

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 ARTROSCOPIA – 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 ótima 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 glenoid¹ (Fig. 1).

These tendinous and ligamentous structures are frequently pathologically altered during the life course of most active individuals² 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 Departments³.

The most commonly affected RC tendon is the supraspinatus⁴ 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^{5,6}.

Clinical evaluation of shoulder pain context is unspecific regarding tear differentiation, and the subjective approach intrinsic to these exams leads to considerable interobserver variability^{7,8}.

Shoulder magnetic resonance imaging (MRI) conveys optimal sensitivity and specificity rates in rotator cuff tear evaluation and characterization, allowing useful additional information in terms of patient management, namely

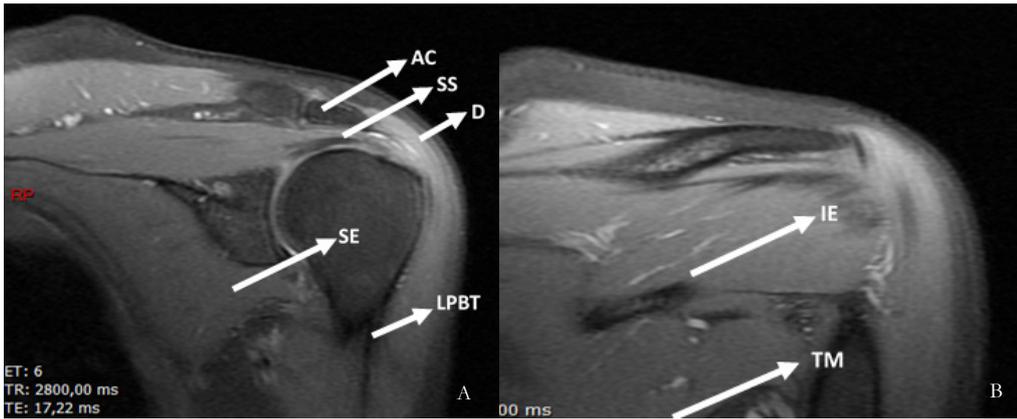


Figure 1 – Coronal oblique PD FS depicting normal rotator cuff anatomy. A) AC: acromio-clavicular joint, SS: supraspinatus tendon; D: deltoid muscle; SE: subscapularis tendon; LPBT: long portion of biceps tendon. B) IE: infraspinatus tendon; TM: teres minor tendon.

regarding muscle atrophy, reducing unnecessary arthroscopic procedures^{9,10}.

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 conclusions¹¹. 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 implications¹².

Partial thickness tears

Partial thickness tears (PTT) should be classified regarding location, bursal-sided, articular-sided or intrasubstance

(Fig. 2). Articular-sided tears are much more common, frequently in the anterior aspect of the tendon, supposedly due to a sparser articular-side vascularization, prone to injury¹³. A partial thickness tear is present when there are visible bursal-sided intact fibers with articular-sided defect or vice versa. The three 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

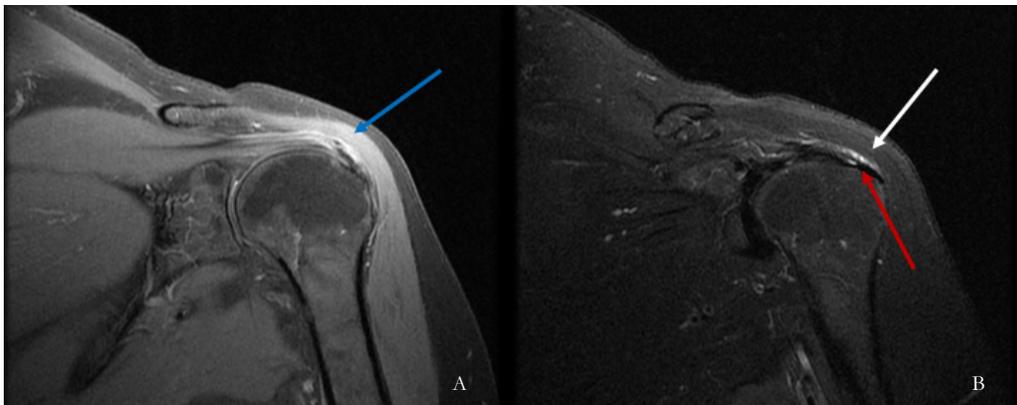


Figure 2 – Bursal sided supraspinatus partial thickness tear. T2 weighted FS coronal oblique image (A) complemented with PD FS coronal oblique evaluation (B). Liquid in the subdeltoid bursa (blue and white arrow) as well as insinuating through bursal sided partial tear of the supraspinatus tendon (red arrow).

