (46%)
Bursitis	34 (34%)
Synovitis	04 (04%)
Rotator Cuff Tears	50 (50%)
Impingement Syndrome	01 (01%)
Hill-Sachs	20 (20%)
Bankarts/Variants	24 (24%)
Bone Bruise/Contusion/Edema	06 (06%)
Fractures	05 (05%)
Joint effusion	64 (64%)
Degenerative diseases	42 (42%)
Cysts	08 (08%)
Infection	01 (01%)
Benign tumours	02 (02%)
Malignant tumours	01 (01%)

Continued...

Tendinopathy by MRI findings	
Tendinopathy	**Number (Percentage)**
Biceps	23 (50%)
Supraspinatus	21 (45.65%)
Subscapularis	02 (04.35%)
Total	46 (100%)
Rotator cuff tears by MRI findings	
Rotator cuff tears	**Number (Percentage)**
Supraspinatus-Complete	14 (28%)
Supraspinatus-Partial	35 (70%)
Infraspinatus-Complete	00 (0%)
Infraspinatus-Partial	06 (12%)
Subscapularis-Complete	01 (02%)
Subscapularis-Partial	06 (12%)
Teresminor-Complete	00 (0%)
Teresminor-Partial	01 (02%)
Cysts by MRI findings	
Cysts	**Number (Percentage)**
Paralabral Cysts	02 (25%)
Humeral Cysts	06 (75%)
Total	08 (100%)

Table 3: Association between pathology and co-morbidity

Pathology	Number of patients with pathology	Number of patients with pathology and co-morbidity
Adhesive Capsulitis	05	1
Tendinopathy	46	9
Bursitis	34	7
Synovitis	04	1
Rotator cuff tears	50	15
Impingement syndrome	01	0
Hill-Sachs	20	1
Bankarts/variants	24	1
Bone bruise/contusion/edema	06	1
Fractures	05	0
Joint effusion	64	15
Degenerative diseases	42	13
Cysts	08	2
Infection	01	0
Benign tumors	02	0
Malignant tumors	01	0

Table 4: Relation of rotator cuff tears and age

Rotator cuff tears	Age (years)		Total	*p*
	⩽30	>30		
Supraspinatus-Complete	01	13	14	0.08
Supraspinatus-Partial	03	32	35	0.007
Infraspinatus-Partial	00	06	06	0.31
Subscapularis-Complete	00	01	01	1.00
Subscapularis-Partial	00	06		0.31
Teresminor-Partial	00	01	01	1.00

Table 5: Relation of Bankarts/variants and age

Bankarts/Variants	**Age (years)**		**Total**	***p***
	⩽30	**>30**		
Present	10	14	24	$p = 0.04$ Significant
Absent	16	60	76	
Total	26	74	100	

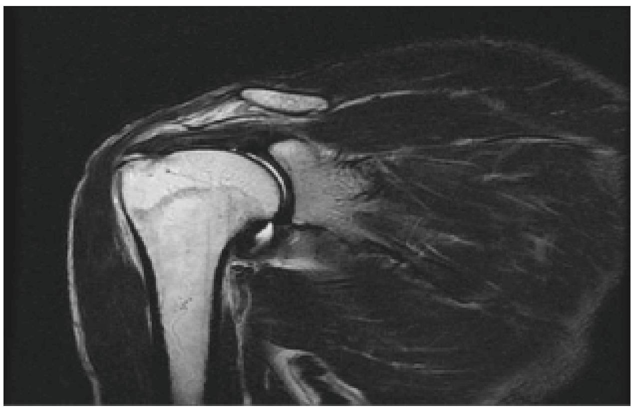


Figure 1: Coronal T2WI showing rim rent tear of supraspinatus muscle

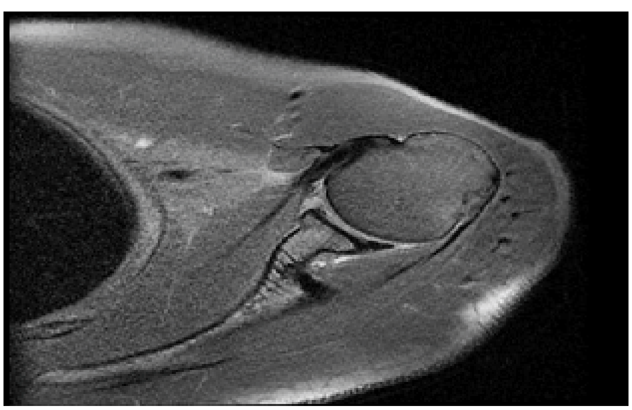


Figure 2: Axial PD fat sat image shows attenuation and irregularity of anterior-inferior labrum representing Bankart's lesion

