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RESEARCH ARTICLE

THE ROLE OF THE LOW FIELD MAGNETIC RESONANCE IMAGING IN THE DIAGNOSIS OF THE COMMON SHOULDER JOINT LESIONS

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Abstract

This article reviews the role of the low field magnetic resonance imaging (MRI) with magnetic field strengths of 0.4 Tesla in the evaluation of the main pathologic conditions of the shoulder joint commonly encountered in clinical practice. Shoulder pain is a common clinical complaint that may be caused by abnormalities of the rotator cuff tendon, labrum and a variety of other pathological conditions. The differential diagnosis is extensive and includes tendinosis and rotator cuff pathology, instability, labral lesions, biceps disorders, radiculopathy, and thoracic outlet syndrome. In older patients, arthritis may even be a factor. The goal of this study was to evaluate the feasibility and diagnostic confidence of an open low field MRI in patients with shoulder joint pain. Our data was obtained from 40 patients: 24 Male (60%) and 16-Female (40%). Their ages ranged between 17 and 70 years. All patients were investigated by conventional X-rays and MRI in the medical diagnostic center of Aden Resonance in Al-Mansoura district in Aden city. MRI was performed at an open 0. 4 Tesla MR-unit (Hitachi - Japan-Aperto Lucent). The study protocol comprised axial, sagittal & coronal STIR-T2 and T1 weighted images of 3-4 mm thickness. 55 patients (52.4%) were investigated by high field MRI 1. 5 T (Neusoft) as a reference method.

Keywords: Low field, MRI, Shoulder , Tendon, labrum.

Introduction

The shoulder is a unique joint because it allows for excellent motion in all planes. This motion is necessary for the placement of the hand and upper extremity in positions of function. To accommodate this range of motion, the shoulder is a relatively unconstrained joint that depends on soft-tissue structures for stability and function.

Shoulder pain is a common clinical complaint that may be caused by abnormalities of the rotator cuff, labrum and a variety of other pathological conditions. The differential diagnosis is extensive and includes tendinosis and rotator cuff pathology, instability, labral lesions, biceps disorders radiculopathy, and thoracic outlet syndrome [1, 2] In older patients, arthritis may even be a factor. Understanding the anatomy of the shoulder tendons, labrum and ligaments is important for correct diagnosis and treatment [3].

With respect to its low foot-print among the claustrophobic patients, children and subject accessibility, the open low field MRI has become a routine imaging tool in diagnosing disorders of the shoulder joint, benefiting from many of the developments that have occurred in open low-field MRI [4, 5, 6, 7]

Objectives:

To evaluate the feasibility and diagnostic confidence of low field an open MRI System understanding the anatomy & common pathology of the shoulder joint.

Material & methods:

Material of this study is based on the analytical data obtained from 40 patients. 24 Male (60%) and 16-Female (40%). Their ages ranged between 17 and 70 years.

Twenty-four patients (60%) were complaining of shoulder pain with limitation of shoulder movements, they were suspected to have rotator cuff disease. The other sixteen patients (40%) were complaining of shoulder pain with a history of shoulder dislocation, they were suspected to have glenohumeral instability.

All patients were investigated by conventional X-rays and MRI in the medical diagnostic center of Aden Resonance in Mansoora district in Aden city. MRI was performed at an open 0. 4 Tesla MR-unit (Hitachi - Japan-Aperto Lucent). The study protocol comprised axial, sagittal & coronal STIR-T2 & T1 weighted images of 3-4 mm thickness. 31 patients (77.5%) underwent arthroscopy & open surgery was done for 5 patients (12.5%).

