Original Article

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Comparative Study of the Diagnostic Ability of Ultrasonography and Magnetic Resonance Imaging in the Evaluation of Chronic Shoulder Pain

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Abstract

Introduction: Shoulder pain is recognized as a disabling problem. The most common causes of shoulder pain in primary care are reported to be rotator cuff disorders, acromioclavicular joint diseases, and glenohumeral joint disorders. The final diagnosis in case of chronic shoulder pain is based on a collective clinical as well as radiological evaluation which includes radiographs, ultrasonography (USG), and magnetic resonance imaging (MRI).

Materials and Methods: After obtaining ethical clearance, 85 cases of chronic shoulder pain were enrolled for the study. A detailed history with clinical examination was done. Patients were subjected to X-ray anterior-posterior and axial as initial investigation. On viewing, the X-ray next modality was decided. All those cases where no obvious bony lesion was seen were further evaluated by USG and MRI. The diagnosis was confirmed by arthroscopy.

Result: For partial thickness tear of supraspinatus, USG had a sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of 60%, 97.6%, 95.5%, 74.1%, and 80.3%, respectively, as compared to 88.6%, 96.0%, 93.9%, 92.3%, and 92.9%, respectively, for the same parameters on MRI. For full thickness tear of supraspinatus, USG had a sensitivity, specificity, PPV, NPV, and accuracy of 95.2%, 90.6%, 76.9%, 98.3%, and 91.8%, respectively, as compared to 95.2%, 98.4%, 95.2%, 98.4%, and 97.6%, respectively, for the same parameters on MRI.

Conclusion: As far as comparative evaluation of USG and MRI, except for full thickness tear where both the modalities had equal sensitivity, for all the other diagnoses MRI showed a higher sensitivity. However, for partial thickness tear, USG had a higher specificity as compared to MRI; for all the other diagnoses, MRI showed a higher specificity. In terms of overall accuracy, MRI had a higher accuracy as compared to USG, for all the diagnoses except for full thickness tears.

Key words: Arthroscopy, Chronic shoulder pain, Full thickness tear, Partial thickness tear, Tendinosis, Ultrasonography

INTRODUCTION

Shoulder pain is recognized as a disabling problem and is one of the most common reasons for visit to a general practitioner with nearly 1% of the adult population reporting with new episodes of shoulder pain.[1]

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Shoulder pain is defined as chronic when it has been present for longer than 6 months. Compromised shoulder movement due to pain, stiffness, or weakness can cause substantial disability and affect a person's ability to carry out daily activities (eating, dressing, personal hygiene) and work.

Thus, it is a severe disability and results in a heavy loss of working days and disability. Shoulder complaints may have an unfavorable outcome, with only about 50% of all new episodes of shoulder complaints presenting in medical practice showing a complete recovery within 6 months.[1,2] After 1 year, this proportion increases to 60%.[2]

Although community data on shoulder pain is limited, the prevalence of shoulder pain among in urban and rural

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populations of India has been reported to be 2% and 7.4%, respectively.[3,4]

The most common causes of shoulder pain in primary care are reported to be rotator cuff disorders, acromioclavicular joint disease, and glenohumeral joint disorders,[5] with classification of these disorders based primarily on results of clinical tests.[6-9] However, inconsistent diagnostic terminology,[10] lack of universally accepted diagnostic classification criteria,[11,12] and poor specificity of many physical examination tests,[13,14] hamper confidence in classification systems that use clinical test criteria alone.

