A MULTICENTER STUDY COMPARING THE ACCURACY OF MRI TO ARTHROSCOPY FOR THE DIAGNOSIS OF GLENOHUMERAL JOINT PATHOLOGIES

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ABSTRACT

Background: The number of patients with shoulder pathology who seek medical treatment is on the increase. It affects approximately18-26% of adult population. The symptoms can sometimes be debilitating affecting not only the person's occupation but also activities of daily living. Among the diagnostic modalities for glenohumeral pathologies, clinical examination remains the key but MRI and arthroscopy are more accurate and can play a complimentary role. The MRI is highly sensitive, specific, non-invasive with no radiation. On the contrary, shoulder arthroscopy is considered to be the "Gold Standard" for diagnosis and treatment of glenohumeral joint pathologies. It is accurate and less invasiveness compared to open shoulder surgery. However, it is expensive.

Objective: The aim was to determine the degree of accuracy of MRI compared to arthroscopy in the diagnosis of glenohumeral joint pathologies.

Design: A multicenter prospective consecutive cross-sectional study. The sites included: The Nairobi, Aga Khan University, Mater, Kikuyu, Kijabe, Coptic and MP Shah hospitals.

Methodology: The patients with traumatic soft tissue injury or degenerative syndromes of the glenohumeral joint were recruited over a period of 8 months. Clinical examinations were done followed by MRI and then arthroscopy. The SPSS version 25 computer software was used to code the collected data. The final results were presented in charts, tables and graphical forms. The Sensitivity, Specificity, PPV, and NPV were calculated to determine the accuracy of the MRI and clinical examination. This were compared to the findings of arthroscopy. For the categorical variables, chi-square test was used. The P value < 0.05 was considered significant.

Results: The sample size was 74 participants. The age range was 16 to 73 years with an average of 48 years. The male to female ratio was 1:1. Majority 46 (62%) of the patients had joint pathology on the right side while 28(37.8%) was on the left. This might be related to hand dominance. The three modalities of investigations found the frequencies of the glenohumeral joint pathologies are as follows. The Rotator Cuff Tears ranged from 35 to 42 (47.3% to 56.8%), Subacromial Impingement Syndrome ranged from 21-24 (28.4 % to 32.4%), and Bankart lesions ranged from 9-10 (12.2 % to 13.5%). The result revealed a strong positive relationship between MRI and arthroscopic finding for Rotator Cuff Tear ($r = 0.663$, $p<0.05$), Subacromial Impingement Syndrome ($r = 0.652$, $p<0.05$) and Bankart lesion ($r = 0.699$). However, the clinical examination showed a moderate positive relationship for Rotator Cuff Tear ($r =0.46$, $p<0.05$) and Subacromial Impingement Syndrome ($r = 0.445$, $p<0.05$). The sensitivity for MRI ranges from 0.7 for Bankart lesions to 0.914 for Rotator Cuff Tears. Furthermore, the positive predictive value was 0.762 (76%) for Rotator cuff tear and 0.8 (80%) for Subacromial Impingement Syndrome.

Conclusion: The study revealed a significant correlation between clinical examination, MRI and arthroscopy for the diagnosis of glenohumeral pathologies. Both MRI and clinical examination are complimentary to each other. Consequently, in low income countries, arthroscopy can be done after thorough clinical examination without preliminary MRI in resources limited situations based on the resolution of the surgeon.

Key words: Glenohumeral, MRI, Arthroscopy, Clinical examination, Rotator Cuff Tears

INTRODUCTION

Shoulder disorders are becoming common in the society. They usually present with pain that can be disabling. In the primary health care setting, the annual incidence is 14.7 per 1000 patient per year and the life time prevalence is 70%. The time for recovery can be slow and the recurrence rate is high. Approximately, 25% of the patients may report previous attacks and about 40-50% of them may have persistent pain (1). Although there are many causes, Rotator Cuff tears account for about 75% of glenohumeral pain (2).

The glenohumeral disorder is becoming a public health concern due to the high socio-economic burden on the healthcare and the society as a whole. The affected individual may be forced to go into earlier retirement due to inefficiency (3).

Like many other clinical conditions, the management of glenohumeral pathologies starts by taking a comprehensive clinical history. This will then be followed by systematic clinical examination, radiological (plane radiograph, CT-scan) and MRI evaluation and any other relevant investigations. It is most unlikely that one single investigation will give an accurate diagnosis (4).

