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Post Traumatic Shoulder Pathology – Is conventional Magnetic Resonance Imaging still useful..?

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Abstract

Objective: Non –invasive conventional Magnetic resonance imaging is a routine diagnostic investigation carried out in patients of gleno-humeral pathology; however, the gold standard modality to evaluate these lesions is still Arthroscopy. In recent times, MRI has revolutionized to become the ideal modality to diagnose shoulder pathology with increased accuracy. The purpose of this prospective study was to determine the diagnostic ability of conventional Magnetic resonance imaging (MRI) in present day scenario as compared with a reference standard, Arthroscopy, in patients of post traumatic shoulder pathology.

Materials and Methods: Fifty patients of post traumatic shoulder pathology of either sex, and between 18 to 50 years of age who has undergone pre-operative MRI evaluation and subsequent Arthroscopy were included in the study. The MRI findings were compared with the findings of operative Arthroscopy. Statistical analysis of the data was compared with the help of statistical package for the social science system version SPSS 17.0.

Results: The sensitivity/ specificity of bony lesions detected in both the modalities varied between 1/1 to 1/0.94; that of rotator cuff lesions varied between 1/1 to 1/0.89; and that of capsulolabral lesions varied between 1/0.93 to 0.58/0.86 respectively.

Conclusion: The study showed moderately high diagnostic accuracy of conventional MRI towards diagnosing osseous and rotator cuff shoulder pathology. The result of capsulolabral lesions doesn't show very high diagnostic accuracy but are still encouraging as compared with other previous similar studies.

Keywords: Arthroscopy, Bankart, Capsulolabral, Glenohumeral, Hill sach's, Magnetic resonance imaging (MRI), Rotator cuff, Shoulder.

1. Introduction

The shoulder's glenohumeral joint is vital in performing activities of daily living which require a great range of motion. Large range of motion makes the joint unstable and susceptible to injury [1]. Timely and accurate detection of the lesion is essential in alleviating the

immediate morbidity and other long term complication or morbidity.

Magnetic resonance imaging with multiplanar slice capability has a better soft tissue contrast, and since its debut has revolutionized to become the ideal modality for imaging complex anatomy of the shoulder joint and diagnosing shoulder pathologies. The accuracy of results in detecting the lesions on MRI shows an improving trend over time with improved technical specifications of the machine and better visualization of the pathology.

Another advanced clinical modality in the diagnosis of intracapsular shoulder pathology is Arthroscopy, which has been the gold standard since a long time and can also be used as a therapeutic tool. Arthroscopy is costlier, done under anaesthesia and can cause post procedural complications. On the contrary, Magnetic resonance imaging is non- invasive, cost effective, and patient friendly procedure which causes no post procedural complications.

The purpose of this study was to determine the diagnostic ability of conventional magnetic resonance imaging, being non- invasive tool, in present day scenario as compared with a reference standard, arthroscopy, in patients complaining of post traumatic shoulder pathology, by comparing and correlating the findings of both these modalities. We further compared the result of this study with the results of other similar studies available in the literature.

2. Materials and Methods:

2.1 Study design: The proposed study was carried out in a tertiary care hospital of North India. Fifty patients comprising of both males and females, in the age group of 18 years to 50 years, who reported with shoulder symptoms like pain, restriction of movements, locking or instability, following a traumatic event, and who were subjected to Arthroscopy following a thorough clinical and Magnetic resonance imaging evaluation done prior, were included in this prospective study. Patients with atraumatic shoulder symptoms or who has undergone any surgical / arthroscopy were excluded from the study. MRI findings were recorded in the performa form of the patient, for later reference. Arthroscopy was subsequently performed by the experienced surgeon and findings of the same were recorded in patient's performa form to compare it with the MRI findings. Prior approval was obtained from the ethical committee of the institution before the start of the study, and written informed consent was also obtained from each of the patient included in the study.

2.2 Machine: Magnetic resonance imaging study was conducted on GE HDX 1.5 Tesla machine and image analysis was done using the image processor AW MR Advantage Windows 4.4 volume share, which has multiplanar reconstruction capability. Following protocol of MRI sequences was followed :

- Localizer sequences in axial, oblique sagittal, and oblique coronal planes.
- Coronal Oblique T1FSE (TR/TE= 400/25), T2FRFSE (TR/TE= 3500/110), PDFS (TR/TE= 2000/50)
- Sagittal Oblique PDFS
- Axial T1FSE, PDFS, T2 GRE (TR/TE= 500/25),

(FSE= Fast Spin Echo; FRFSE= Fast Repetition Fast Spin Echo; PDFS= Proton Density Fat suppressed sequence; GRE= Gradient Echo)

Fast spin- echo images were widely used for shoulder imaging as they offer considerable time savings over conventional spin echo and display similar contrast to those of conventional spin echo. However, fat suppression was required in T2W images and there is some loss of edge definition as compared to conventional spin echo. Gradient echo was used because of short acquisition time and excellent visualisation of the labrum.