The final diagnosis in case of chronic shoulder pain is based on a collective clinical as well as radiological evaluation. The clinical evaluation includes both medical history as well as physical assessment. The role of occupational history in the causation of chronic shoulder pain is also important and makes an essential part of history taking. Diagnostic imaging remains to be the next in the algorithm of achieving a final diagnosis. These include radiographs, magnetic resonance imaging (MRI), arthrography, computed tomography, and ultrasonography (USG). However, use of appropriate imaging technique depends mainly on the findings of clinical evaluation and suspected pathology. For example, for suspected diagnosis of rotator cuff disorders, MRI is preferred; whereas for suspected labral pathology, MRI arthrography is suggested.[15] Each of these diagnostic modalities has its own economic and financial implications as well as limitation of accuracy. Techniques such as USG are cost-effective, yet they are highly technician dependent and, therefore, have not yet gained widespread acceptance.[15] The vast differences in the responsible pathologies of chronic shoulder pain make it difficult to adopt a single, cost-effective diagnostic test for the final diagnosis. Thus, the diagnostic process often becomes prolonged and leads to prolongation of the quality of life of affected patient which has physical, financial, social, and psychological repercussions too.

In this research study, we made an attempt to carry out a clinico-radiological evaluation of chronic shoulder pain and comparing the diagnostic findings of two different modalities USG and MRI with arthroscopically/surgically confirmed the diagnosis to come up with a more valuable and clinically relevant algorithm for the efficient diagnosis of chronic shoulder pain.

MATERIALS AND METHODS

Study Design

The present study was carried out as a prospective observational study.

Settings

The study was carried out at the Department of Radiodiagnosis, Era's Lucknow Medical College, Lucknow, Uttar Pradesh, India.

Duration of Study

About 18 months starting from January 2014 to June 2015.

Sampling Frame

Patients presenting with the complaints of shoulder pain were selected for the purpose of the study. The sampling frame of the study was bound by the following inclusion and exclusion criteria:

Inclusion criteria:

- Either gender, aged 21-60 years
- Presenting with shoulder pain for last 6 months or more.

Exclusion criteria:

- Patients not providing consent to participate in the study
- Having shoulder pain for less than 6 months
- History of any congenital deformity of shoulder
- Contraindication of MRI: Pacemakers and metallic implants.

Clearance and Approvals

Clearance for carrying out the study was obtained from the Institutional Ethical Committee, Era's Lucknow Medical College, Lucknow, Uttar Pradesh, India. Informed consent was obtained from all the patients.

Sample Size

Sample size is 85.

Methodology

All the patients falling in the sampling frame were invited to participate in the study.

After obtaining informed consent, demographic information was noted. An elaborate history was taken from all the patients which was followed by a thorough clinical evaluation, in which duration of symptoms, affected side, dominant hand, range of movement was noted. A thorough medical history, nature of complaints, symptoms, and signs were noted. In case of an injury being the cause of shoulder pain, cause of injury was also noted.

Patients were subjected to X-ray anterior-posterior (AP) and axial as initial investigation. On viewing, the X-ray next modality was decided. All those cases where no obvious bony lesion was seen were further evaluated by USG and MRI. The diagnosis was confirmed by arthroscopy.

X-ray machine

In plain radiography, AP view (kv - 55 mAs - 12) and axial view (kv - 50 mAs - 9) were taken on 800 mA Siemens machine and in few cases under fluoroscopy using collimation where ever required.

Ultrasound machine

USG was done with a high-frequency 7.5-12 MHz broadband linear transducer on GE, Voluson P8 machine.

MRI machine

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Statistical Analysis

The statistical analysis was done using Statistical Package for Social Sciences Version 15.0 statistical analysis software. The values were represented in number (%) and mean.

RESULTS

According to arthroscopic findings, partial thickness tear of supraspinatus (n = 35; 41.2%) was the most common diagnoses followed by full thickness of supraspinatus (n = 21; 24.7%) and tendinosis of supraspinatus (n = 16; 18.8%). Among other diagnoses (n = 13; 15.3%) – labral tear was most common (n = 4; 4.7%) subacromial-subdeltoid bursitis; partial thickness tear of subscapularis, full thickness tear of infraspinatus, and adhesive capsulitis was diagnosed in 2 (2.4%) patients each; and full thickness tear of long head of biceps in 1 (1.2%) patient (Table 1).