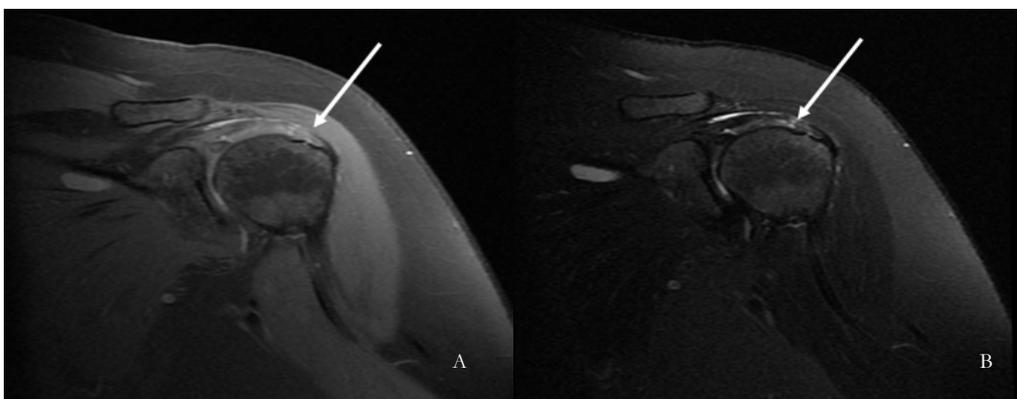


Figure 3 – Multiple small intrasubstance supraspinatus partial thickness tears (white arrows). T2 weighted FS coronal oblique image (A) complemented with PD FS coronal oblique evaluation (B).

must undergo surgical repair, namely transtendon repair techniques, and small ruptures can be treated only with surgical debridement and favorable outcomes¹⁴.

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 fibers¹⁵.

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)⁴ (Fig. 4).

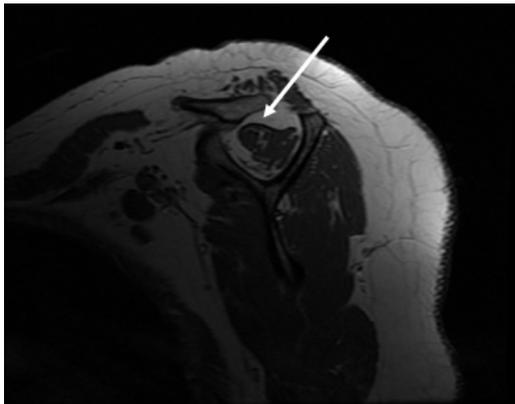


Figure 4 – In the previous partial thickness supraspinatus tear there is concomitant muscular atrophy, with reduced supraspinatus fossa muscular occupation, although superior to 50% (white arrow).

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 measured¹⁶. Primary repair requires the tendon stump to be adjacent to the greater tubercle, since tendon

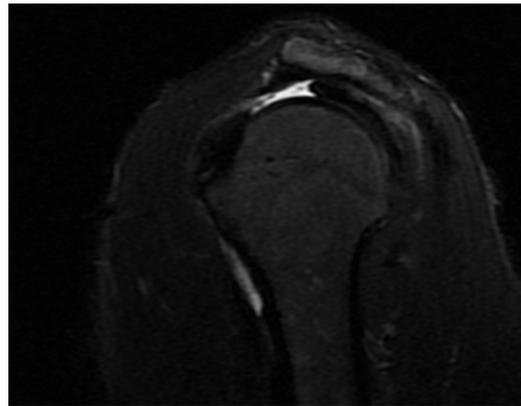


Figure 5 – Massive supraspinatus full thickness tear. Sagittal STIR acquisition demonstrating the anteroposterior width of the defect.

retraction medial to the glenoid fossa is usually irreparable¹⁷ (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 cm¹⁸. This information is determinant in 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 graft¹⁹. A large amount of fluid in the subdeltoid bursa frequently represent extension of joint fluid through the capsule and tendon defect into the bursa²⁰.