MRI was performed with an open MRI 0.4 Tesla (Hitachi Japan- Aperto Lucent. This is open permanent magnet MRI system with field strength of 0.4Tesla, with a multiparous coil. Hitachi company – 2014 product. Currently its Fuji company)

Pulse sequences: MRI obtained included axial, oblique coronal and oblique sagittal planes with different pulse sequences as following:

Oblique Coronal T1 weighted images

Oblique Coronal T2 weighted images

Oblique Coronal T2 weighted fat suppressed images

Oblique Coronal Proton Density weighted images

Oblique Sagittal T2 weighted images

Oblique sagittal T2 weighted fat suppressed images

Axial T2 weighted images

Axial Proton Density weighted image

Axial T2 weighted fat suppressed image

Results:

This study included forty patients divided into two groups;

***Group I (Patients with rotator cuff disease** included 24 patients)*

***Group II (Patients with shoulder instability** included 16 patients)*

Group I (Patients with rotator cuff disease)

Table (1): Age and sex distribution in group I patients.

Age	Male		Female		Total	
	N.	%	N.	%	N.	%
20 - < 30 years	1	7.7%	0	0%	1	**4.2%**
30 - < 40 years	3	23.1%	0	0%	3	**12.5%**
40 - < 50 years	1	7.7%	4	36.3%	5	**20.8%**
50 - < 60 years	5	38.4%	5	45.5%	10	**41.7%**
60 - < 70 years	3	23.1%	1	9.1%	4	**16.6%**
≥ 70 years	0	0%	1	9.1%	1	**4.2%**
Total	**13**	**100%**	**11**	**100%**	**24**	**100%**

Table (2): Different rotator cuff lesions.

Rotator cuff lesions	Number	%
Tendinosis	3	12.5%
Partial tear	10	41.7%
Full thickness tear	11	45.8%
Total	**24**	**100%**

Table (3): MRI findings in patients with rotator cuff lesions

MRI findings	Tendinosis		Partial tear		Full thickness tear	
	No.	%	No.	%	No.	%
Intact tendon with PD & T2 WI high signals (Less than fluid)	3	100%	0	0%	0	0%
Focal disruption with PD & T2 WI high signals (equal to fluid)	0	0%	10	100%	2	18%
Complete disruption with PD & T2 WI high signals (equal to fluid)	0	0%	0	0%	9	82%
Total	**3**	**100%**	**10**	**100%**	**11**	**100%**

Table (4): Surgical arthroscopic findings versus MRI in patients with rotator cuff tear

Rotator cuff lesion	Surgery (Arthroscopic & open)	MRI
Partial tear (Articular side)	6	7
Partial tear (Intratendinous)	3	4
Partial tear (Bursal side)	1	1
Full thickness tear	11	9

Table (5): Different MRI findings associated with rotator cuff lesions.

Associated MRI findings	Tendinosis (N=3)		Partial tear (N=10)		Full thickness tear (N=11)	
	No.	%	No.	%	No.	%
Thinning of the tendon	0	0%	0	0%	4	36.4%
Medial retraction of the musculotendinous junction	0	0%	0	0%	7	63.6%
Atrophic changes of the muscle	0	0%	0	0%	3	27.2%
Superior migration of the humeral head	0	0%	0	0%	6	54.5%
Subacromial bursal fluid	0	0%	5	50%	9	81.8%
Obliterated Subacromial – subdeltoid fat plane	0	0%	7	70%	11	100%

* More than one abnormality were seen in one patient

Table (6): Acromial shape distribution in patients with rotator cuff lesions.

Acromial type	Tendinosis		Partial tear		Full thickness tear		Total	
	No.	%	No.	%	No.	%	No.	%
Type I	1	33.3%	2	20%	5	45.5%	8	33.3%
Type II	2	66.7%	7	70%	5	45.5%	14	58.4%
Type III	0	0%	1	10%	1	9%	2	8.3%
Total	**3**	**100%**	**10**	**100%**	**11**	**100%**	**24**	**100%**

Table (7): Associated osseous abnormalities in patients with rotator cuff lesions.

Associated abnormality	Tendinosis N=3		Partial tear N=10		Full thickness tear N=11		Total N=24	
	No.	%	No.	%	No.	%	No.	%
Subacromial spur	0	0%	3	30%	6	54.5%	9	37.5%
Acromioclavicular hypertrophy	1	33.3%	2	20%	5	45.5%	8	33.3%
Acromial lateral downward slopping	1	33.3%	4	40%	3	27.2%	8	33.3%
Os acromiale	1	33.3%	0	0%	0	0%	1	4.2%

* More than one abnormality were seen in one patient

Table (8): Associated osseous abnormalities in patients with rotator cuff lesions.