Many diagnostic imaging modalities have emerged in recent years for the diagnosis of glenohumeral disorders to compliment the efforts of the orthopaedic surgeons. Among them are plane radiograph, MRI, ultrasound and arthroscopy. However, the MRI and arthroscopy have remained superior.

The MRI is sensitive, specific, no radiation and not invasive. It can help in decision making for treatment options (5). However, the arthroscopy is both a diagnostic and therapeutic tool and is considered to be the gold standard. In the diagnosis, it is more accurate than MRI and can lead to definitive diagnosis. For therapeutic purposes, it is less invasive than open shoulder surgery but it is expensive with a steep learning curve.

In many developing nations like Kenya, the accessibility, availability and cost of these two diagnostic modalities are a big challenge for the patients.

The aim of this study was to determine the degree of accuracy of clinical examination and MRI and compare them to arthroscopy in the diagnosis of glenohumeral joint pathologies. Such studies have not been conducted in the local setting. The information gathered from this research will guide the orthopaedic surgeon in management planning. In addition, it will also point out areas that need improvement on the side of the radiologist. At the end, there will be an accurate diagnosis that is cost effective which will lead to better surgical outcome for the patients.

MATERIALS AND METHODS

This prospective cross-sectional multicenter study was conducted at the following hospitals: The Nairobi, Aga Khan University, MP Shah, Mater, Kijabe, Copitc and Kikuyu. It lasted for eight months starting from the 1st August 2019 to 30th April 2020.

Study population: All the participants that satisfied the inclusion criteria and were fit for surgery were recruited until the sample size was completed. This included the patients with soft tissues trauma or degenerative glenohumeral pathologies and having MRI results with no previous shoulder surgeries. There was no age limit. Those with signs of infection at the operation sites were excluded

Sampling and study method: The consecutive sampling method was used to recruit the participants in this study. The Fleiss' statistical formula for rates and Proportion 3.19 (6) was used to determine the sample size. The patients with traumatic soft tissue injury or degenerative syndromes of the glenohumeral joint were recruited. The participants had informed and written consent and were clinically stable to undergo the surgery.

Clinical examination was done by the primary surgeons during the initial visits but was also repeated before surgery. The principal investigator worked directly with the arthroscopic surgeons from all the centers. This was through directly taking part in some of the surgeries, getting and operation notes from the surgeons or by telephone conversation where certain information was not clear. In addition, senior registrars or COSECSA students rotating in these hospitals were included as research assistants to help in the data collection. The MRI reports were also discussed with radiologists where necessary.

The clinical, MRI and arthroscopic findings were recorded on the data collection sheet which were serially numbered. The following parameters were used as a checklist for both MRI and arthroscope: Rotator Cuff Tears (Full or Partial), Subacromial impingement syndrome, SLAP lesions, Bankart's lesions and Hill-Sachs lesions.

All the preoperative MRI reports were obtained from a recognized radiological centers using the available scanners including 3T Philips Achieva, 3T

Seimens Verio, 1.5 T G. E Segna Explorer, 3T Philips Ingenia and 3T Seimens Magnetom Spectrum. There were a wide range of indices including T1 and T2 weighted with sagittal, coronal and axial sequencing. All the MRI images were interpreted by consultant radiologists.

All the arthroscopic surgical procedures were performed under general anaesthesia in either Beach chair or lateral decubitus positions. The shoulder traction was used to position the shoulder. The portals included standard anterior, posterior and lateral. To view all the anatomical structures, the 30° or 70° arthroscopic lens were used.

The MRI reports were categorized into:

1. *True Positive (TP):* MRI diagnosis correlate with arthroscopic diagnosis
2. *True Negative (TN):* No diagnosis on the MRI also confirmed by the arthroscope.
3. *False Positive (FP):* MRI shows a diagnosis which is not shown on the arthroscope.
4. *False Negative (FN):* MRI did not show any diagnosis but was found on the arthroscope.

