RESEARCH ARTICLE

ROLE OF 3D MR SEQUENCES IN THE EVALUATION OF GLENOID LABRAL TEARS IN COMPARISON WITH CONVENTIONAL MRI

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ABSTRACT

Aim: The aim of this study is to evaluate the role of 3D MRI in diagnosing glenoid labral tears in comparison to conventional MRI considering arthroscopy as the gold standard investigation.
Materials and Methods: Forty five patients between 15-60 years of age with shoulder pain and suspected glenoid labral pathologies are included in the study.MRI of the shoulder joint including 3D sequences was done and findings are compared with the final diagnosis obtained by arthroscopy. Post arthrogram 3D sequences are also acquired whenever arthrogram was performed and the findings are compared with those of conventional MRI and Arthroscopy. MR arthrogram was considered as gold standard in cases where arthroscopy was not done. The analysis was done using kappa statistics.
Results: Maximum patients (23 out of 45)are students with athletic activity in the age group of 21-30 years and ninety percent of the patients are male. Most of the patients presented with recurrent shoulder subluxation/dislocation and there is tear of anteroinferior labrum in fifty percent of the patients. 3D MRI showed improved sensitivity and specificity for labral tears (100% accuracy for superior segment tears with subtle false negativity for inferior segment tears). Pre and post arthrogram 3DMRI showed perfect agreement with arthroscopy with kappa score of 0.9 and 0.94 respectively.
Conclusion: 3D MRI is a sensitive tool in detection of labral tears and correlates better with arthroscopic findings but was not found to substitute conventional MRI.

INTRODUCTION

Shoulder joint is the most mobile and unstable joint in the body. Dislocation of shoulder joint is commonly seen in young athletes and anterior dislocation accounts for 95% of all shoulder dislocations (Hawkins and Mohtadi, 1991). Patients with recurrent anterior dislocation of shoulderpresent with labroligamentous injuries(disruption of inferior glenohumeral ligament) (Arciero *et al*., 1994; Arciero *et al*., 1995; Moseley and Övergaard, 1962; Liu and Henry, 1996; Grana *et al*., 1993; Rowe *et al*., 1978) MRI is proved to be an accurate imaging modality for evaluating labroligamentous structures of shoulder joint. There are few drawbacks in conventional MRI in detection of tears due to the following reasons as described. (1) Transitional zone between fibrocartilage and hyaline cartilage of labrum mimics tear because of the abnormal signal. (2) Partial volume averaging artefacts with the glenohumeral ligaments. (3) Magic angle phenomenon in the posterosuperior labrum.3D MRI is an isotropic imaging which can create multiplanar reformatted images thus resulting in reduced scan time which improves patient comfort and reduces motion

Artifact (Lu *et al*., 2005; Wieslander *et al*., 1998; Kijowski *et al*., 2009). Some of the earliest studies on 3D MRI of shoulder joint were performed by multiple investigators (Cicak *et al*., 1992; Jung*et al*., 2009; Mohana-Borges *et al*., 2003) and attained comparable accuracy of conventional and 3D MRI. A few authors compared 3DMR arthrography with conventional arthrography and found no significant difference between the two techniques for detection of labral tears (Choo *et al*., 2012; Oh *et al*., 2009; Rybak *et al*., 2012). To the best of our knowledge, no preliminary study has used volume isotropic turbo spin-echo acquisition (VISTA) sequence to evaluate glenoid labral pathologies. The purpose of this study is to evaluate the diagnostic accuracy of this sequence in detecting labral lesions in comparison with conventional MRI considering Arthroscopy/MR Arthrogram (in patients where arthroscopy is not performed) as gold standard investigation. Arthroscopic evaluation was done by expert orthopaedic surgeon in patients who underwent arthroscopic repair surgery. The primary indication of Arthroscopy in patients with glenohumeral instability was persistent shoulder pain that has not responded to minimum six months of non operative treatment (NSAIDS and physiotherapy). MR arthrography enables thorough evaluation of the structures of shoulder joint. It involves intraarticular injection of the contrast material using

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a posterior approach under ultrasound guidance (Cicak *et al.*, 1992) which helps in delineation of labral tear as the contrast seeps into the tear.

Aim

The aim of the study is to evaluate the role of 3D MRI in evaluation of glenoid labral tears and to determine its sensitivity and specificity considering arthroscopy/MR arthrogram as gold standard investigation.