On USG, in a total of 16 (18.8%) patients, all the findings were found to be normal. Maximum number of patients were diagnosed as full thickness tear of supraspinatus (n = 26; 30.6%) followed by partial thickness tear of supraspinatus (n = 22; 25.9%) and tendinosis of supraspinatus (n = 11; 12.9%). A total of 10 (11.8%) patients were collectively placed under diagnosis "others" – these included 2 (3.5%) cases each of partial thickness tear of subscapularis, full thickness tear of infraspinatus, adhesive capsulitis, and labral tears; and 1 (1.2%) case each was diagnosed as subacromial deltoid bursitis and full thickness tear of long head of biceps (Table 2).

As per MRI diagnosis, maximum number of cases had partial thickness tear of supraspinatus (n = 33; 38.8%) followed by full thickness tear of supraspinatus (n = 21; 24.7%) and tendinosis of supraspinatus (n = 16; 18.8%). There were 12 cases (14.1%) placed under 'others' category that included – 3 (3.5%) labral tear, 2 (3.5%) each as subacromial deltoid bursitis, partial thickness tear of subscapularis, full thickness tear of infraspinatus, adhesive capsulitis, and 1 (1.2%) full thickness tear of long head of biceps. On MRI, 3 (3.5%) cases were diagnosed as normal (Table 3).

For partial thickness tear of supraspinatus, USG had a sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of 60%, 97.6%, 95.5%, 74.1%, and 80.3%, respectively, as compared to 88.6%, 96.0%, 93.9%, 92.3%, and 92.9%, respectively for the same parameters on MRI.

For full thickness tear of supraspinatus, USG had a sensitivity, specificity, PPV, NPV, and accuracy of 95.2%, 90.6%, 76.9%, 98.3%, and 91.8%, respectively, as compared to 95.2%, 98.4%, 95.2%, 98.4%, and 97.6%, respectively, for the same parameters on MRI.

Table 1: Distribution according to final diagnosis based on arthroscopy

Group	Final diagnosis	*N* (%)
I	Partial thickness tear of supraspinatus	35 (41.2)
II	Full thickness tear of supraspinatus	21 (24.7)
III	Tendinosis of supraspinatus	16 (18.8)
IV	Others	13 (15.3)
	Subacromial subdeltoid bursitis	2 (2.4)
	Partial thickness tear of subscapularis	2 (2.4)
	Full thickness tear of infraspinatus	2 (2.4)
	Adhesive capsulitis	2 (2.4)
	Full thickness tear of long head of biceps	1 (1.2)
	Labral tear	4 (4.7)

Table 2: Correlation between final diagnosis and USG diagnosis

Characteristic	*N* (%)			
	Group I (*n*=35)	Group II (*n*=21)	Group III (*n*=16)	Group IV (*n*=13)
Normal	7 (20.0)	0 (0.0)	6 (37.5)	3 (23.1)
Partial thickness tear of supraspinatus	21 (60.0)	1 (4.8)	0 (0.0)	0 (0.0)
Full thickness tear of supraspinatus	6 (17.1)	20 (95.2)	0 (0.0)	0 (0.0)
Tendinosis of supraspinatus	1 (2.9)	0 (0.0)	10 (62.5)	0 (0.0)
Others	0 (0.0)	0 (0.0)	0 (0.0)	10 (76.9)

USG: Ultrasonography. χ^2=166.47 (df=12); P<0.001

Table 3: Correlation between final diagnosis and MRI diagnosis

Characteristic	*N* (%)			
	Group I (*n*=35)	Group II (*n*=21)	Group III (*n*=16)	Group IV (*n*=13)
Normal	1 (2.9)	0 (0)	1 (6.3)	1 (7.7)
Partial thickness tear of supraspinatus	31 (88.6)	1 (4.8)	1 (6.3)	0 (0.0)
Full thickness tear of supraspinatus	1 (2.9)	20 (95.2)	0 (0.0)	0 (0.0)
Tendinosis of supraspinatus	2 (5.70	0 (0.0)	14 (87.50)	0 (0.0)
Others	0 (0.0)	0 (0.0)	0 (0.0)	12 (92.3)

MRI: Magnetic resonance imaging. χ^2=217.77 (df=12); P<0.001

For tendinosis of supraspinatus, USG had a sensitivity, specificity, PPV, NPV, and accuracy of 62.5%, 91.3%, 62.5%, 91.3%, and 85.9%, respectively, as compared to 87.5%, 97.1%, 87.5%, 97.1%, and 95.3%, respectively, for the same parameters on MRI.