2.3 Patient positioning: Patients were imaged supine, going head- first into the gantry. The arm of the patient was kept by their side in a neutral to slightly externally rotated position. Elbow support with padding was used to reduce patient's motion. Shoulder surface coil was used for adequate signal and optimum signal to noise ratio.

2.4 Data analysis: The Magnetic resonance imaging and Arthroscopic findings were grouped under three heads, namely Bony lesions, Rotator muscles lesion and Capsulo-labral lesions for ease of comparison. The data was then tabulated on Microsoft Excel spreadsheet in a master chart and studied for correlation. Statistical analysis of the data was conducted with the statistical package for the social science system version SPSS 17.0. Nominal categorical data between the groups were compared using Chi-squared test or Fisher's exact test as appropriate. Sensitivity, Specificity, Positive predictive value(PPV), Negative predictive value(NPV) and Accuracy was calculated to analyze the diagnostic accuracy of MRI findings as correlated and compared with the Arthoscopic findings being reference standard.

3. Results

Present study was carried out in fifty (50) patients, out of which forty three (86%) were males, and seven (14%) were females. Majority of patients in the present study were in the age group of 20 – 40 years (74%) with the mean age of 30.36 years. In our study, twenty three (56%) patients suffered from shoulder injury on the right side and twenty two (44%) on the left side. Twenty-seven (54%) patients suffered injury in sport activities (like football, basketball, wrestling, volleyball, boxing, kabaddi, badminton), fourteen (28%) patients had a history of fall, five (10%) got injured while lifting heavy weight, and four (8%) suffered injuries in road traffic accidents. Patient findings on MRI are shown in **Figure 1**, and patient findings on Arthroscopy are shown in **Figure 2**. In the present study, the MR Imaging findings were compared with the Arthroscopic findings for each patient and were classified into true positive, false positive, true negative and false negative. The Arthroscopic findings were taken as reference standard for comparison. For each finding separately, rates of sensitivity, specificity, positive predictive value, negative predictive value, accuracy and *P* value was calculated, as demonstrated in **Table 1** and **Table 2.**

4. Discussion

Magnetic resonance imaging is an effective non-invasive examination that does not require ionising radiation, provides high resolution soft tissue contrast and has multiplanar capability to diagnose any pathology. The accuracy of MRI in diagnosing shoulder pathology has been found to be both reader and operator dependant [2, 3]. However, the technical advancement in MRI over the past thirty years has been extraordinary in the evaluation of musculoskeletal imaging, and has now become the cornerstone of the radiologist's diagnostic armamentarium [4]. Arthroscopy, which has been the gold standard and used as a therapeutic tool, on the other hand is an invasive procedure with certain risks and discomfort to the patient. It is costlier, done under anaesthesia and can cause post procedural complications.

The sensitivity, specificity and accuracy of Magnetic resonance imaging for shoulder lesions vary widely in literature. Previous studies have indicated that MRI is very accurate in the identification of complete rotator cuff tears, less so for partial thickness tears or tendinopathy, and inconsistent in the identification of labral pathologic conditions [3, 5, 6, 7]. However, the accuracy of results in detecting the lesions on MRI shows an improving trend over time with improved technical specifications of the machine and better spatial resolution.

In our prospective study done on fifty patients, a total of twenty two bony lesions, twenty seven rotator cuff lesions and thirty two labral tears were detected on MRI. Arthroscopy, on the other hand, detected twenty bony lesions, fifteen rotator cuff lesions, and thirty labral tears.

4.1 Bony lesions : In our study, MRI detected two types of bony injuries, namely, Bony Bankart lesion and Hill Sach's lesion, and displayed better results. Bony Bankart lesion showed 100% accuracy with 100% sensitivity and specificity, however the sample size of this lesion was small (only four lesions were detected). In the present study, out of eighteen positive Hill Sach's lesions detected on MRI, sixteen were confirmed by Arthroscopy thereby giving an accuracy of 96%, with sensitivity of 100% and specificity of 94.1%. This shows significant improvement as compared to the study by Kalson et al [8] in the year 2011, who studied Hill Sach's lesion in their study with a sensitivity of 71% and specificity of 95%.