The formula below was used to measure the accuracy of the MRI.

a. Sensitivity =True Positives X 100/ (True Positives + False negatives)
b. Specificity=True Negatives X 100/ (True Negatives+ False Positive)
c. Positive Predictive Value=True Positives X 100/ (True Positives + False Positives)
d. Negative Predictive Value=True Negatives X 100/True negatives + False negatives)

$$\text{Accuracy} = \frac{(\text{True positives} + \text{False negatives}) \times 100}{(\text{True positive} + \text{True Negatives} + \text{False Positives} + \text{False negatives})}$$

Statistical analysis of data: The clinical, MRI and arthroscope findings were documented from the data collection sheet. The results for clinical examination and MRI were compared to arthroscopy. The SPSS version 25 computer software was used to code the collected data. The final result was presented in charts, tables and graphical forms. The Sensitivity, Specificity, PPV, and NPV were calculated to determine the accuracy of the MRI as shown above. This was compared to the findings of the arthroscopy. For the categorical variables, chi-square test was used. The P value < 0.05 shows a significant result.

RESULTS

Distribution of patients across the study sites: The findings showed that The Nairobi Hospital had the highest number of patients 20(27%), MP Shah, Mater, Kikuyu and Aga Khan University Hospitals had 10 (13.3%) participants each while Kijabe and Coptic Hospitals had 7(9.5%) each as shown in Table 1.

Table 1

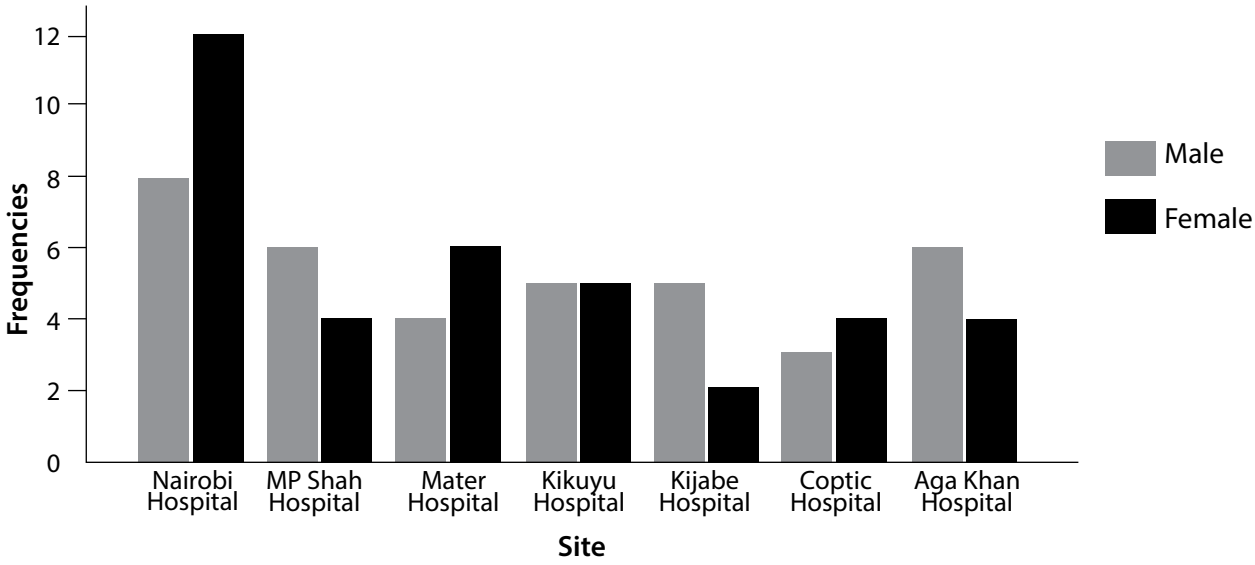
Distribution of the study respondents

Site	Frequency	(%)
Nairobi Hospital	20	27.0
MP Shah Hospital	10	13.5
Mater Hospital	10	13.5
Kikuyu Hospital	10	13.5
Aga Khan University Hospital	10	13.5
Kijabe Hospital	7	9.5
Coptic Hospital	7	9.5
Total	74	100.0