For "other" diagnoses, USG had a sensitivity, specificity, PPV, NPV, and accuracy of 76.9%, 100%, 100%, 96.0%, and 96.5%, respectively, as compared to 100%, 100%, 100%, 100%, and 100%, respectively, for the same parameters on MRI (Table 4).

DISCUSSION

In this study, an attempt was made to compare the role of high-resolution USG and magnetic resonance imaging in the evaluation of chronic shoulder pain with follow-up to ascertain the accuracy of clinical and radiological findings.

For this purpose, a total of 85 patients with complaints of chronic shoulder pain were enrolled in the study. The mean age of patients was 45.21 years, majority of them were males. Similar to results of present study Shrestha and Alam[16] and Vijayvargiya *et al.*[17]

In this study, chronic shoulder pain was defined as the presence of shoulder pain for more than 6 months and majority of patients had shoulder pain over 6-9 months (56.5%). There were 32 (37.6%) with shoulder pain over 9-12 months and 5 (5.9%) with shoulder pain for more than a year. This study showed a high predominance of the right side (76.5%) as compared to the left side (23.5%). In this study, a total of 17 (20%) cases had a history of diabetes.

History of trauma was reported in 48 (56.5%) cases. This is in consistence with the observation of Donovan and Paulos,[18] who observed that overuse and traumatic injuries make up most of the causes features such as tenderness (34.1%) and complaints such as night pain (65.9%) were also common. As far as range of motion was concerned, it was normal to >45° in 50/85 (58.8%) patients, thus indicating that in general the patients were able to perform their routine tasks – and this might be the reason for the chronic condition. In resource-poor settings such as our people often tend to ignore their medical needs until it leads to restriction of their routine functions which leads to the development of a chronic condition.

In this study, clinically a total of 56 (65.9%) were diagnosed as rotator cuff-tear followed by supraspinatus impingement (n = 15; 17.6%), calcific tendinitis (n = 8; 9.4%), subacromial-subdeltoid bursitis (n = 4; 4.7%), and adhesive capsulitis (n = 2; 2.4%), respectively. Clinical diagnosis is often based on the outcome of a host of clinical tests which have a varying efficacy.[19,20]

The final diagnosis was based on the arthroscopic evaluation. Partial thickness tear of supraspinatus (n = 35; 41.2%) was the most common diagnoses followed by full thickness of supraspinatus (n = 21; 24.7%) and tendinosis of supraspinatus (n = 16; 18.8%). Among other diagnoses (n = 13; 15.3%) – labral tear was most common (n = 4; 4.7%) subacromial-subdeltoid bursitis, partial thickness tear of subscapularis, full thickness tear of infraspinatus, and adhesive capsulitis was diagnosed in 2 (2.4%) patients each, and full thickness tear of long head of biceps in 1 (1.2%) patient.

The arthroscopic findings, in turn, showed the varying underlying pathologies for different clinical diagnoses and as indicated above showed the need of inclusion of more refined diagnostic modalities to avoid chronicity.

On correlating the clinical findings with arthroscopic findings, it was seen that for almost all the arthroscopic diagnoses majority number of patients showed rotator cuff tear as the clinical diagnosis. Similarly, clinical diagnosis of supraspinatus impingement coincided with a large proportion of patients with varying arthroscopic findings. The arthroscopic findings in such a condition provide a much better pathological condition than the generalized clinical diagnosis vis-à-vis a generalized rehabilitation/treatment approach which failed to provide a substantial clinical improvement and in turn resulted in the evolution of a chronic condition.