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 thickening²¹ (Fig. 8).

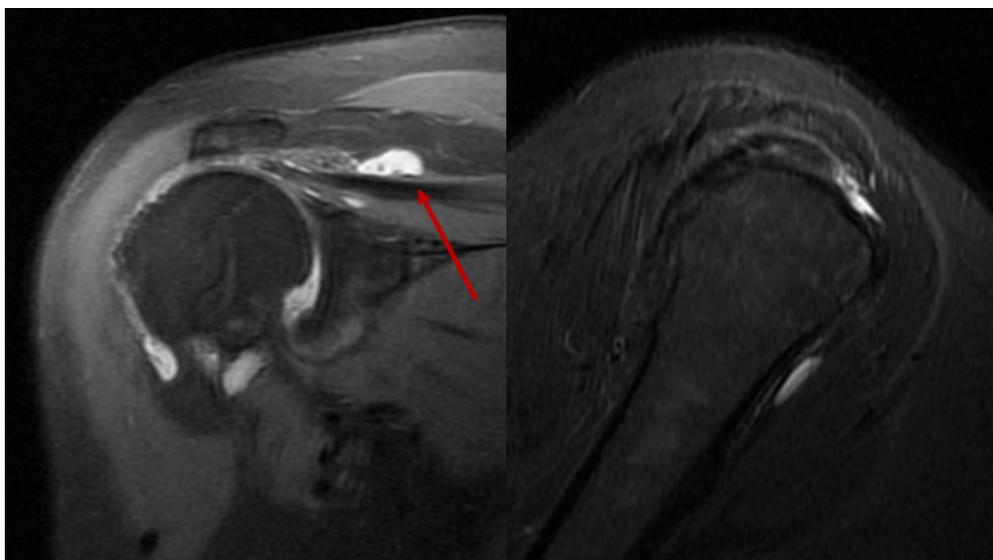


Figure 6 – Complete (full width and full thickness) supraspinatus tear. PD FS coronal oblique evaluation (A) complemented with sagittal STIR acquisition (B), demonstrating absence of trochanter coverage by the tendon with tendinous stump retraction to the level of the glenoid. Note subacromial bursitis (red arrow).

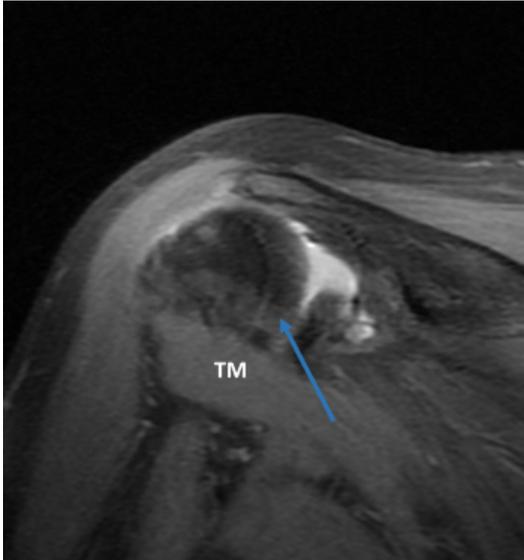


Figure 7 – In the previous setting of complete (full width and full thickness) supraspinatus tear, PD FS coronal oblique evaluation demonstrates concomitant complete tear of the infraspinatus tendon (blue arrow). TM: Teres minor.