Socio demographics

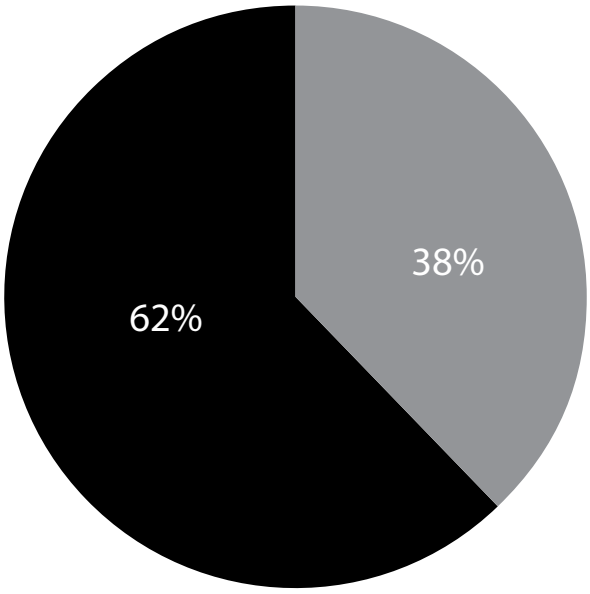
Gender of the participants: The overall male to female ratio was 1:1. There were however gender variation in the different hospitals. The Nairobi, Mater and Coptic hospitals showed predominantly females (n=12, 6 and 4 respectively) while MP Shah, Kijabe and Aga Khan Hospitals revealed male predominance (n= 6,5 and6 respectively). In Kikuyu Hospital, there was equal number of male and female participants (n =5) as shown in Figure 1.

Figure 1
Gender of the respondents



Location of the joint pathology by side: The findings showed that majority 46(62%) of the patients had joint pathology on their right side while 28 (37.8%) was on the left as shown in Figure2.

Figure 2
Location of the pathology



Age and duration of injury: The age range was 16 to 73 years with an average of 48 years. The duration of the pathologies ranged between 1 month and 31 months with an average of 9 months.

Table 2
Descriptive statistics per site

	Age (M,SD)
Nairobi Hospital	M =47 SD =15 Min =16 Max =69
MP Shah Hospital	M =49 SD =14 Min =20 Max =73
Mater Hospital	M =43 SD =14 Min =26 Max =64
Kikuyu Hospital	M =48 SD =18 Min =18 Max =72
Kijabe Hospital	M =58 SD =5 Min =52 Max =67
Coptic Hospital	M =51 SD =11 Min =32 Max =67
Aga Khan Hospital	M =50 SD =15 Min =24 Max =73
Total	M =48 SD =14 Min =16 Max =73

Frequencies of the glenohumeral joint pathologies: The clinical examination found 37 (50%) Rotator Cuff Tear 24 (32.4%), Subacromial Impingement Syndrome and 13 (17.6%) instability. MRI findings showed 42 (56.8%), Rotator Cuff Tear 21 (28.4%), Subacromial Impingement Syndrome and 9 (12.2%), Bankart lesion. Two participants had more than one diagnosis on the MRI giving the total number of 76. Arthroscopy findings highlighted 35 (47.3%) Rotator Cuff Tear, 24 (32.4%), Subacromial Impingement Syndrome 10 (13.5%), Bankart lesion and 3 (4.1%) SLAP lesions as shown in Table 3.

Table 3
Frequencies of joint pathologies across clinical, MRI and arthroscopy

Joint pathology	Frequencies of joint pathologies		
	Clinical findings No. (%)	MRI findings No. (%)	Arthroscopy No. (%)
Rotator cuff tear	37(50)	42(56.8)	35(47.3)
Subacromial impingement syndrome	24(32.4)	21(28.4)	24(32.4)
Slap lesion		3(4.1)	3(4.1)
Bankart lesion		9(12.2)	10(13.5)
Hill-Sachs lesion		3(4.1)	1(1.4)
Biceps tendinopathy		1(4.1)	1(4.1)
instability	13(17.6)	-	-

Correlation between clinical findings and arthroscopy findings: A correlation analysis was done to determine the strength and significance of the relationship between clinical findings and arthroscopy findings. The results showed that there was a moderate positive relationship between clinical finding and arthroscopy findings for rotator cuff tear ($r = 0.46$, $p<0.05$) and Subacromial Impingement Syndrome ($r = 0.445$, $p<0.05$) as shown in Table 4.