Associated abnormality	Tendinosis N=3		Partial tear N=10		Full thickness tear N=11		Total N=24	
	No.	%	No.	%	No.	%	No.	%
Subacromial spur	0	0%	3	30%	4	36.4%	7	29.2%
Acromioclavicular hypertrophy	1	33.3%	3	30%	5	45.5%	9	37.5%
Acromial lateral downward slopping	1	33.3%	4	40%	2	18.1%	7	29.2%
Os acromiale	1	33.3%	0	0%	0	0%	1	4.1%

* More than one abnormality were seen in one patient

Group II (Patients with shoulder instability)

Table (9): Age and sex distribution in group II patients.

Age	Male		Female		Total	
	N.	%	N.	%	N.	%
10 - < 20 years	3	27.3%	1	20%	4	25%
20 - < 30 years	6	54.5%	4	80%	10	6.25%
30 - < 40 years	1	9.1%	0	0%	1	6.25%
40 - < 50 years	0	0%	0	0%	0	
50 - ≤ 60 years	1	9.1%	0	0%	1	6.25%
Total	11	100%	5	100%	16	100%

Table (10): Different lesions in patients with shoulder instability

Instability lesions	Number	%
Labral tear	14	87.5%
Occult fracture of the greater tuberosity	1	6.25%
Fracture posterior dislocation	1	6.25%
Total	16	100%

Table (11): Surgical arthroscopic findings compared to MRI and direct MR arthrographic findings in patients with labro-ligamentous tear

Lesion	Arthroscopy	MRI
Bankart lesion	4	0
Perthes lesion	2	0
Total	6	0

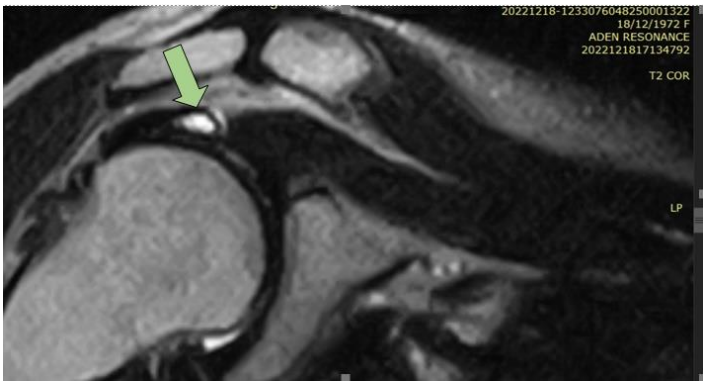
Table (12): Surgical arthroscopic findings compared to MRI findings in patients with SLAP (superior labrum anterior posterior) lesions

Lesion	Arthroscopy	MRI
SLAP I	0	0
SLAP II	7	3
SLAP III	0	0
SLAP IV	1	0
Total	8	3

Case 1: Supraspinatus tendinosis

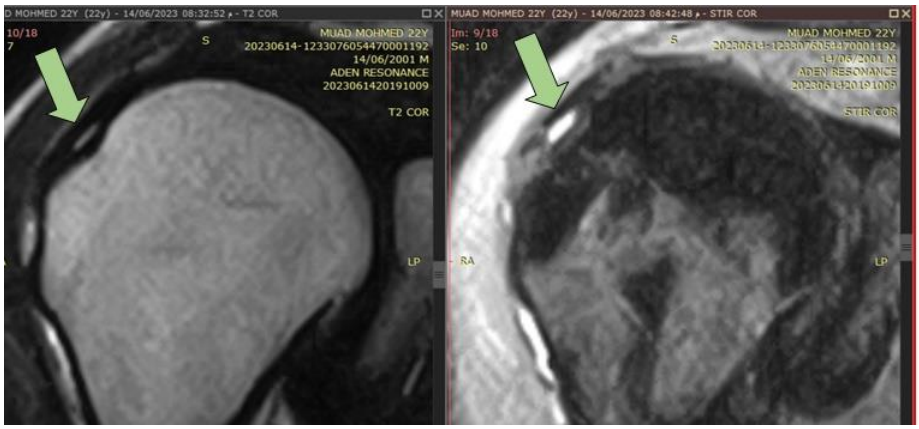
T2 oblique-coronal Weighted Images (WI) T1 oblique-coronal WI
An intrasubstancealtered intermediate signal intensity on T2 & T1 weighted images seen within the supraspinatus tendon at its musculotendinous junction.