4.2 Rotator muscles lesion : For full thickness rotator cuff tears on conventional MRI, reported sensitivity and specificity in the literature varies between 80 – 100% and 94 – 100% respectively; while the same for partial thickness tears on MRI ranges upto 92% and between 83 – 100% respectively [9, 10, 11, 12]. Palmer et al [12] for the first time established the role of fat saturation sequences in accurately determining the rotator cuff pathology on MRI. In their study, use of non-fat saturated sequences causes a fall in reported sensitivity, specificity and accuracy to 90%, 75% and 84% respectively. Importance of fat saturated sequences in detection of partial and full thickness rotator cuff tears was also reflected later in the year 1995 by Quin et al [13], and Robertson et al [14] in their series. In the year 1998, Sahin- Akyar et al [15] in their study reported a sensitivity of 83 – 100% for detecting full thickness rotator cuff tear, and also found the importance of T2 gradient echo images and fast spin echo with fat saturation images in diagnosing shoulder pathology. In year 2006, Magee and Williams [16] in their study showed increased performance on use of 3 Tesla Magnetic resonance imaging for diagnosing rotator cuff tears and reported a sensitivity and specificity of 98% and 96% respectively for diagnosing full thickness tears. A reported sensitivity and specificity of 92% and 100% respectively was given by them for partial thickness tears. Hitachi et al, Adams et al, Lambert et al and Shalaby MH et al [17 - 20] has reported 100% specificity on conventional shoulder MRI in detection of full thickness rotator cuff tears. Studies conducted by Teefey et al. and Lambert et al. has reported 98% and 97% specificity respectively on conventional shoulder MRI in detecting partial thickness rotator cuff tears [21, 19]. In a study by Mohtadi et al [21] in year 2004, seventy three patients with shoulder pain were prospectively evaluated with MRI and Arthroscopy. A reported accuracy of 74.1%, 72.4%, 74.1% and 60.4% were found in diagnosing supraspinatus pathology, infraspinatus pathology, subscapularis pathology and Biceps tendon pathology respectively in their study. In the present study, all three full thickness supraspinatus tears that was detected on MRI was confirmed on Arthroscopy giving a 100% sensitivity and 100% specificity. Out of eleven partial thickness supraspinatus tears detected on Magnetic resonance imaging, Arthroscopy confirmed six lesions giving a sensitivity of 100%, specificity of 88.6%, and accuracy of 90%. However, all negative findings of partial thickness supraspinatus tears detected on MRI was confirmed by Arthroscopy thereby giving a negative predictive value of 100%. Full thickness and partial thickness supraspinatus tears give a combined sensitivity of 100% and combined specificity of 87.8%. These results are comparable with the previous studies in the literature. Two of the subscapularis partial tear were over- reported and one

partial infraspinatus tear was missed on MRI in this study giving an accuracy of 96% and 98% respectively. Out of eight supraspinatus tendinopathy lesions detected on MRI, only three were confirmed on Arthroscopy giving a specificity of 89.4% and positive predictive value of 37.5%. One lesion each of infraspinatus tendinopathy and dislocated tendon of long head of biceps brachii muscle detected on MRI were confirmed on Arthroscopy. In the present study, one hidden lesion which was detected on MRI was not seen on Arthroscopy giving a specificity and accuracy of 98% each. In a study by Field et al [22], fifteen patients with surgically proved rotator interval defects were retrospectively evaluated. Out of these, preoperative MR imaging was performed in four cases, but the reports failed to comment on capsular irregularities. Also, in two patients out of these, arthroscopy was performed before the definitive surgery, which had also failed to detect capsular defect. In another study by Le Huec et al [23], preoperative MR imaging failed to demonstrate surgically proved rotator interval capsular tears.

4.3 Capsulolabral lesions : The diagnosis of labral pathology by MRI is less consistent than that for rotator cuff disease. The reported accuracy of MRI in delineating labral pathologic conditions vary widely in literature. In 1995, Tuite et al [24] gave sensitivity for labral tears ranging between 36 – 50%, specificity of 90% and accuracy between 55 – 67%. Gusmer et al [25] in the year 1996 gave improved sensitivity of 89%, specificity of 97% and accuracy of 95%. Liu et al [26] in their study demonstrated a sensitivity of 59% and specificity of 85% for detection of anterior labral tears.

Much variation is seen in the literature for the detection of superior labral anterior – posterior (SLAP) tears on MRI. Legan et al [6] in the year 1991 and Gusmer et al [25] in 1996 found sensitivity of 75% and 86%, and specificity of 99% and 100% respectively in their studies for detection of SLAP lesions. In another study by Yoneda et al [27] for detection of SLAP lesions, a sensitivity of 41%, specificity of 86% and accuracy of 63% was reported. Connell et al [28] studied one hundred and forty patients of SLAP tear and reported a sensitivity of 98%, specificity of 89.5% and accuracy of 95.7%. Magee and Williams [29] in the year 2006 reported sensitivity of 90%, 89%, and 86% in detecting SLAP tears, anterior labral tears and posterior labral tears on 3-T MRI respectively. In the year 2009, Thomas Magee again reported sensitivity of 83% in detection of anterior labral tears and SLAP tears on conventional MRI [30]. In a study by Safaa Aboelkaseem Mohamed et al [31], reported conventional MRI sensitivity and specificity for anterior labral tears was 76.9% and 100%, while that of SLAP tears was 54.5% and 98.9% respectively.