Table 4
Correlation between clinical findings and arthroscopy findings

Condition	N	Pearson correlation (r)	P-value
Rotator cuff tear	74	0.46	0.000
Subacromial impingement syndrome	74	0.445	0.00
Instability	74	-	-

Correlation between MRI findings and Arthroscopy findings: The findings showed that there was a strong positive relationship between MRI findings and Arthroscopy findings for Rotator cuff tear ($r = 0.663$, $p<0.05$), Subacromial impingement syndrome ($r = 0.652$, $p<0.05$), SLAP lesion ($r = 0.653$, $p<0.05$), Bankart lesion ($r = 0.699$) and Hill-Sachs lesions ($r= 0.569$, $p<0.05$) as shown in Table 5.

Table 5
Correlation between MRI findings and arthroscopy findings

Condition	N	Pearson correlation (r)	P-value
Rotator cuff tear	74	0.663	0.000
Subacromial Impingement syndrome	74	0.652	0.000
Slap lesion	74	0.653	0.000
Bankart lesion	74	0.699	0.000
Hill-Sachs lesion	74	0.569	0.000

Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of clinical findings: The sensitivity of clinical findings was highest for Rotator cuff tear (0.74) followed by Subacromial impingement syndrome (0.625). The highest specificity was in Subacromial Impingement Syndrome (0.82) and rotator cuff tear (0.743). The highest positive predictive value was found for rotator cuff tear (0.703) and Subacromial impingement syndrome (0.625). The highest negative predictive value was found in Subacromial Impingement Syndrome (0.82) and Rotator cuff (0.757) as shown in Table 6.

Table 6

Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of clinical findings for each pathology

	Clinical findings (n)	Arthroscopy (n)	Sensitivity	Specificity	PPV	NPV
Rotator cuff tear	37	35	0.743	0.718	0.703	0.757
Subacromial Impingement Syndrome	24	24	0.625	0.82	0.625	0.82
Instability	13			0.892		1

Sensitivity, Specify, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of MRI findings: The Sensitivity, Specificity, PPV and NPV for Rotator Cuff Tears were 0.914, 0.744, 0,762 and 0.906 respectively. As for Subacromial Impingement Syndrome the results were 0.708, 0.92. 0.8 and 0.986 respectively. Additionally, the values for Bankart lesions were 0.7, 0.969. 0.778 and 0.954 respective while SLAP lesions showed 0.667, 0.986, 0.667 & 0.986 respectively. The Hill-Sachs lesion showed 1, 0.973, 0.333 and1 respectively as indicated in Table 7.

Table 7

Sensitivity, Specify, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of MRI for each pathology

	MRI findings(n)	Arthroscopy(n)	Sensitivity	Specificity	PPV	NPV
Rotator cuff tear	42	35	0.914	0.744	0.762	0.906
Subacromial impingement syndrome	21	24	0.708	0.92	0.8	0.986
SLAP lesion	3	3	0.667	0.986	0.667	0.986
Bankart lesion	9	10	0.7	0.969	0.778	0.954
Hill-Sachs lesion	3	1	1	0.973	0.333	1

DISCUSSION

The accurate preoperative diagnosis of glenohumeral disorders is necessary for surgical planning. Clinical examination will guide the surgeon for the type of imaging needed. The plain radiograph will pick up bony lesions but not soft tissue pathology. MRI is instrumental for the diagnoses of soft tissue pathologies. Diagnostic arthroscopy is minimally invasive and can directly visualize intraarticular structures. All these modalities are significantly essential for accurate diagnosis of glenohumeral joint pathologies. Arthroscopy has an added advantage of treatment.

Seventy-four patients were successfully evaluated. Gender and age are among the predisposing factors for glenohumeral pathologies. Although there were gender variations between the study institutions, the total gender ratio was 1:1. This is similar to a study done by Cadogan *et al* (7) who found little difference with respect to gender. This is contrary to other studies. Sharma *et al* (8) showed male predominance of 60% and Onyambu *et al* (9) also revealed male predominance of 62%. The age range was 16 to 73 years with an average of 48 years. This correlate with a study conducted by Van Der Windt *et al* (10) which showed majority of the patients above the age of 45 years and Muthani *et al* (9) which found majority of their patient between the ages of 45 to 49 years.

The findings also showed that majority 46(62%), of the patients had joint pathology on the right side while 28(37.8%) was on the left. This might be due to hand dominance as majority of the participants were right handed. This is similar to the results of Abhinav *et al* (2) which showed 69.23% on the right and 30.77% on the left.