MATERIALS AND METHODS

This is a prospective study conducted over a period of two years in the Department of Radiodiagnosis and Imaging, Kasturba Medical College, Manipal. Institutional ethics committee approval was obtained. Forty five patients with shoulder pain and suspected glenoid labral tears are selected for the study. The sample size was decided by the statistician who was provided with the relevant data. Patients with previous shoulder surgery and with tumour in the joint are excluded from the study. Study was performed with 1.5T MR imaging system by Achieva, PHILIPS, Netherlands using a dedicated 8 channel shoulder coil in supine position with shoulder in neutral position. These patients were evaluated with conventional MRI (PDFS (coronal, axial), GRE axial, T2W sagittal, T2W FS Coronal and 3D MRI (PD VISTA) prior to MR arthrography (T1W TSE with fat saturation and T1WVISTA) and findings are compared with the final diagnosis obtained by arthroscopy (whenever performed). Procedure of MR Arthrography in brief: Patient lies in prone position and under USG guidance, intraarticular injection of 15-20ml diluted solution of gadolinium (12 drops of gadolinium with bupivacaine and normal saline) was done (Cicak *et al.*, 1992). Later MRI sequences were acquired within fourty five minutes to one hour. Labrum is divided in to six segments based on clock positions for localization of tear. They are superior, antero-superior, antero-inferior, inferior, postero-inferior and postero-superior labral segments. Categorization of all labral segments was made into either normal or abnormal (tear absent/present-suspicious/definitive). Normal labrum shows normal contour and signal intensity without any irregularity. Suspicious tear is defined as ill-defined hyperintensity with irregular margins / contour abnormalities / attenuation of a part of labrum/no contrast extension into hyperintensity on MRA. Definitive tear is defined as sharp defect in the labrum with gap measuring >2 mm/ extension of contrast material into the defect on MRA/ non visualization of labrum.

Images are initially acquired in axial plane and later reformatted into oblique sagittal and oblique coronal planes using Insta 3D software. The whole labrum can be visualised in a single plane in oblique sagittal reformatted images.

Arthroscopic evaluation was done by well experienced orthopedic surgeon and following findings are noted.

- Presence or absence of labral tears.
- Segment wise localization of labral tears.

Statistical analysis

Statistical analysis was performed using SPSS 16 software to obtain the sensitivity, specificity, positive predictive value and negative predictive values of conventional and 3D MRI in detecting labral tears. Kappa analysis was conducted -Level of agreement of Conventional MRI, 3D MRI and MR Arthrogram with Arthroscopy or MR Arthrogram * as gold standard.

RESULTS

All the patients withclinical suspension of labral pathologies are evaluated using conventional MRI and 3DMRI. Arthroscopy, considered to be the gold standard was done in 30 patients. MR arthrogram considered to be the alternative gold standard was done in 28 patients. Maximum patients (23 out of 45) are male students with athletic activity, in the age group of 21-30 years and ninety percent of the patients are male. Most of the patients presented with recurrent shoulder subluxation/dislocation and there is tear of anteroinferior labrum in fifty percent of the patients.

Comparison of conventional MRI with Arthroscopy:

Conventional MRI has low sensitivity 75.2% and negative predictive value 78.5%, high specificity 96.6 % and positive predictive value 95.9%. There was 100 % accuracy for detection of anterosuperiorsegment tears whereas low sensitivity for superior segment tears (Table 1)

Table I. 2D MRI & Arthroscopic correlation of labral tears (n=180(number of labral tears))

	Number of tears / segments		
	Present on arthroscopy	Absent on arthroscopy	Total
Present on 2D MRI	70(75.3%)	3(3.4%)	73 (40.6 %)
Absent on 2D MRI	23 (24.7%)	84(96.6%)	107(59.4 %)
Total	93(100 %)	87(100%)	180 100%)

Comparison of 3D MRI with Arthroscopy:

3D MRI has high sensitivity 95.6%, specificity 94.2%, PPV 94.6%and NPV 95.3%.There was 100 % accuracy for detection of superior segment tears and high false positivity for anterosuperior segment tears (Table2)

Table II: 3D MRI & Arthroscopic correlation of labral tears (n=180)

	Number of tears / segments		
	Present on arthroscopy	Absent on arthroscopy	Total
Present on 3D MRI	89(95.6%)	5(5.7%)	94(52.2 %)
Absent on 3D MRI	4 (4.4%)	82(94.3%)	86(47.8 %)
Total	93(100 %)	87(100%)	180 100%)

Comparison of 3D MRI with MR Arthrogram:

3D MRI has high sensitivity 96.3%, specificity 92.0%, PPV 91.8% and NPV 96.4%.There was 100 % accuracy for detection of anteroinferior and posteroinferior segment tears and high false positivity for anterosuperior segment tears (Table 3)

Comparison of MR arthrogram with Arthroscopy:

3D MRI has high sensitivity 92.1%, specificity 92.6%, PPV 96.0% and NPV 86.0%.There was 100 % accuracy for

detection of all the segment tears except postero-superior and inferior segments where one tear is missed in each segment (Table 4). Comparison was done using kappa analysis which showed that 3D MR arthrogram and 3D MRI have stronger agreement with arthroscopy than conventional MRI (Table 5).