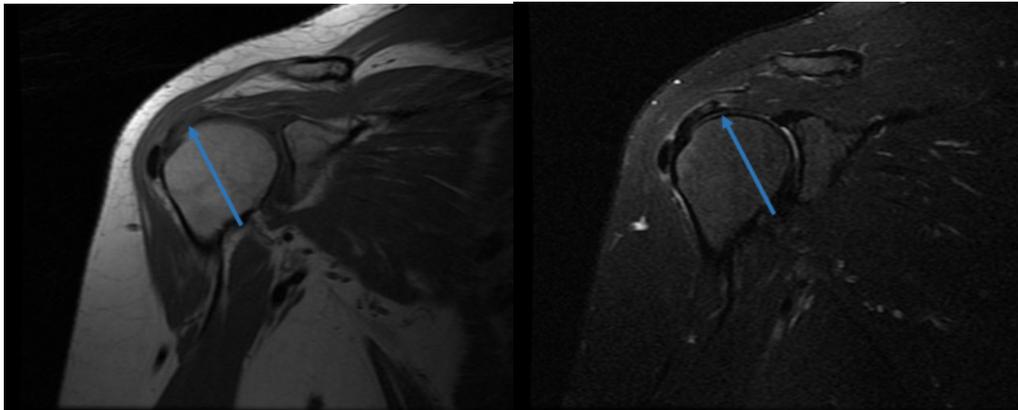


Figure 8 – Intrasubstance intermediate signal in the supraspinatus tendon, due to tendinosis (blue arrows). T2 weighted coronal oblique image (A) complemented with PD FS coronal oblique evaluation (B).

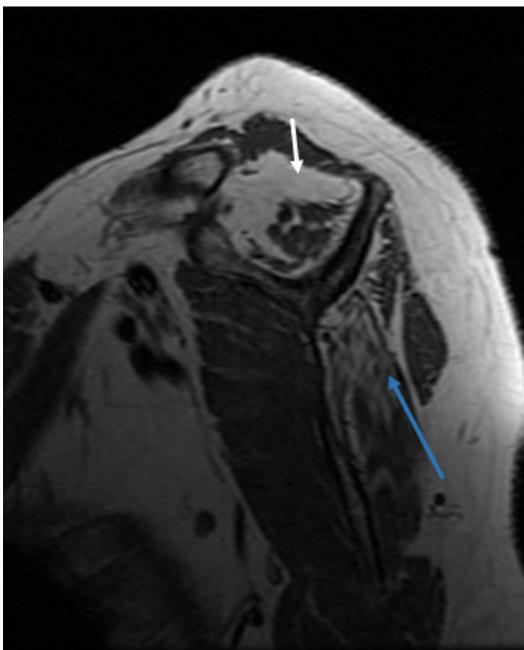


Fig. 9 – In a supraspinatus full thickness tear, sagittal T1 weighted sequence demonstrates significant muscular atrophy, with reduced supraspinatus (white arrow) and infraspinatus (blue arrow) muscular fossa occupation, inferior to 25%.

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 prognosis²² (Fig. 9).

Material, methods and discussion

MRI shoulder evaluation was performed with a 1,5 Tesla MR imaging unit (Excite HDX, GE®), 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

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 1 | Partial thickness tear | Full thickness tear | Tendinosis |
|-------------------|------------------------|---------------------|------------|
| Surgical findings | 1 | 7 | 3 |
| MRI findings | 1 | 7 | 3 |

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-analysis³.