Case 2: Supraspinatous Partial tear (Bursal surface)



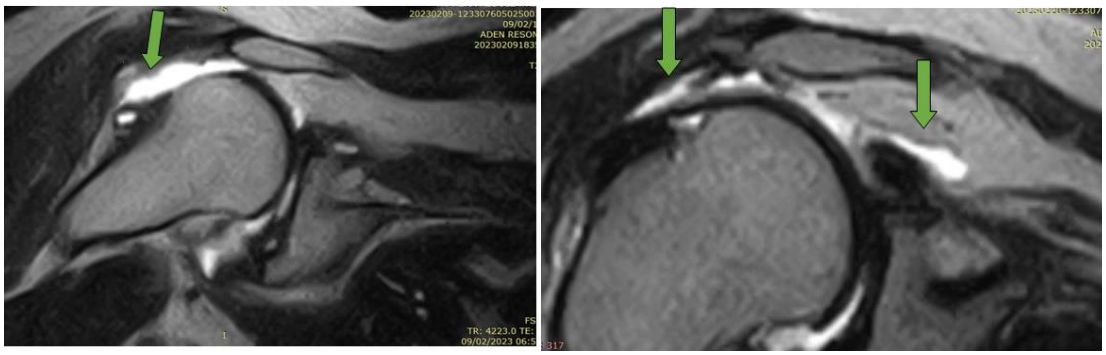
T2 oblique-coronal WI
An intrasubstance abnormal high signal intensity seen within the supraspinatus tendon at its musculotendinous junction reaching to its bursal surface

Case 3: Supraspinatous Partial tear (Articular surface surface)



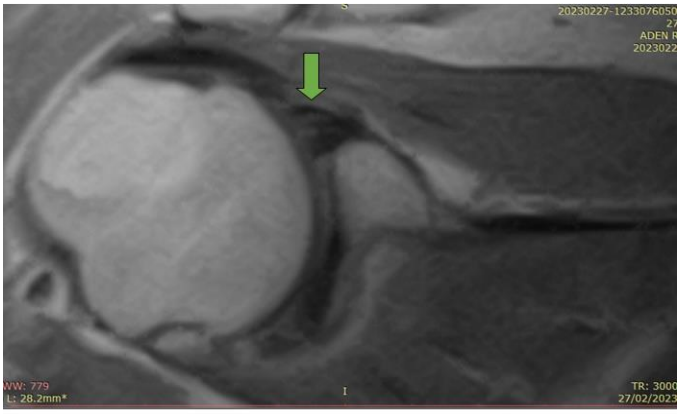
T2 oblique-coronal WI Fat saturation (Stir) oblique-coronal WI
An intrasubstance abnormal high signal intensity seen within the supraspinatus tendon at its musculotendinous junction reaching to its articular surface