In our study, out of thirty two labral tears detected on MRI, twenty were diagnosed as Fibrous Bankart lesion, ten lesions were diagnosed as SLAP tears, and two were detected as anterior labral tears. Between ten SLAP tears, six were diagnosed as SLAP- II lesion, one as SLAP- IV lesion and remaining three as SLAP– V lesions. Out of twenty Fibrous Bankart lesions, eighteen were confirmed by Arthroscopy giving a sensitivity of 100%, specificity of 93.8%, positive predictive value of 90%, negative predictive value of 100% and accuracy of 96%. The calculated sensitivity and specificity of combined labral tears (excluding fibrous Bankart lesion) were 58.3% and 86.8% respectively. Individually, out of six SLAP- II tears detected on MRI, only three were confirmed by Arthroscopy, giving a sensitivity of sensitivity of 100% and specificity of 93.6%. Single SLAP- IV lesion detected on MRI was not reported on Arthroscopy, giving a specificity of 98%. All three SLAP-V lesions detected on MRI were confirmed on Arthroscopy, however two

additional SLAP- V lesions were detected on Arthroscopy causing two false positive results with resultant sensitivity of 60%, specificity of 100%, and accuracy of 96%. This is attributed to the degree of detection of the pathology, as SLAP- II lesion detected on MRI confirmed to be a SLAP- V lesion on Arthroscopy, thereby giving rise to additional false positive and a false negative result. Out of three anterior labral tear detected on MRI, only one lesion was confirmed positive on Arthroscopy. In addition, one lesion was reported positive on Arthroscopy with calculated sensitivity of 33.3%, specificity of 97.9% and positive predictive value of 50%. A single posterior labral tear was reported on Arthroscopy with accuracy of 98%. Analysis of labral pathology in the present study reveals low sensitivity and specificity of MRI in detection of lesion. Except for the anterior labral tears and SLAP- IV lesions other labral lesions show significant correlation between the MRI findings and Arthroscopic findings. Unlike the evaluation of rotator cuff lesions, both the sensitivity and specificity of MRI for identifying labral injury was low. It further revealed that MRI is sensitive for the presence of the labral tear, however its ability to accurately determine the location of the lesion is low. This causes the mismatch or non- correlation between the statistical data during analysis. Another reason of unreliable statistical data is the use of Arthroscopy, in most of the studies and also in this study, as the standard of reference. This presupposes that Arthroscopy is 100% accurate for the diagnosis of any shoulder lesion. However, this might not always be the case. The overall accuracy of Arthroscopy varies between 70 – 100%, depending upon the surgeons' experience. This raises question of Arthroscopy being a standard of reference, as some disease may be missed by arthroscopist as well [32]. One more reason for unreliable correlation is the inability of Arthroscopy to identify the lesion due to anatomic constraints. Like, in a cadaveric study, Fukuda et al [33] described the incidence of purely intratendinous supraspinatus tears to be 7.2% in frequency. The presence of intrasubstance rotator cuff partial tear that can be depicted well on MRI would be missed at Arthroscopy, once again incorrectly reducing the accuracy of MRI [34]. Only one lesion each of dislocated long head of biceps tendon and hidden lesion were detected on MRI, of which only dislocated biceps tendon was confirmed on Arthroscopy. Being only one lesion statistical analysis is of no significant value in this case.

In the present study, conventional MRI performed well and cause further strengthening of its overall diagnostic ability, as supported by the literature, with significant correlation depicted between the MRI and Athroscopic findings. Although few of the rotator cuff pathology doesn't exhibit significant correlation between the MRI and Arthroscopic findings, they can be ignored due to their low prevalence in the study. Diagnosing anterior labral tears also does not exhibit significant correlation between the MRI and Arthroscopic findings in this study with low sensitivity, positive predictive value and accuracy, which can be attributed to shortcoming of conventional MRI and need of additions like MR arthrogram, though a minimally invasive procedure.

Major limitations of the study includes lack of control group and significant prevalence of the disease in the study group, however this was unavoidable due to the selective approach of patients having post traumatic shoulder symptomatology and invasive nature of the study. Patient's claustrophobia and incompatible MR implants were few other limitations of the study.