Table III: 3D MRI & 2D MRA correlation of labral tears (n=168)(Mohana-Borges *et al*., 2003)

	Number of tears / segments		
	Present on 2DMRA	Absent on 2DMRA	Total
Present on 3DMRI	78(96.3%)	7(8.0%)	85(50.6 %)
Absent on 3DMRI	3(3.7%)	80(92.0%)	83(49.4%)
Total	81(100 %)	87(100%)	168(100%)

Table IV: 2D MRA & Arthroscopic correlation of labral tears (n=78)

	Number of tears / segments		
	Present on arthroscopy	Absent on arthroscopy	Total
Present on 2DMRA	47(92.1%)	2(7.4%)	49.0(62.8%)
Absent on 2DMRA	4(7.9%)	25(92.6%)	29.0(37.2%)
Total	51(100 %)	27(100%)	78(100%)

Table V: Comparison of conventional MRI, 3D MRI, MR Arthrogram and arthroscopic findings with calculation of degree of agreement. (Arthroscopy as gold standard)

Investigation	Correlation coefficient
2D MRI	0.71
3D VISTA	0.9
2DMRA	0.83
3DMRA	0.94

A 33 year old with history of pain posterior aspect of right shoulder 10 days after carrying a heavy weight on shoulder-

straight red arrow showing posteroinferior labral tear and curved red arrow showing superior labral tear.

(A) Axial proton density fat satured (PDFS)image

(B) Axial 3D PDFS image

(C) 2D Oblique coronal image

(D) 3DOblique coronal reformatted image

(E) Oblique sagittal reformation from 3D T1WI source image.

F) Oblique sagittal reformation from Post arthrogram 3D T1WI source image.

Inference: The extent of tear is better visualised on 3Dreformatted images.

Figure 1.

A 24 year old male presented with history of recurrent episodes of right shoulder dislocation and pain

Curved red arrow showing anteroinferior labral tear.

(A) Axial 3D PD VISTA image

(B) Axial 2D PDFS image

(C) 3D PD VISTA Oblique sagittal reformatted image

(D)Post arthrogram T1W VISTA Oblique sagittal reformatted image

Inference -

Anteroinferior tear was better seen on axial PDFS images compared to PD VISTA due to presence of joint effusion while acquiring 2D images.