Case 4: Supraspinatous full thickness tear **Case 5:**



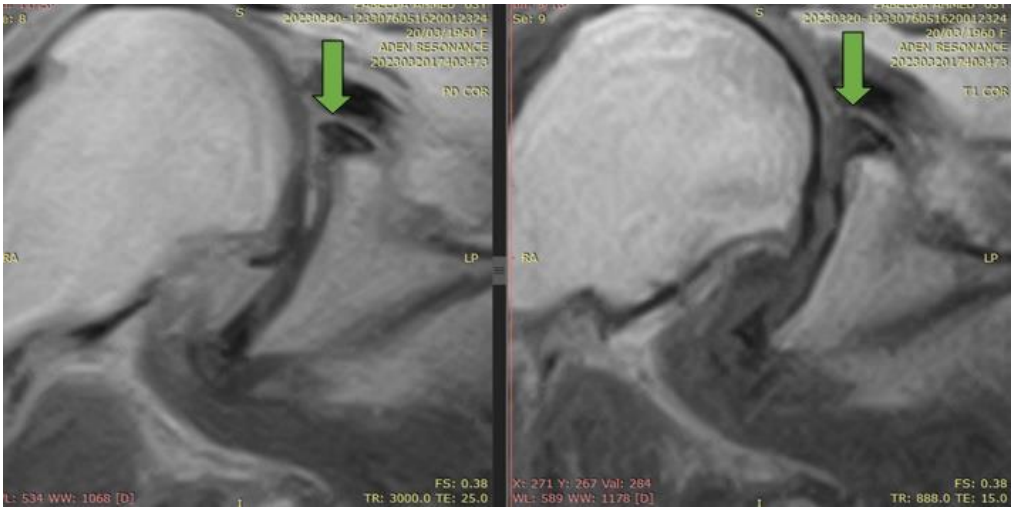
T2 oblique - coronal WIs
Complete tendon defect communication between the superior contours of the humeral head and subacromial bursa. Gap defect 3 and in case 5 4.5 cm. Associated supraspinatous muscle retraction.

Case 6: SLAP Lesion (type I)



Proton Density oblique-coronal WI
Abnormal intrasubstance signal intensity of the superior labrum with no evidence of fragmentation or displacement.

Case 7: SLAP Lesion (type II)

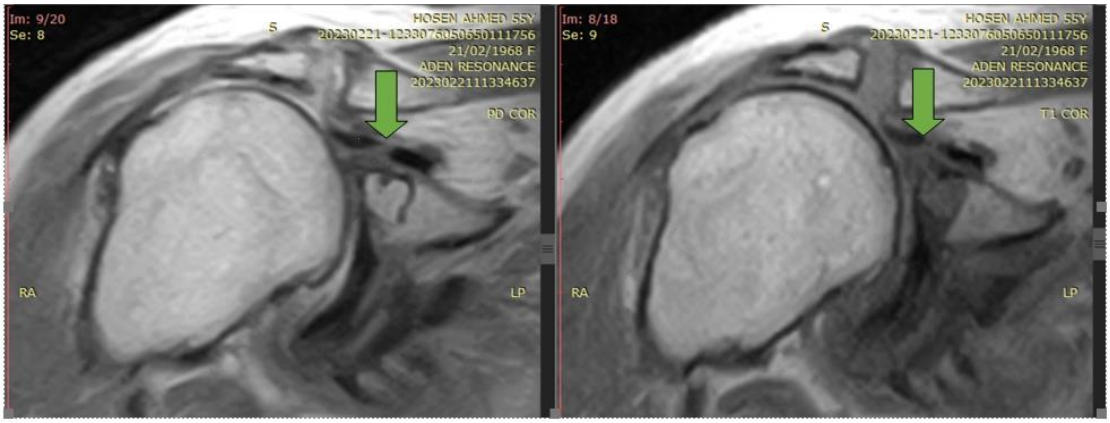


Proton Density oblique-coronal WI T1 oblique-coronal WI
The superior labrum showing intrasubstance isolated linear area of altered signal intensity with normal biceps tendon & glenoid bone.

Case 8: SLAP Lesion (type III)

Proton Density oblique-coronal WI T1 oblique-coronal WI
A bucket handle tear of the superior labrum is seen

