MAGNETIC RESONANCE IMAGING (MRI) SPECTRUM OF ROTATOR CUFF TEARS, WITH ARTHROSCOPIC – MRI CONTEXTUALIZATION

AVALIAÇÃO POR RESSONÂNCIA MAGNÉTICA (RM) DE RUPTURAS DA COIFA DOS ROTADORES, COM CONTEXTUALIZAÇÃO ARTROSCÓPIA – RM

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Abstract
Our understanding of rotator cuff (RC) pathogenesis and the optimal management of RC pathology is evolving and shoulder magnetic imaging (MRI) has a crucial role in this development, as it functionally depicts pathology in the painful shoulder patient, conveys optimal sensitivity and specificity rates in rotator cuff tear evaluation and characterization, and allows useful additional information in terms of patient management, namely regarding muscle atrophy, reducing unnecessary arthroscopic procedures.

We present and discuss the shoulder MRI protocol used at our Institution, and summarize the imaging spectrum of RC pathology by this technique, using a series of patients evaluated by our Department to conclude that MRI has very high levels of sensitivity and specificity transversely seen is most high work volume Radiology Departments.

Key-words
Magnetic resonance; Rotator cuff; Partial tear; Complete tear; Tendinosis; Atrophy; Specificity; Sensitivity.

Resumo
A compreensão clínica da fisiopatologia das alterações da coifa dos rotadores tem evoluído significativamente e para tal contribui de modo crucial a ressonância magnética do ombro, na medida em que caracteriza adequadamente patologia da coifa no examinado com ombro doloroso, apresenta óptima sensibilidade e especificidade na avaliação de ruptura tendinosa e fornece informação suplementar, nomeadamente relativa a atrofia muscular, orientando funcionalmente a terapêutica e evitando intervenções invasivas desnecessárias.

Apresentamos e fundamentamos o protocolo de RM do ombro usado na nossa Instituição e sintetizamos a iconografia patológica em RM de rupturas da coifa, fazendo referência a uma série de examinados avaliados pelo nosso Serviço, concluindo que a alta sensibilidade e especificidade da RM na avaliação da coifa é transversal à maioria dos Serviços de Radiologia.

Palavras-chave
Ressonância magnética; Coifa dos rotadores; Ruptura parcial; Ruptura total; Tendinose; Atrofia; Especificidade; Sensibilidade.

Background
The shoulder is composed of four joints: glenohumeral, acromioclavicular, sternoclavicular and scapulothoracic (the later predominately myotendinous), from which the glenohumeral joint presents as the most mobile joint in the human body, therefore frequently subject to multiple stress.

The rotator cuff (RC), composed by the SITS complex (supraspinatus, infraspinatus, teres minor and subscapularis tendons) in conjunction with the articular capsule as well as important ligamentous structures such as the coracohumeral and superior, middle and inferior glenohumeral ligaments form the major stabilizers of the joint. The long portion of the biceps tendon also contributes to joint stability, namely in abduction, with its intraarticular cephalic segment inserting in the superior glenoid (Fig. 1). These tendinous and ligamentous structures are frequently pathologically altered during the life course of most active individuals and are exquisitely characterized by magnetic resonance imaging (MRI), with very high levels of sensitivity and specificity transversely seen is most high work volume Radiology Departments.

The most commonly affected RC tendon is the supraspinatus and the most commonly observed mechanism of disruption is situated within the tendinosis-rupture spectrum, in which continuous mechanical aggression, namely due to subacromial conflict, results in scarring and tendon collagen degeneration, leading to loss of response to tensile strength and finally, macrorupture. Of course acute tendinitis or rupture are frequent, but not as frequent as the above mentioned chronic pathological mechanism.

Clinical evaluation of shoulder pain context is unspecific regarding tear differentiation, and the subjective approach intrinsic to these exams leads to considerable interobserver variability.

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There are multiple systems to describe RC tears, but the common principle regarding them is that MRI of RC pathology needs to produce precise, simple and management orientated conclusions. The most common lesions described in RC MRI are tendinosis, partial thickness tears and full thickness tears. The degree of fatty muscle atrophy should also be addressed, since significant muscle volume decrease leads frequently to re-rupture after surgery and therefore has important therapeutic implications.

**Partial thickness tears**

Partial thickness tears (PTT) should be classified regarding location, bursal-sided, articular-sided or intrasubstance. A partial thickness tear is present when there are visible bursal-sided intact fibers with articular-sided defect or vice versa. The tree types of mentioned tears can occur simultaneously in complex ruptures and it is important to stress that intrasubstance tears should always be mentioned, because they go unnoticed in standard arthroscopic procedures (Fig. 3). Partial tears should be classified regarding extent of injury: 3mm deep or less and 3mm to 6mm deep tears involving less than 50% of the full tendon thickness; larger than 6mm defects injuring more than 50% of the tendon thickness. This is invaluable information that must be reported, since normally defects larger than 6mm...
must undergo surgical repair, namely transtendon repair techniques, and small ruptures can be treated only with surgical debridement and favorable outcomes\textsuperscript{14}.

Small rim rent tears should always be searched for, with careful examination on sagittal and coronal oblique planes of the most anterior and lateral insertional supraspinatus fibers\textsuperscript{15}.

Fluid, blood and granulation tissue insinuate within tendon tears and has characteristic high signal defects in liquid sensitive weighting, namely fat saturated T2 weighted images, fat saturated protonic density (PD FS) and short tau inversion recovery sequences (STIR)\textsuperscript{4} (Fig. 4).