5. Figures and Tables

Table 1 : MRI findings versus Arthroscopy findings

MRI Findings	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy	*P* value
Bony injury										
Bony Bankart	4	46	0	0	100.0%	100.0%	100.0%	100.0%	100.0%	<0.001
Hill sach's	16	32	2	0	100.0%	94.1%	88.9%	100.0%	96.0%	<0.001
Rotator muscles injury										
Supraspinatus tear (complete)	3	47	0	0	100.0%	100.0%	100.0%	100.0%	100.0%	<0.001
Supraspinatus tear (Partial)	6	39	5	0	100.0%	88.6%	54.5%	100.0%	90.0%	<0.001
Supraspinatus tendinopathy	3	42	5	0	100.0%	89.4%	37.5%	100.0%	90.0%	0.003
Subscapularis tear (partial)	0	48	2	0	0.0%	96.0%	0.0%	100.0%	96.0%	1.000
Infraspinatus tear (partial)	0	49	0	1	-	100.0%	-	98.0%	98.0%	1.000
Infraspinatus tendinopathy	1	49	0	0	100.0%	100.0%	100.0%	100.0%	100.0%	<0.001
Dislocation of long head of biceps	1	49	0	0	100.0%	100.0%	100.0%	100.0%	100.0%	<0.001
Hidden lesion	0	49	1	0	0.0%	98.0%	0.0%	100.0%	98.0%	1.000
Capsulo- labral injury										
Bankart lesion	18	30	2	0	100.0%	93.8%	90.0%	100.0%	96.0%	<0.001
Labral tear (undifferentiated)	7	33	5	5	58.3%	86.8%	58.3%	86.8%	80.0%	0.004

Table 2 : Capsulolabral injuries (differentiated) - MRI versus Arthroscopy findings

Capsulolabral findings	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy	*P* value
Bankart lesion	18	30	2	0	100.0%	93.8%	90.0%	100.0%	96.0%	<0.001
SLAP- II	3	44	3	0	100.0%	93.6%	50.0%	100.0%	94.0%	0.001
SLAP- IV	0	49	1	0	0.0%	98.0%	0.0%	100.0%	98.0%	1.000
SLAP- V	3	45	0	2	60.0%	100.0%	100.0%	95.7%	96.0%	0.0005
Anterior labral tear	1	46	1	2	33.3%	97.9%	50.0%	95.8%	94.0%	0.118
Posterior labral tear	0	49	0	1	0.0%	100.0%	-	98.0%	98.0%	-