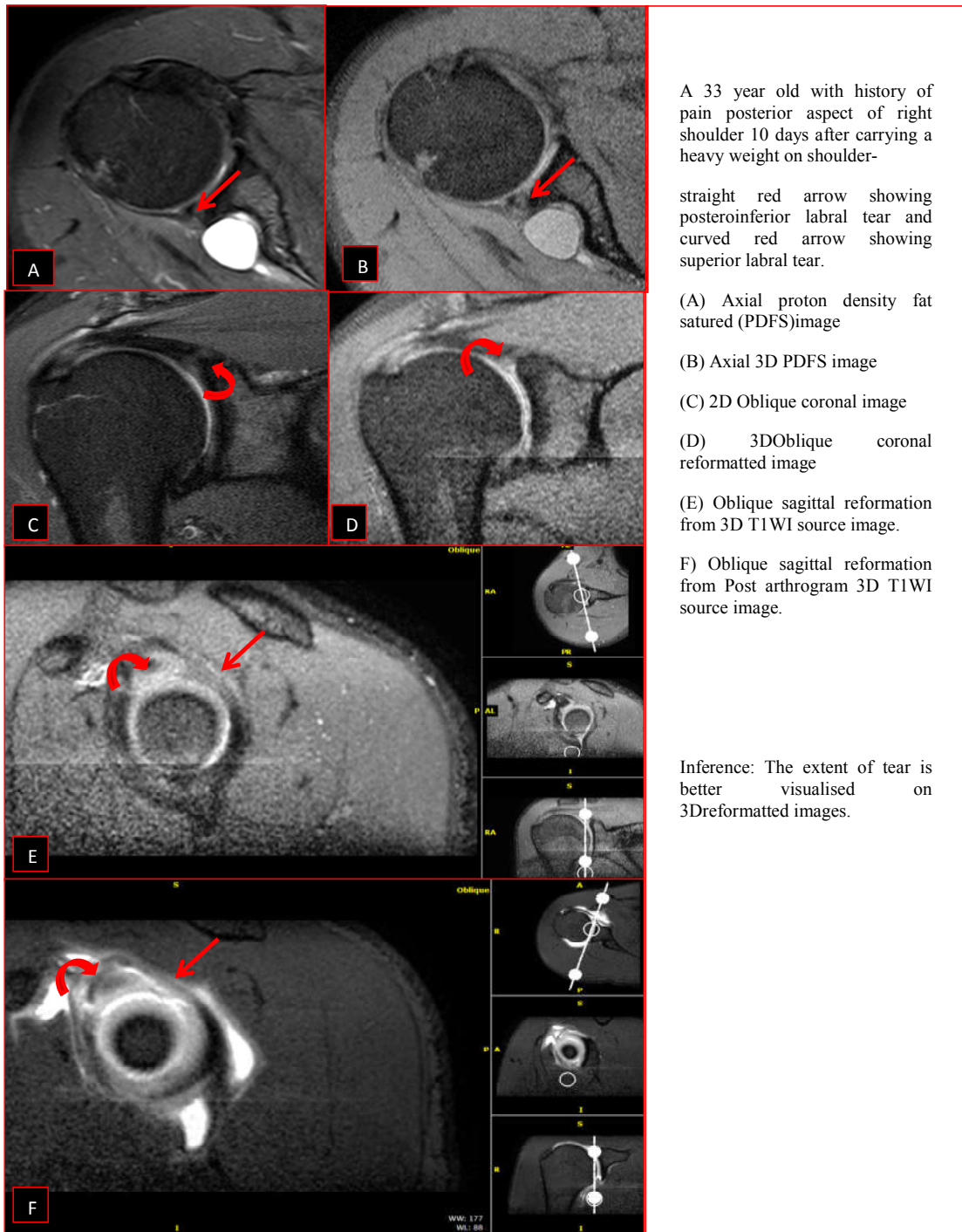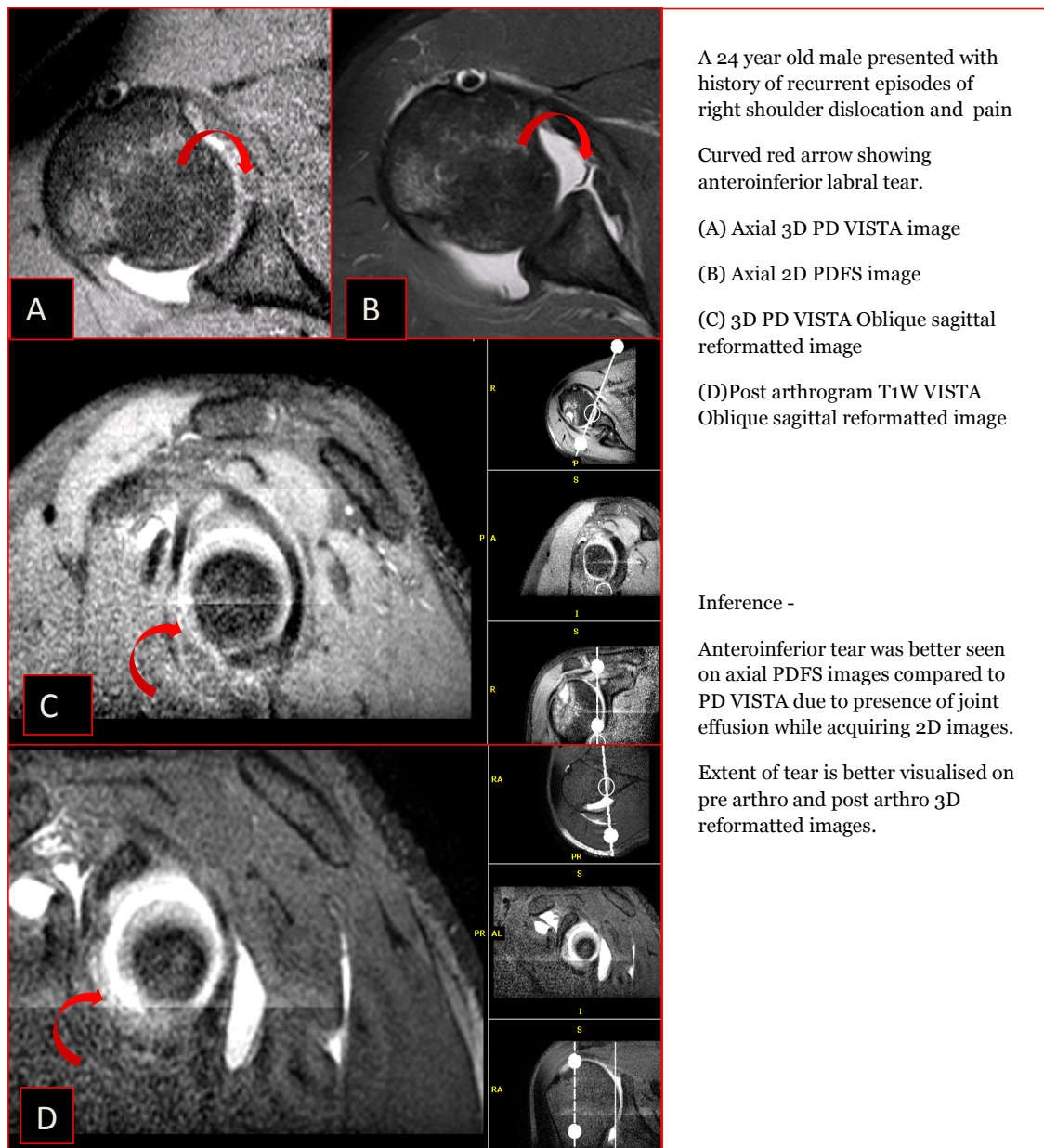Extent of tear is better visualised on pre arthro and post arthro 3D reformatted images.