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Full thickness tears

Full thickness tears (FTT) occur when there is a complete section from articular to bursal side of the tendon, with the defect connecting these two surfaces (Fig. 5). As for partial thickness tears, complete tears fill with fluid, with high signal in liquid sensitive ponderations and are frequently accompanied by articular and subdeltoid fluid, cephalic migration of the humeral head, muscular atrophy, and if there is a complete tear (full thickness as well as full width tear), supraspinatus myotendinous stump medial retraction should be measured\textsuperscript{16}. Primary repair requires the tendon stump to be adjacent to the greater tubercle, since tendon retraction medial to the glenoid fossa is usually irreparable\textsuperscript{17} (Figs. 6, 7).

The size of full thickness tears is measured at its widest point between the two tendinous edges of the torn tendon (the report should refer both to anteroposterior and mediolateral plane measurements of the defect). Small tears are those less than 1 cm, medium size tears are those less than 3 cm, and large tears are those 3 to 5 cm. Massive tears are those greater than 5 cm\textsuperscript{18}. This information is determinant is surgical procedure choice, namely in the case of massive tears, in which patients benefit from specific repair techniques, such as arthroscopic rotator cuff repair reinforced with a graft\textsuperscript{19}.

A large amount of fluid in the subdeltoid bursa frequently represent extension of joint fluid through the capsule and tendon defect into the bursa\textsuperscript{20}.

Tendinosis

Tendon transformation due to tendinosis results in mucoid degeneration and fibrocartilaginous metaplasia, which appear as intermediate to high signal intensity in T2 weighted imaging, although not as high as commonly seen in tendon rupture. Likewise, the appearance of tendinosis is not as morphologically defined and linear as the high signal in liquid sensitive sequences corresponding to a tendon tear. Normally there is also diffuse or focal associated tendon thickening\textsuperscript{21} (Fig. 8).
Fatty atrophy
Supraspinatus and infraspinatus fatty atrophy should be calculated, namely by the muscular fossa occupation ratio. On the T1 weighted sagittal oblique plane, if there is severe fatty degeneration and muscle volume loss, with less than 50% of muscular occupation of the fossa, muscle atrophy can be diagnosed, negatively impacting patient prognosis\(^2\) (Fig. 9).

Material, methods and discussion
MRI shoulder evaluation was performed with a 1.5 Tesla MR imaging unit (Excite HDX, GE\(^\circledR\)), and a surface coil was used. Patients were positioned in dorsal decubitus, with the arm in supine, the shoulder slightly externally rotated, allowing supraspinatus tendon orientation parallel and perpendicular to the oblique coronal and oblique sagittal imaging planes.

MRI shoulder protocol consisted of oblique coronal T1-weighted images, to allow precise anatomical articular characterization, namely of the subacromial space and acromion deformity/type; oblique coronal T2 FS weighted images and PD FS weighted images (T2 FS weighted sequence is used to increase sensitivity to fluid, allowing characterization of tendinous edema/tear, and PD FS weighted sequence is used to better outline fluid filled tendinous tears); oblique sagittal STIR (to allow synchronous evaluation with the coronal views, mainly of the supraspinatus tendon) and T1 weighted images (used mainly to evaluate supra and infraspinatus muscular fossa occupation ratio). We also use transverse T2 FS weighted and PD FS weighted acquisitions, useful in labrum characterization.

A field of view of 18 cm was used, the slice thickness was 3 mm with 0.3 mm spacing and the imaging matrix was 320 x 192. The aforementioned established MRI criteria were used for the diagnosis of a partial-thickness or full-thickness rotator cuff tear.

From 14.12.2012 to 14.12.2015 32 patients underwent rotator cuff surgical repair in our Hospital. Of this sample prior MRI evaluation was requested in 11 patients (ages between 36 years old and 70 years old – mean age of 57 years)

We used surgical findings as the gold standard in detecting rotator cuff tears, namely supraspinatus tendon pathology, in comparison with the MRI findings.

According to the surgical findings, there were 7 FTT (64%), 1 PTT (9%) and 3 cases of tendinosis (27%).
MRI detected 1 cases of PTT and agreed with surgery in this case. MRI detected 7 cases of FTT and agreed with surgery in 6 of them. One case of FTT was wrongly diagnosed as tendinosis in MRI and one case of tendinosis was wrongly diagnosed as FTT by MRI.

MRI, and surgical findings are summarized in Table 1. Sensitivity and specificity of MRI in diagnosing partial and full thickness tears are given in Table 2.

Table 1 – MRI and surgical findings

<table>
<thead>
<tr>
<th>Partial thickness tear</th>
<th>Full thickness tear</th>
<th>Tendinosis</th>
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<tr>
<td>Surgical findings</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>MRI findings</td>
<td>1</td>
<td>7</td>
</tr>
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In summary, MRI has an optimal accuracy in rotator cuff tear characterization, with high sensitivity and specificity rates, in our sample, comparable to those observed in large meta-analysis.

References

Table 2 – Sensitivity and specificity of MRI in detecting partial and complete tears

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<thead>
<tr>
<th>MRI</th>
<th>Sensitivity</th>
<th>Specificity</th>
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<tr>
<td>PTT (%)</td>
<td>FTT (%)</td>
<td>PTT (%)</td>
</tr>
<tr>
<td>100</td>
<td>86</td>
<td>100</td>
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