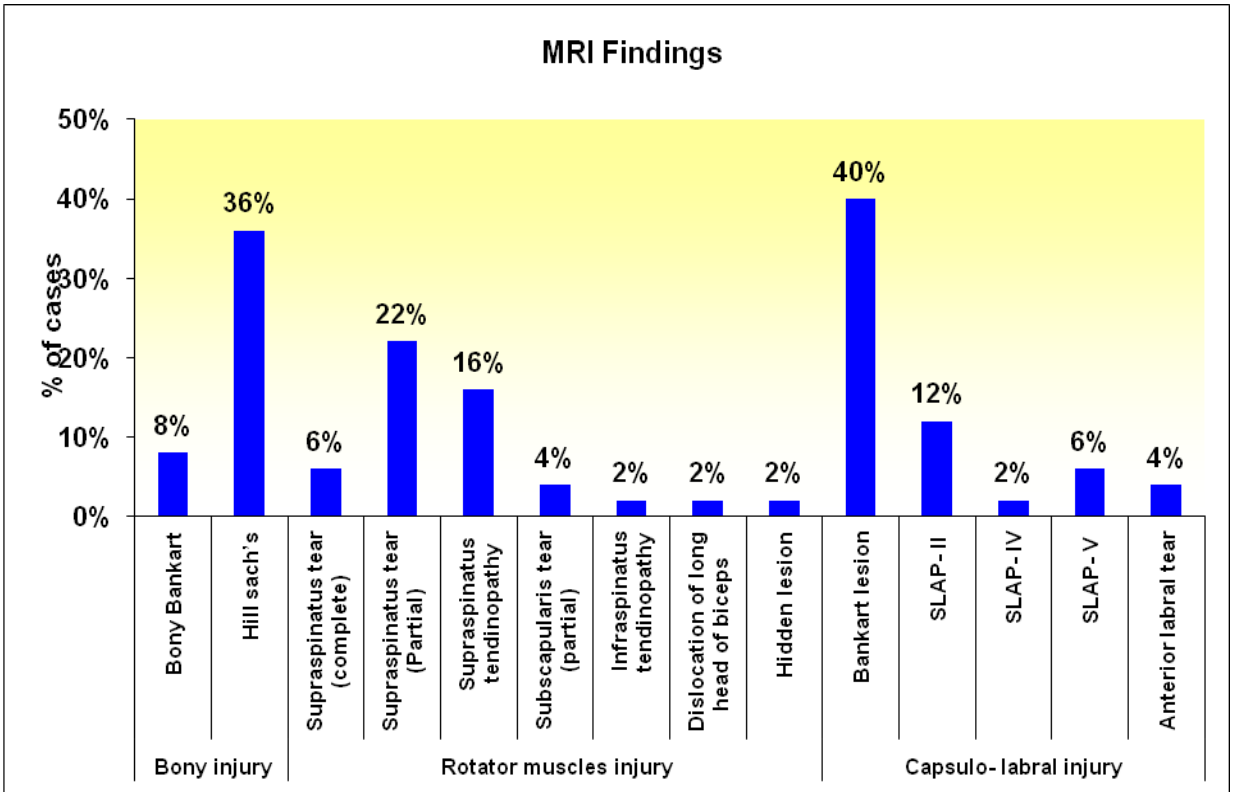

Figure 1 : Column chart representing MRI findings

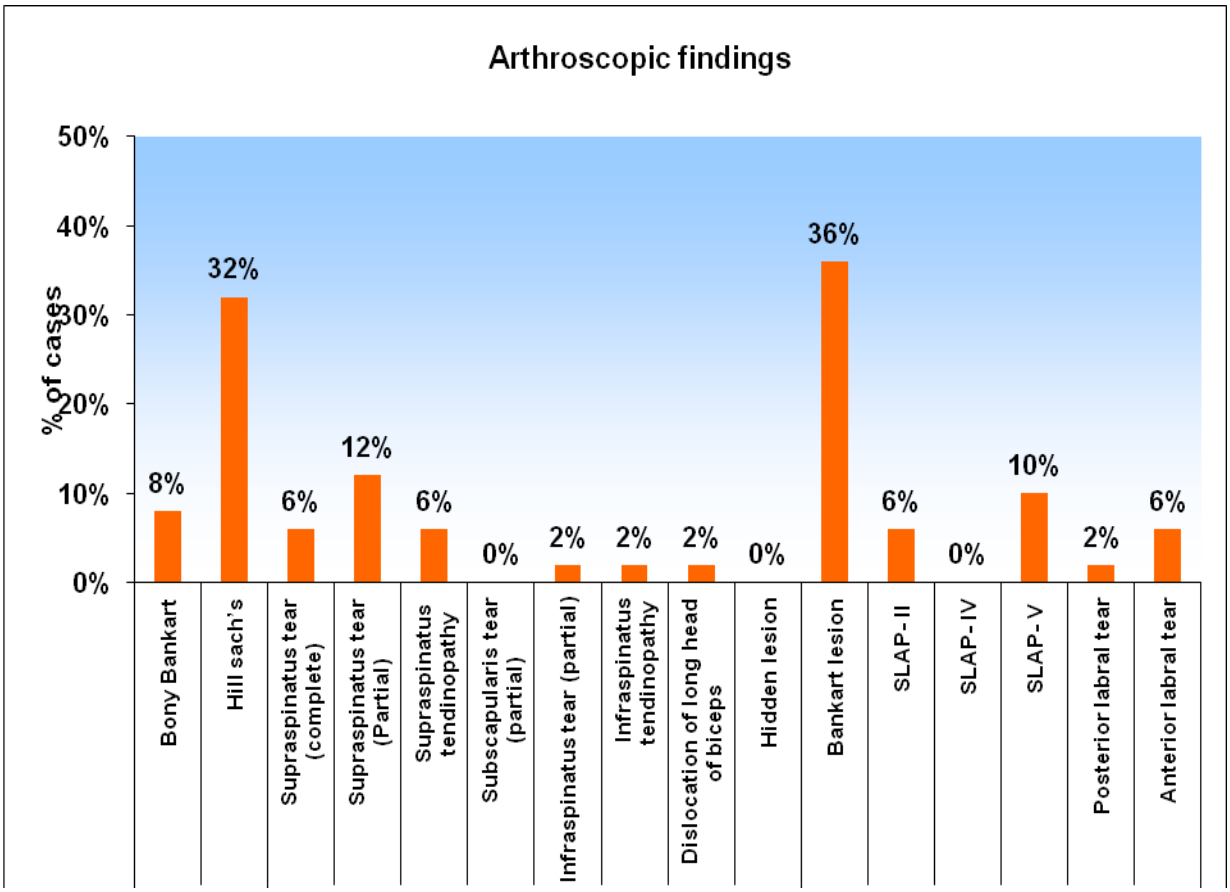

Figure 2 : Column chart representing Arthroscopic findings

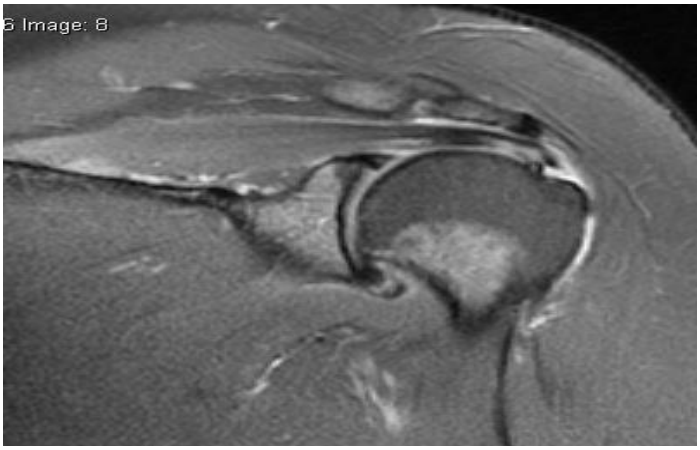

Figure 3 : A 38 yrs old female showing complete supraspinatus tear in oblique coronal proton density – weighted fat suppressed image