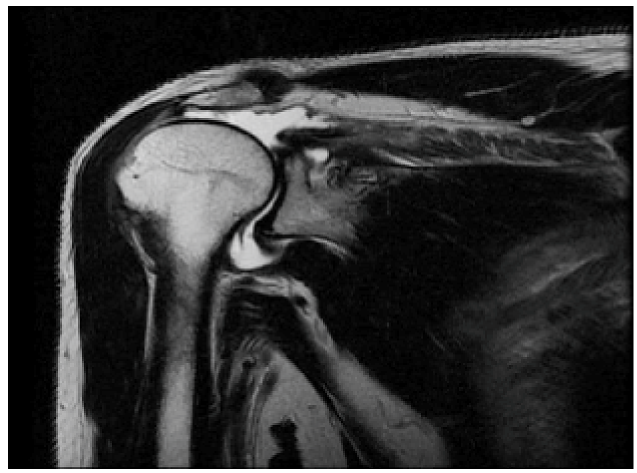
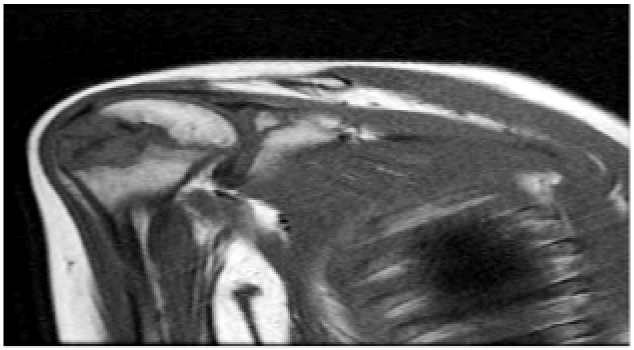
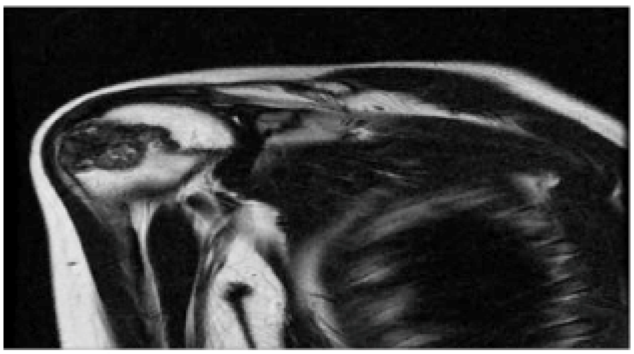


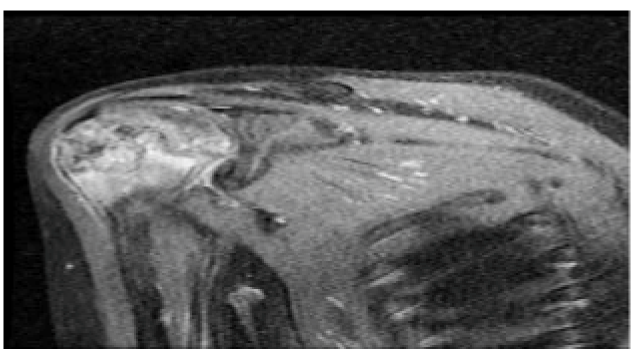
Figure 3: Coronal T2WI showing complete tear of supraspinatus with retracted tendon fibres and a trophy of the muscle



(a)

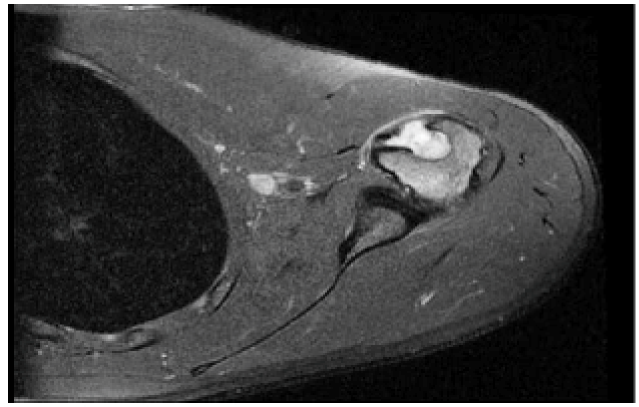


(b)