Table 4: Comparative evaluation of diagnostic efficacy of USG and MRI for different causes of chronic shoulder pain

Confirmed cause	USG					MRI				
	Sensitivity	Specificity	PPV	NPV	Accuracy	Sensitivity	Specificity	PPV	NPV	Accuracy
Partial thickness tear of supraspinatus	60.0	97.6	95.5	74.1	80.3	88.6	96.0	93.9	92.3	92.9
Full thickness tear of supraspinatus	95.2	90.6	76.9	98.3	91.8	95.2	98.4	95.2	98.4	97.6
Tendinosis of supraspinatus	62.5	91.3	62.5	91.3	85.9	87.5	97.1	87.5	97.1	95.3
Others	76.9	100.0	100.0	96.0	96.5	92.7	100.0	100.0	98.6	98.8

PPV: Positive predictive value, NPV: Negative predictive value, USG: Ultrasonography, MRI: Magnetic resonance imaging

Shoulder injuries are difficult to differentiate pathologically merely on the basis of demography. No doubt, they mostly affect the younger age groups and males – practically owing to their relatively heavier activity profile. In fact, almost all the age groups can be victims of different types of shoulder injuries; they are more dependent on the activity level of an individual and etiology.

In this study, for different arthroscopically diagnosed types of shoulder injuries, statistically no significant association of age, gender, duration of complaints, affected side, dominant side, and history of diabetes could be seen. However, history of trauma was less common for the tendinosis and more common for partial and full thickness tear. Tendinosis is a chronic degeneration of tendon's collagen related with overuse. When overuse is continued without giving the tendon time to heal and rest such as with repetitive strain injury, tendinosis results. Even tiny movements, such as clicking a mouse, can cause tendinosis when done repeatedly.[21] Owing to association with traumatic etiology, partial, and full thickness tears are often accompanied with tenderness. Clinical examination of tendinosis is often accompanied with localization of tear guided by tenderness.[22] The findings of this study also highlighted the relevance of this clinical finding in differentiating rotator cuff tears and tendinosis.

In this study, night pain was significantly higher in all the arthroscopic diagnosis except tendinosis. Thus, this study showed a high prevalence of night pain in full and partial tears.

In this study, both MRI as well as USG had more than 90% sensitivity for full thickness tears which is in agreement with the reported comparative efficacy of USG and MRI. According to Dinnes *et al.,*[23] for full-thickness tears, overall sensitivities and specificities are high with MRI Ultrasound is considered to be accurate when used for the detection of full thickness tears; although sensitivity is lower for detection of partial thickness tear, specificity remained high.[23] The findings of this study supported this point of view. In this study, USG showed a poor sensitivity toward partial thickness tears, whereas MRI showed a high sensitivity for both partial (n = 32/37; 86.5%) as well as full thickness tears (n = 21/23; 91.3%). Kenn *et al.*[24] in their study also showed a high sensitivity of MRI for both partial as well as full thickness tears. In this study, USG had a slight edge over MRI in the diagnosis of full thickness tear (n = 22/23; 95.7%).

In this study, both USG as well as MRI showed a better efficacy for full thickness tears as compared to partial thickness tears. Observation to a similar effect regarding the performance of USG was also made by Cullen *et al.*;[25] de Jesus *et al.*[26] In our study, MRI had a higher efficacy for both full thickness as well as partial thickness tears, whereas USG had a higher efficacy for full thickness tears only.

This study shows MRI to be a highly sensitive as well as specific technique for differentiation among different shoulder pathologies.

As far as comparative evaluation of USG and MRI, except for full thickness tear where both the modalities had equal sensitivity; for all the other diagnoses; MRI showed a higher sensitivity. However, for partial thickness tear, USG had a higher specificity as compared to MRI; for all the other diagnoses, MRI showed a higher specificity. In terms of overall accuracy, MRI had a higher accuracy as compared to USG for all the diagnoses except for full thickness tears.