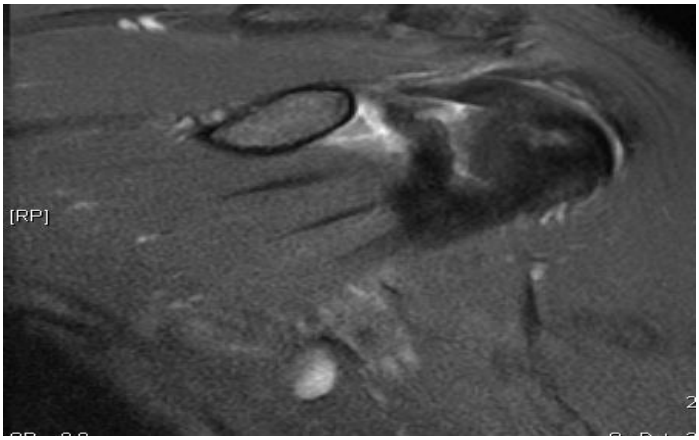

Figure 4 : A 25 yrs old male showing anterior labral tear in oblique coronal proton density – weighted fat suppressed image

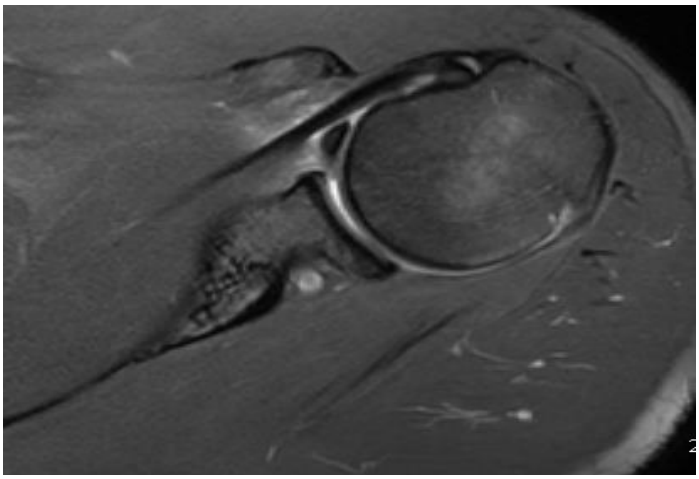

Figure 5 : A 24 yrs old male showing anterior labral tear in axial proton density – weighted fat suppressed image

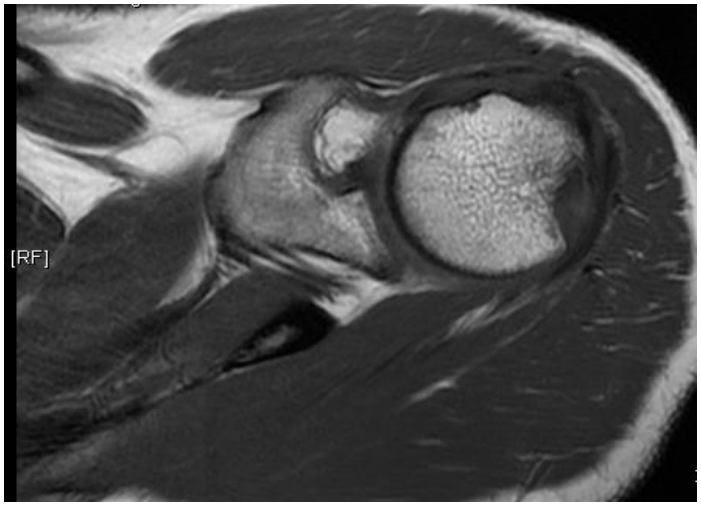

Figure 6 : A 24 yrs old male showing Hill Sach's lesion in axial proton density – weighted fat suppressed image

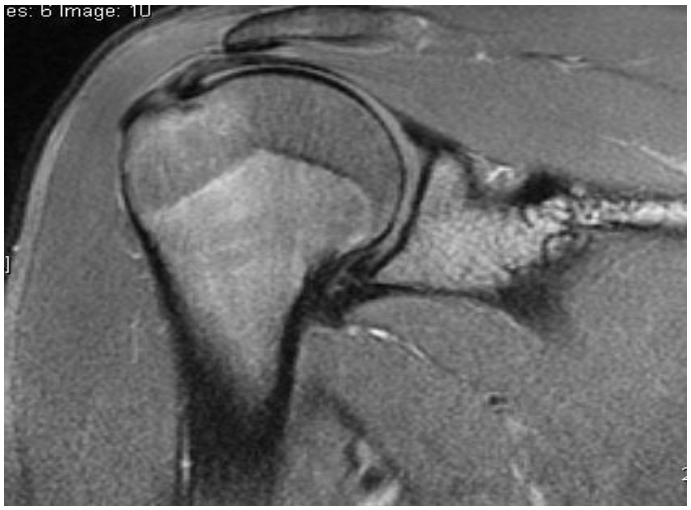

Figure 7 : A 27 yrs old male showing partial supraspinatus tear in oblique coronal proton density – weighted fat suppressed image