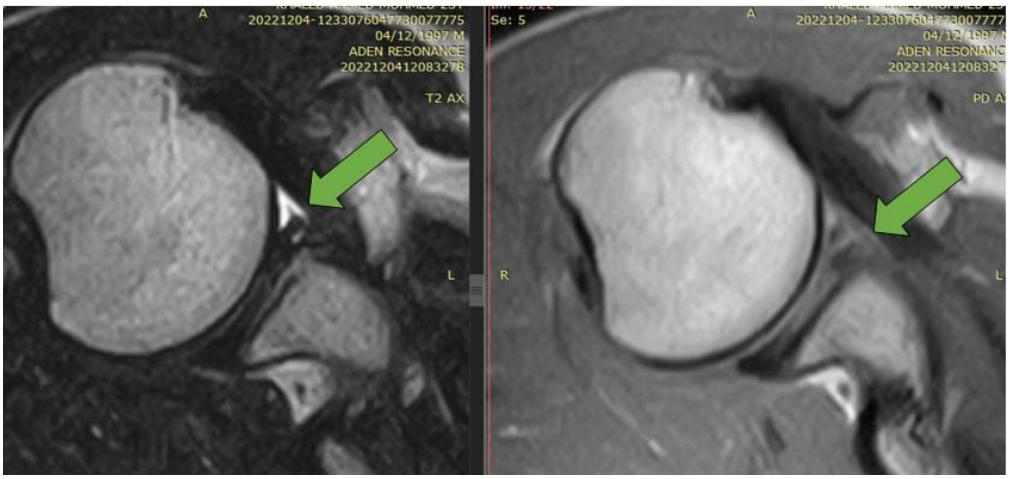
Case 9: SLAP Lesion (type IV)



Proton Density oblique-coronal WI T1 oblique-coronal WI

Superior labral tear extending to the long head of the biceps tendon

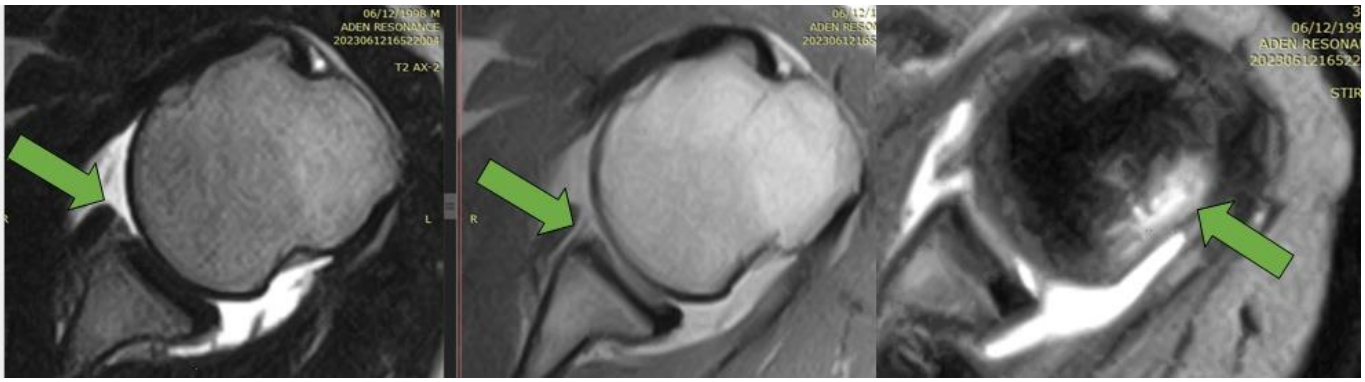
Case 10: Bankart Lesion



T2 axial WI Proton Density axial WI

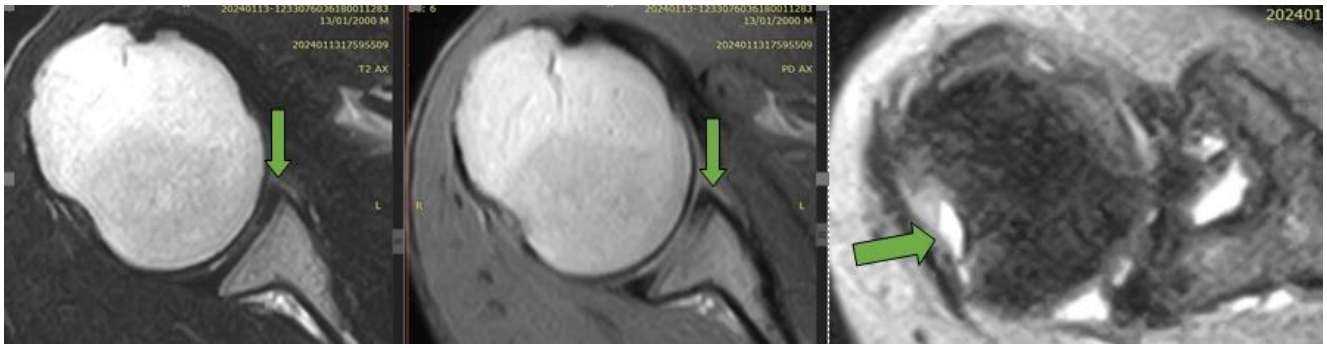
Detached anterior glenoid labrum with high signal intensity at its glenoid attachment (Bankart lesion)