All the three diagnostic methods indicated that the Rotator Cuff Tears is the commonest shoulder pathology. This correlates with other studies by van der Windt *et al* (10) and Minagawa *et al* (11). It is followed by Subacromial impingement syndrome and Bankart lesions.

Correlation between clinical findings and arthroscopy findings: The results showed that there was a moderate positive relationship for Rotator Cuff Tear ($r = 0.46$, $p<0.05$) and Subacromial Impingement Syndrome ($r = 0.445$, $p<0.05$). Nonetheless, clinical examination cannot detect other pathologies. This is similar to the findings of Malhi and Khan (14).

Correlation between MRI and arthroscopy findings: The current study showed a strong positive relationship between MRI and Arthroscopic findings. This indicates that it can be used to rule out other possible disorders of the glenohumeral joint. This supports the findings of Momenzadeh *et al* (7).

Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value of MRI findings: The sensitivity for MRI ranges from 0.7 for Bankart lesions to 0.914 for Rotator Cuff tears. However, specificity was high for all glenohumeral pathologies (0.744 to 1). This is similar to the findings of Iannotti *et al* (13) with a sensitivity ranging between 82% to 100% and specificity ranging from 85% to 95% for various pathologies.

Furthermore, the positive predictive value was high, 0.762 for Rotator cuff tear, 0.778 for Bankart lesion, and 0.8 for Subacromial impingement. It was lowest for 0.33 for Hill-Sachs lesion. This indicates that MRI cannot be routinely used for the diagnosis of this pathology. The negative predictive values were very high for all the pathologies ranging from 0.90 to 1. Therefore, MRI can be used to rule out various glenohumeral pathologies.

Some studies for Rotator Cuff tears showed varying results. In this current study, the sensitivity was 0.91 and specificity was 0.744. This is closely related to a study conducted by Momenzadeh *et al* (14) which indicated sensitivity of 0.92 and specificity of 1. Loffler *et al* (15) also reported sensitivity of 85% and specificity of 100%. On the contrary, Muthami *et al*(9) reported sensitivity at 46% but specificity at 88%. This might be due to varying sample sizes.

Clinical evaluation showed high sensitivity (0.743 to 0.625) and specificity (0.718 to 0.82) for Rotator Cuff Tears and Subacromial impingement syndrome respectively. This is comparable to the study of Srinivas *et al* (16) with a sensitivity of 80%, sensitivity of 71% and accuracy of 75%.

Comparing the MRI to clinical examination in the diagnosis of Rotator cuff tears with respect to arthroscopy, MRI is more sensitive (0.91) but the specificity of the two modalities is very similar 0.744 for MRI and 0.718 for clinical examination. Oster *et al* (17) found clinical examination being highly sensitive but of low specificity compared to MRI with respect to arthroscopy.

Joshi *et al* (18) observed that diagnostic accuracy of MRI was considerably higher in comparison to clinical examination for both anterior and posterior shoulder instability. On the other hand, Bryan *et al* (19) suggested that clinical evaluation with focused history-taking and special tests can diagnose anterior shoulder instability as reliably as MR imaging.

Furthermore, the current study found strong correlation between clinical examination and the diagnosis of instability and Subacromial impingement syndrome. This is in line with the finding of Malhi *et al* (12).

Therefore, this study emphasizes that effective clinical evaluation in addition to MRI can increase the diagnostic accuracy of common glenohumeral pathologies. It will serve as a useful guide for future studies. Nevertheless, there is a need for a large-scale multicenter randomized study.

The study limitations were the patients' hesitation for the invasiveness of the arthroscopy. Additionally, the costs of MRI and arthroscopy were high for many patients.

CONCLUSION

The glenohumeral pathologies are more common among people in their 40s but do not show any gender difference. Complete and meticulous clinical examination remain the first diagnostic criteria with no added cost. It has been shown in this study to be highly sensitive and specific. However, MRI is more reliable, accurate, sensitive and specific in the diagnosis of Rotator Cuff Tears, Subacromial impingement syndrome and Bankart lesions. Its disadvantage is the added cost on the patients. Hence, both MRI and clinical examination are complimentary in the diagnoses of glenohumeral pathologies. Consequently, in low income countries, arthroscopy can be done after thorough clinical examination without preliminary MRI in resource limited situations based on the surgeon's judgment.

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