Correlation of USG and MRI with clinical diagnosis showed that clinical diagnosis failed to diagnose the tears, especially clinical diagnosis of supraspinatus impingement which was later on diagnosed as full/partial thickness tear and tendinosis by MRI and USG. Thus, these imaging techniques helped to identify the underlying shoulder pathologies more clearly.

However, of the two techniques being used, MRI diagnosed shoulder pathologies in relatively more number of cases (78/80; 97.5%) as compared to USG (74/80; 92.5%). Ultimately, MRI was both more sensitive as well as specific for most of the underlying pathologies as compared to USG.

The findings in this study helped to understand various underlying pathologies of chronic shoulder pain and showed that reliance on clinical diagnosis only delays the management and hence the development of chronicity. A high efficacy of both the techniques was observed for all the underlying pathologies except for partial thickness tears where MRI had a definitive upper edge over USG. Because diagnosis of full thickness tear is more crucial from the point of view of surgical management, where both the techniques were almost equally efficient, in low-resource settings, USG is the diagnostic modality of choice, whereas in a well-equipped setting, MRI should be the preferred mode of diagnosis. This study was one of the pioneering studies with respect to the evaluation of diagnostic techniques for chronic shoulder pain owing to different etiologies, a problem less explored; hence, further studies are recommended to substantiate the findings of present study (Figures 1-6).

CONCLUSION

On the basis of observations made during study and their analysis, the following conclusions have been drawn:

Figure 1: Anterior-posterior X-ray showing calcification of supraspinatus tendon in case of chronic tear

Figure 3: Full thickness supraspinatus tear as seen on high-resolution ultrasonography