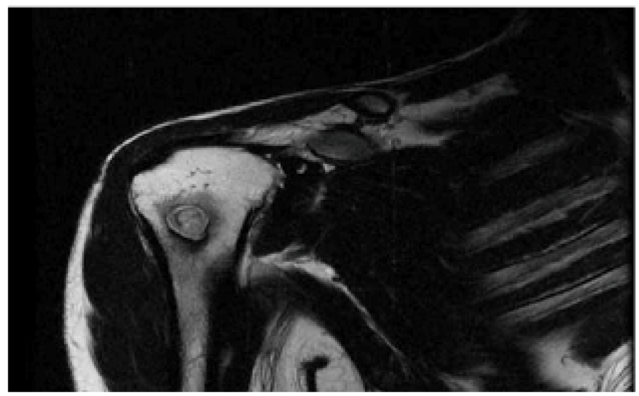


(c)

Figure 4: Coronal T1WI (a), T2WI (b) and T1 FS post contrast image (c) showing osteosarcoma involving the humeral head



(a)



(b)

Figure 5: Axial PD fatsat image (a) and Coronal T2WI showing Osteomyelitis of upper humerus metaphysis in the region of bicipital groove causing anterior cortical destruction with surrounding soft tissue edema

Discussion

A detailed analysis of patient demographics revealed that shoulder pain primarily affected the middle-aged individuals. Most patients in the study were in the age group of 41-60 years (44%), followed by 21-40 years (31%). The mean age of patients was 45.34 ± 16.10 years. In the present study, most patients were males (72%), followed by females (28%). This male predominance aligns with other studies suggesting a higher incidence of shoulder pathologies in males, possibly due to differences in occupational and recreational activities. The most common co-morbidities observed in the present study were hypertension (13%), diabetes mellitus (10%), CVD (5%), and CVA (2%). These findings are consistent with previous research highlighting the association between these co-morbid conditions and musculoskeletal disorders. The right side was more commonly affected than the left side (60% vs. 40%). Additionally, a history of trauma was present in 9% of cases. This distribution suggests that while trauma is a contributing factor, many shoulder pain cases arise without a clear traumatic event, indicating the need for comprehensive diagnostic imaging like MRI. In the present study, joint effusion (64%), rotator cuff tear (50%), tendinopathy (46%), degenerative diseases (42%), and bursitis (34%) were the most common lesions observed. Hill Sachs's lesion was observed in 20% of patients, while Bankart's was in 24%. A malignant tumor was present in only one patient. These results underscore the broad spectrum of shoulder pathologies that MRI can detect, emphasizing its role in diagnosing conditions ranging from common degenerative changes to rare malignancies. Similarly, a study by Kvalvaag *et al*. (2017) on shoulder MRI features observed the mean age of patients was 47 years, among which there were 62 women and 53 men [7]. While evaluating the role of MRI in shoulder pain, Mohamed *et al*. (2014) observed their ages ranged between 19 and 69 years, with a mean age of 31 years, among which there were 56 were males and 44 females [8]. In this study acromioclavicular joint osteoarthritis was the most common pathologic finding (85%) followed by supraspinatus tendinosis (45%). Chaudhary and Aneja (2012) observed that rotator cuff tendinopathy accounted for maximum cases in which supraspinatus tendinopathy was found in 67.65% of cases (55 patients) and subscapularis tendinopathy in 8 (9.9%) cases. Biceps tendinopathy was found in 10 (12.35%) cases, Bankart lesion in 7 (8.61%) cases and Hill Sachs lesion in 9 (11.11%) cases. Subacromiansubdeltoid bursitis accounted for 30 (37.04%) cases. There were 22 (27.16%) cases who were associated with joint effusion and 6 (7.40 %) cases with synovial thickening. 3 (3.70%) cases were found with adhesive capsulitis, 3 (3.70%) cases with tuberculosis, 3 (2.47%) cases with malignancy [9]. Chaudhari (2017) demonstrated the role of MRI in detecting shoulder pathologies encountered in cases with shoulder pain [10]. Out of the 40 cases, the age of the patients was between (18 - 80) years. Singh *et al*. (2017) observed MRI findings in 50 cases and found 12 (24%) patients had full-thickness tears, while 28 (56%) patients had partial-thickness tears [11]. In 28 cases diagnosed with full-thickness tears, 13 patients had full-thickness tears without retraction and 14 cases had full-thickness tears with retraction. In 13 out of 50 cases, biceps tendon effusion was seen in 7 (54%) cases on MRI.