Case 11: Bankart Lesion with Hill-Sachs defect



T2 axial WI Proton Density axial WI Stir (fat saturation) axial WI

Case 12: Bankart Lesion with Hill-Sachs defect



T2 axial WI Proton Density axial WI Stir (fat saturation) axial WI

Cases 11 and 12: A cortical bony defect of the postero-lateral aspect of the proximal humeral head manifesting with associated bone marrow edema (**Hill-Sachs lesion**) and detached, avulsed anteroinferior labrum, displaced from the glenoid margin (**soft tissue Bankart lesion**)

Discussion

Shoulder lesions as rotator cuff tear & labral injuries are common cause for shoulder pain & instability [8]. MRI playing vital role in the assessment of the shoulder pathology such as tendons and labral tears along with shoulder instability including osseous lesions [9, 10, 11]. The open nature of low field MRI reduce the incidence of claustrophobia, require less space & comfortable for children and teenagers patients. The newer extremity coils and software's designed to improve image quality [12, 13].

The low-field scanner used in this study was a good predictor of rotator cuff tears, with higher accuracy for tendinopathy & tendons tears (figures 1 to 5). The results suggest that low-field MRIs are an excellent indicator of differentiation partial tear (figures 2-3) from full-thickness rotator cuff tears (Figures 4-5). This is an important finding because distinguishing between partial- and full-thickness tears can affect the treatment plan of a patient [14].

Compared interpretations in our patients who underwent MRI in a 0.4-Tesla with findings at arthroscopy, they found that the predictive values for low field MRI of rotator cuff and labral tears compared favorably [15]. Diagnosis of anterior labral lesions (Bankart lesion)) and superior labral Anterior Postrrior (SLAP) lesions was accurate (Figures 6 to 12). Such lesions are confirmed by arthroscopic surgery.

In comparison with the rotator cuff, decreased accuracy for identifying pathology of the glenoid labrum is not isolated to low-field MRIs. Mid- and high-field MRIs without arthrogram also showed varied results when evaluating labral lesions. To better evaluate the glenoid labrum, MR arthrography may be recommended.

In an effort to reduce confounding factors, we discussed our data with a highly experienced radiologists in musculoskeletal radiology, especially in shoulder MRI.

MRI has some limitations. One significant aspect is the cost and accessibility of this technology. Patient cooperation is another crucial factor to consider when opting for MRI examinations. Unlike some imaging modalities, a successful MRI procedure requires patients to remain perfectly still for an extended period, ranging from 25 minutes to an hour. This demand for immobility can be particularly challenging for individuals with severe pain, claustrophobia, or conditions limiting their mobility. In such cases, patient comfort and their ability to comply with the examination requirements can significantly impact the quality and success of the imaging results .

Conclusion

- Low-field MRI is an accurate tool for evaluation of tendons degeneration, partial- and full-thickness rotator cuff tears.
- Open nature of the low-field MRI markedly reduced the incidence of claustrophobia due to large open space of the magnet, with improve image quality, using a newer extremity coils and software.
- Like high field, low field MRI does not involve ionizing radiation, ensuring the safety of patients
- Like high field, low field MRI has the advantages exceptional soft tissue contrast & multiplanner projection allowing the visualization of both intra- and extra-articular osseous and soft tissue structures of the shoulder joint.