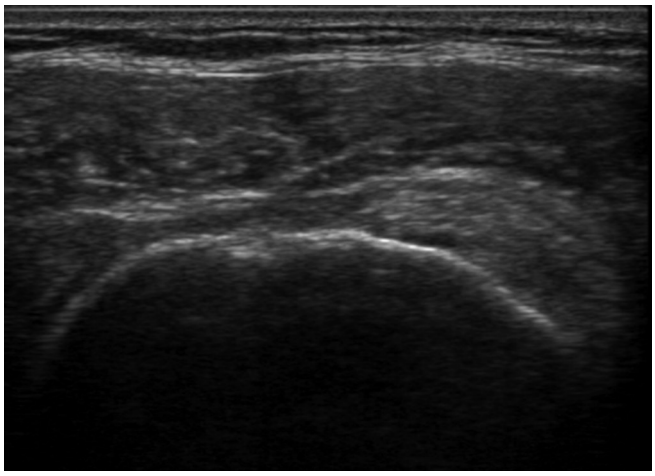

Figure 2: Partial tear of supraspinatus on high-resolution ultrasonography

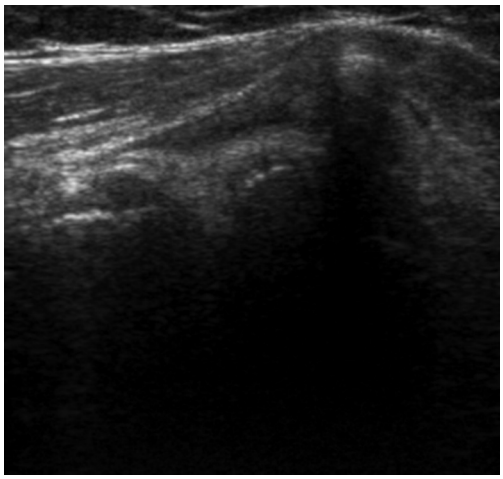

Figure 4: Calcification of tendon of supraspinatus as seen on ultrasonography

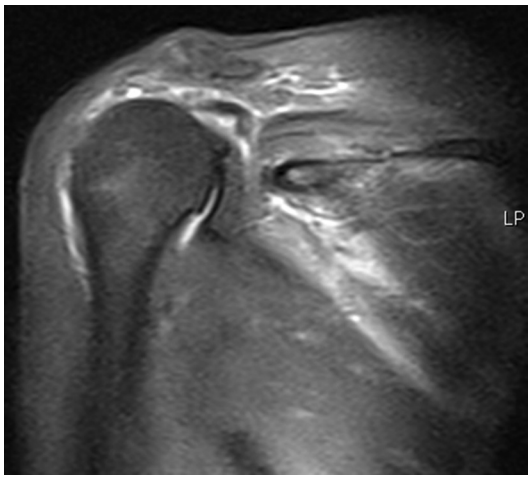

Figure 5: Coronal sagittal short tau inversion recovery image demonstrating full thickness supraspinatus tendon tear

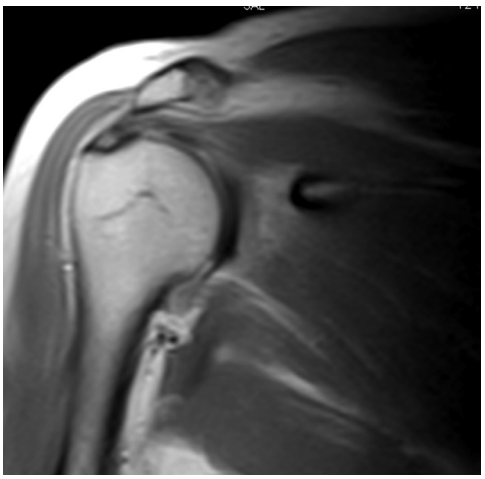

Figure 6: Coronal proton-density image showing focal altered signal intensity in supraspinatus tendon with no obvious disruption of fibers suggesting - tendinosis of supraspinatus

1. For partial thickness tear of supraspinatus, USG had a sensitivity, specificity, PPV, NPV, and diagnostic accuracy of 60%, 97.6%, 95.5%, 74.1%, and 80.3%, respectively, as compared to 88.6%, 96.0%, 93.9%,

92.3%, and 92.9%, respectively, for the same parameters on MRI.

2. For full thickness tear of supraspinatus, USG had a sensitivity, specificity, PPV, NPV, and diagnostic accuracy of 95.2%, 90.6%, 76.9%, 98.3%, and 91.8%, respectively, as compared to 95.2%, 98.4%, 95.2%, 98.4%, and 97.6%, respectively, for the same parameters on MRI.
3. For tendinosis of supraspinatus, USG had a sensitivity, specificity, PPV, NPV, and diagnostic accuracy of 62.5%, 91.3%, 62.5%, 91.3%, and 85.9%, respectively, as compared to 87.5%, 97.1%, 87.5%, 97.1%, and 95.3%, respectively, for the same parameters on MRI.
4. For other diagnoses, USG had a sensitivity, specificity, PPV, NPV, and diagnostic accuracy of 76.9%, 100%, 100%, 96.0%, and 96.5%, respectively, as compared to 92.3%, 100%, 100%, 98.6%, and 98.8%, respectively, for the same parameters on MRI.
5. In others, category labral tear was the most common ($n = 4$; 4.7%); however, it was diagnosed correctly only in 2 cases on USG and in 3 cases in MRI. Subacromial-subdeltoid bursitis, partial thickness tear of the subscapularis, full thickness tear of infraspinatus, and adhesive capsulitis were seen in 2 (2.4%) cases each, among these subacromial-subdeltoid bursitis was missed in 1 case on USG however in MRI all these were matched accurately. Full thickness tear of the long head of biceps was seen in 1 (1.2%) and both the techniques detected it accurately.
6. Confirmation of cause of chronic pain was more precise in MRI as compared to USG. Considering the diagnostic supremacy of MRI, it is therefore recommended to be used as a non-invasive diagnostic tool of choice as an aid to clinical assessment.

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