Tendinopathy was most frequently identified in the biceps tendon (50%), followed by the supraspinatus (45.65%) and subscapularis (4.35%). The prevalence of rotator cuff tears was notable, with partial tears of the supraspinatus being the most common (70%), followed by complete supraspinatus tears (28%). These findings highlight the importance of MRI in diagnosing specific tendon pathologies and guiding treatment strategies. Similar prevalence and findings were seen Redondo-Alonso *et al*. (2014) [12]. The most common appearance of a full-thickness tear is a high signal intensity in a T2-weighted image that extends from the articular surface of the rotator cuff to the subacromialsubdeltoid bursa. In chronic rotator cuff tears in which the shoulder joint has little or no effusion, the humeral head may have an elevated conduction so that a very high signal at the site of tears is not observed. That can imitate an intact tendon in the absence of a stroke; therefore, it is important to trace a low signal structure when it passes over the humeral head. The cuffs of the rotator cuff will end in their insertion in the greater tuberosity, while the abrupt thickening of the pouch will continue in depth to the deltoid muscle below the greater tuberosity. MRI findings also identified cysts, with humeral cysts being the most common (75%), followed by paralabral cysts (25%). The detection of cysts is crucial as they can be associated with underlying labral tears or other structural abnormalities. Mangi *et al*.,(2022) also showed similar sensitivity and specificity of MRI in identifying cysts in humeral head [13]. Rotator cuff tears were significantly more common in patients over 30 years old, particularly partial tears of the supraspinatus, which showed statistical significance ($p < 0.05$). Smith *et al*., (2012) also had concordant findings [14]. Conversely, Bankart's lesions and its variants were more commonly observed in patients under 30 years old, with statistical significance ($p < 0.05$). These age-related trends highlight the diverse etiologies of shoulder pain across different age groups and the utility of MRI in tailoring age-appropriate diagnostic and treatment approaches. The accuracy of MRI in detecting the cause for painful shoulder was 94.34% in the present study, as the MRI studies were normal in 6 patients. Similar findings were also noted in Houtz *et al*., (2011) and Mohtadi *et al*., (2004) [15,16]. MRI is a vital diagnostic tool in the evaluation of shoulder pain, offering detailed insights into a wide range of shoulder pathologies. The data presented in this article underscore the prevalence of various conditions such as joint effusion [17, 18], rotator cuff tears [19-21], and tendinopathy [22-24] and highlight the importance of considering patient age and co-morbidities in the diagnostic process. MRI shoulder is also significantly important in the diagnosis of other rare entities like the absence of suprascapular notch [25] and subdeltoidbursa tuberculosis with rice body formation [26], bilateral anterior fracture dislocation of shoulder [27] and in evaluating bone tumors and their mimics [28]. Future research should continue to refine MRI techniques and explore their applications in improving patient outcomes in shoulder pain management [29].

Conclusion

MRI is highly specific and sensitive in diagnosing a range of pathologies including rotator cuff tears, labral injuries, biceps tendon abnormalities, and bursitis. In our study the most common causes for shoulder pain were found to be joint effusion, rotator cuff tear, tendinopathy and degenerative diseases. It also helps in identifying less common conditions such as tumors, infections, and vascular lesions.

Limitations and pitfalls of MRI in diagnosing shoulder pathologies

One significant limitation is its inability to always distinguish between symptomatic and asymptomatic lesions. MRI may also produce false positives, especially in detecting partial rotator cuff tears and labral lesions. Also, the diagnosis of dynamic pathologies like particularly pertaining to impingement syndromes are difficult to diagnose on MRI. Therefore, the expertise of the radiologist and correlation with clinical findings and other diagnostic modalities are crucial for accurate assessment.

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