Figure 2.

DISCUSSION

3D MRI sequences have been incorporated into routine MRI protocols in Musculoskeletal imaging at many institutions in the recent years because of its improved spatial resolution. In this study, we investigated whether 3D volume isotropic turbo spin-echo acquisition (VISTA) MRI sequence is comparable or superior to conventional MRI in diagnosing labral tears considering Arthroscopy/MR arthrogram as gold standard. In this study of 45 patients who underwent Arthroscopy, there were 38 anteroinferior labral tears, 34 anterosuperior labral tears, 33 superior and posterosuperior labral tears each, 24 posteroinferior labral tears and 21 inferior labral tears. Additional tears were seen on 3D MRI correlating with Arthroscopy which was not seen on conventional MRI. The number of suspicious tears on conventional MRI were 38 where as it was only 10 on 3D MRI. This is possibly due to high spatial resolution in 3D MRI which gives better information about the existence and extent of tear. In this study, 3D MRI yielded a sensitivity of 95.6% and specificity of 94.2% in detection of labral tears which are on the higher side in

comparison with previously published results. Jung *et al.* (2009) reported similar sensitivity and specificity of 3DMRI as multi-planar 2D sequences for imaging of glenoid labral tears. Joon-Yong Jung *et al.* (Mohana-Borges *et al.*, 2003) reported 90% sensitivity and 85% specificity for conventional MRI and 81% sensitivity and 86% specificity for 3DMRI respectively, with no statistically significant differences. PARK (Park *et al.*, 2015) *et al.* retrospectively analyzed shoulder MRI and attained comparable accuracy for 3D eTHRIVE in comparison with 2D FSE T2FS. In our study, we achieved 96% sensitivity and 100%specificity for 3D MR arthrography where as 92.1%sensitivity and 92.6% specificity for2D MR arthrographyin detection of labral tears. Other articles have addressed sensitivity and specificity of conventional and 3D MRI arthrography in comparison with Arthroscopy. Choo *et al.* (2012) assessed the accuracy of labral injury detection with MR arthrography which was 77–88% and 81–84% for conventional 2D sequences and 82–88% and 75–84% for 3D isotropic FSE sequences without significant statistical difference. Oh *et al.* (2009) compared isotropic 3D MR Arthrography with conventional MR arthrography and found

no significant difference between the two techniques for detection of labral tears. Rybak *et al*. (2012) performed a study for evaluation of 3D MR sequence in comparison to a standard 2D arthrographic protocol using arthroscopy as the gold standard and achieved sensitivity which was slightly better but specificity (81%)was less than that of 2D (86%).In this study, we attempted to determine whether 3D MRI provided enough additional benefit in detection of labral tears in shorter image acquisition times. The reason for improved sensitivity of 3D MRI is due to improved spatial resolution through acquisition of thinner slices.

Conclusion

- Our study demonstrated that 3D MRI (pre and post MR arthrogram)can be used in conjunction with conventional MR sequences to improve accuracy for labral tear detection, but was not found to substitute conventional MRI.
- Multiplanar image reformats give better information about the extent of tear and sharp details through acquisition of thinner slices.
- Improved confidence scores were recorded in diagnosis of labral tears with reduced false positivity.
- Post arthrogram 3D MRI showed stronger correlation with Arthroscopy as compared to pre arthrogram 3D MRI as the contrast seeps into the tear resulting better delineation.

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