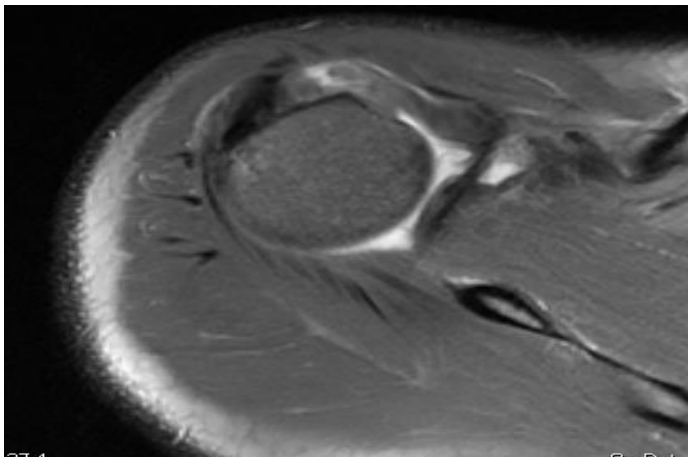

Figure 8 : A 33 yrs old male showing biceps pulley lesion with extracapsular dislocated tendon of long head of biceps brachii in axial proton density – weighted fat suppressed image

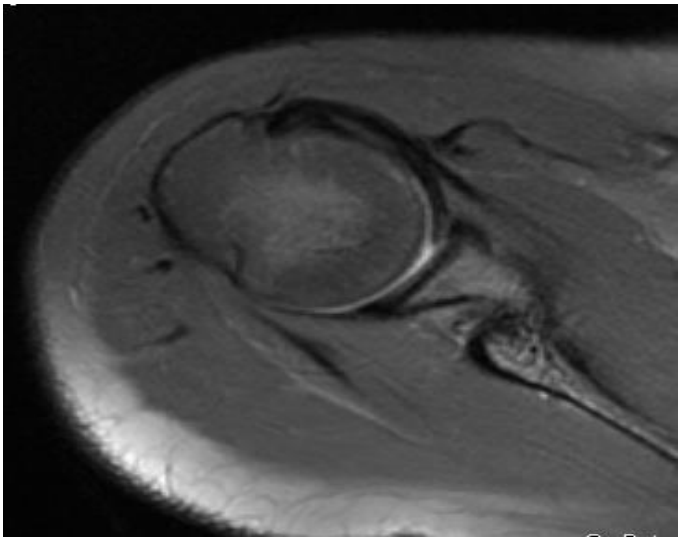

Figure 9 : A 21 yrs old female showing soft tissue bankart's lesion in axial proton density – weighted fat suppressed image

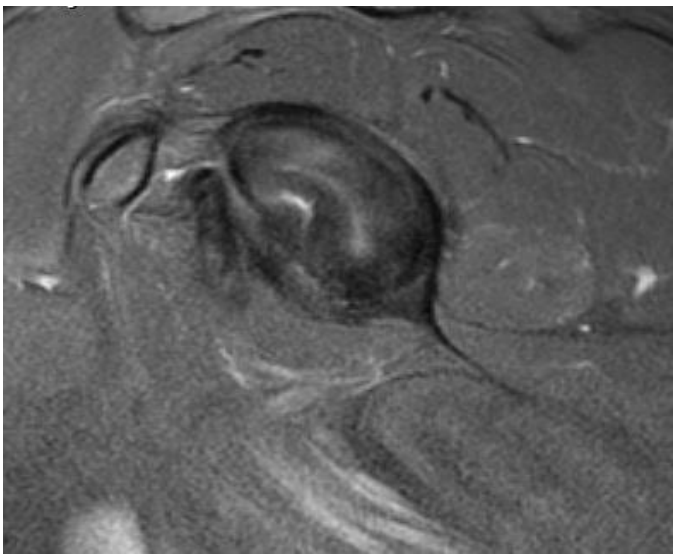

Figure 10 : A 31 yrs old male showing SLAP - V tear in oblique sagittal proton density – weighted fat suppressed image

6. Conclusion

The study reveals that conventional MRI is a useful non-invasive modality having high diagnostic accuracy in assessing shoulder pathology before subjecting any patient to diagnostic arthroscopy, which is an invasive and expensive surgical procedure. Although, arthroscopy has proven itself superior in detecting labral lesions as compared to conventional MRI alone, MRI done prior always acts as an useful adjunct in planning any therapeutic surgical intervention.

7. **Conflict of interest :** The authors declare that they have no conflict of interest.

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