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مقالة بحثية

دور الرنين المغناطيسي المنخفض القوة في تشخيص الحالات المرضية لمفصل الكتف

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المُلخّص

تستعرض هذه المقالة دور التصوير بالرنين المغناطيسي المنخفض القوة بقوة مجال مغناطيسي تبلغ 0.4 تسلا في تقييم الحالات المرضية الرئيسية لمفصل الكتف التي تحدث عادة في واقعنا الطبي. آلام الكتف هي شكوى شائعة في واقعنا الطبي قد تكون ناجمة عن تشوهات في اوتار الكفة المدورة للكتف او شفة المفصل وكذلك ومجموعة متنوعة من الحالات المرضية الأخرى. التشخيص التفريقي واسع النطاق ويشمل اعتلال الأوتار واصابات أوتار الكفة المدورة للكتف، عدم استقرار مفصل الكتف، افات شفة المفصل، اصابات العضلة ذات الرأسين، واعتلال الجذور العصبيه، ومتلازمة مخرج الصدر. اما في المرضى الأكبر سنا، قد يكون التهاب المفاصل عاملا رئيسيا. كان الهدف من هذه الدراسة هو تقييم الجدوى والثقة التشخيصية للتصوير بالرنين المغناطيسي المفتوح ذات المجال المنخفض في المرضى الذين يعانون من آلام مفصل الكتف. تم الحصول على بياناتنا من 40 مريضًا: 24 ذكرًا (60%) و16 أنثى (40%). وتراوحت أعمارهم بين 17 و70 عاما. تم فحص جميع المرضى بواسطة الأشعة السينية التقليدية والرنين المغناطيسي في مركز التشخيص الطبي لرنين عدن في منطقة المنصورة في مدينة عدن. تم إجراء التصوير بالرنين المغناطيسي في وحدة الرنين المفتوح بقوة 0.4 تسلا (هيتاشي - -أبيرتو لوسنت - اليابان). يتألف بروتوكول الدراسة من صور عرضيه، سهمية وإكليلية بالزمن رقم واحد والزمن رقم اثنين وكذلك ببرنامج كبخ الدهون. سمك المقطع 3-4 مم. تم فحص 55 مريضاً (52.4%) بواسطة التصوير بالرنين المغناطيسي عالي المجال 1.5 تي (نيوسوفت) كطريقة مرجعية. تم تقسيم الأربعين مريضا الى مجموعتين: 1) المجموعة الأولى المرضى المصابون بإصابات الكفة المدورة للكتف، 2) المجموعة الثانية المرضى المصابون بعدم استقرار الكتف. أظهرت النتائج ان بان المجوعة الأولى هي الأكثر (24اصابه) وهي المتعلقة بإصابات الاوتار للعضلات المدورة للكتف. الفئة العمرية الأكثر عرضة لهذه الإصابة تتراوح اعمارها بين الخمسين والستين سنه (10 حالات –45.5%). معظم هذه الحالات اكتشف فيها تمزق كامل لأوتار العضلة فوق الشوكية (11 حالة 45.8%)، (عشر حالات تمزق جزئي -41,7%). البقيه (3 حالات-12,5) اكتشف فيها انتكاسات اعتلالا للأوتار. المجموعة الثانية (16 حالة) مصابه بعم استقرار الكتف. معظم هذه الحالات كانت من الشباب (20-29 سنة) وتمثل 80% من الحالات وتميل الى الذكور (6) مقابل (4) للأناث. إصابات شفا المفصل كانت هي السائدة (14 حاله-87,5%) بينما الحالتين المتبقية أحداهما كانت مصابه بكسر خفي للحدبة الأكبر والأخرى بخلع خلفي. خلصت الدراسة الى ان تصوير إصابات الكتف بالرنين المغناطيسي المنخفض القوة (الرنين المفتوح) يتميز بدقة عالية بحسب الاحصائيات المرفقة ويمكن استخدامه للمرضى المصابين بتمزق أوتار الكتف وعند إصابات شفا المفصل خاصة عند المرضى الذين يخافون من الأمكنة المغلقة وذلك بحسب النتائج المقاربة للرنين المغناطيسي ذي المجال المغنطيسي العالي.

الكلمات المفتاحية: المجال المنخفض، التصوير بالرنين المغناطيسي، الكتف، الوتر، الشفا.

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