References

- Petchprapa CN, Beltran LS, Jazrawi LM, et al. The rotator interval: a review of anatomy, function, and normal and abnormal MRI appearance. *AJR Am J Roentgenol.* 2010;195:567-76.
- Brox JI. Regional musculoskeletal conditions: Shoulder pain. *Best Pract Res Cn Rheumatol.* 2003;17:33-56.
- Lenza M, Buchbinder R, Takwoingi Y, Johnston RV, Hanchard NC, Faloppa F. Magnetic resonance imaging, magnetic resonance arthrography and ultrasonography for assessing rotator cuff tears in people with shoulder pain for whom surgery is being considered. *Cochrane Database Syst Rev.* 2013 Sep;24:9.
- Ehab A, Abd-ElGawad, Mohammed A. Ibraheem, Ezzat H. Fouly. Evaluation of supraspinatus muscle tears by ultrasonography and magnetic resonance imaging in comparison with surgical findings. *Egyptian Journal of Radiology and Nuclear Medicine.* 2013;12.
- Hashimoto T, Nobuhara K, Hamada T. Pathologic evidence of degeneration as a primary cause of rotator cuff tear. *Clin Orthop Relat Res.* 2003;415:111–20.
- Khan KM, Cook JL, Bonar F, Harcourt P, Åström M. Histopathology of common tendinopathies. Update and implications for clinical management. *Sports Med.*1999;27:393-408.
- Hegedus EJ, Goode A, Campbell S, et al. Physical examination tests of the shoulder: A systematic review with meta-analysis of individual tests. *Br J Sports Med.* 2008;42:80-92.
- Beaudreuil J, Nizard R, Thomas T, et al. Contribution of clinical tests to the diagnosis of rotator cuff disease: A systematic literature review. *Joint Bone Spine.* 2009;76:15-19.
- de Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. *AJR Am J Roentgenol.* 2009;192:1701-7.
- Sher JS, Iannotti JP, Williams GR et al. The effect of shoulder magnetic resonance imaging on clinical decision making. *J Shoulder Elbow Surg* 1998;7(3):205-9.
- Spencer EE, Jr., Dunn WR, Wright RW, et al. Interobserver agreement in the classification of rotator cuff tears using magnetic resonance imaging. *Am J Sports Med.* 2008;36:99-103.

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

| Table 2 | Sensitivity | Specificity |
|---------|---------------|-----------------|
| | PTT(%) FTT(%) | PTT (%) FTT (%) |
| MRI | 100 86 | 100 80 |

MRI evaluation should therefore be gradually implemented as standard procedure in pre-operative assessment of the painful shoulder patient.

As mentioned earlier, a tendon tear is filled with fluid and granulation tissue, with high signal in liquid sensitive weighting. Nonetheless, full thickness tears can also contain intermediate T2 signal intensity, owing to scarring and volume averaging from adjacent histopathologic changes that can be confused for transformation due to tendinosis²³, which can explain the case of one FTT diagnosed as tendinosis and vice versa.

- Liem D, Lichtenberg S, Magosch P, Habermeyer P. Magnetic resonance imaging of arthroscopic supraspinatus tendon repair. *J Bone Joint Surg Am.* 2007;89:1770-6.
- Lohr JF, Uthoff HK. The microvascular pattern of the supraspinatus tendon. *Clin Orthop Relat Res.* 1990;35-8.
- Strauss EJ, Salata MJ, Kercher J, Barker JU, McGill K, Bach BR Jr, Romeo AA, Verma NN. The arthroscopic management of partial-thickness rotator cuff tears: a systematic review of the literature. *Arthroscopy.* 2011 Apr;27(4):568-80.
- Vinson EN, Helms CA, Higgins LD. Rim-vent tear of the rotator cuff: A common and easily overlooked partial tear. *AJR Am J Roentgenol.* 2007;189:943-6.
- Farley TE, Neumann CH, Steinbach LS, et al. Full-thickness tears of the rotator cuff of the shoulder: Diagnosis with MR imaging. *AJR Am J Roentgenol.* 1992;158:347-51.
- Thomazeau H, Boukobza E, Morcet N, Chaperon J, Langlais F. Prediction of rotator cuff repair results by magnetic resonance imaging. *Clin Orthop Relat Res* 1997;344:275-83.
- Ciepiela MD, Burkhead WZ. Classification of rotator cuff tears. In: Burkhead WZ Jr., ed. *Rotator cuff disorders.* Baltimore: William and Wilkins, 1996:100-10.
- Agrawal V. Healing rates for challenging rotator cuff tears utilizing an acellular human dermal reinforcement graft. *International Journal of Shoulder Surgery.* 2012;6(2):36-44.
- Zlatkin MB, Reicher MA, Kellerhouse LE, McDade W, Vetter L, Resnick D. The painful shoulder: MR imaging of the glenohumeral joint. *J Comput Assist Tomogr.* 1988.
- Sein ML, Walton J, Linklater J, et al. Reliability of MRI assessment of supraspinatus tendinopathy. *British Journal of Sports Medicine.* 2007;41(8):e1-e4.
- Goutallier D, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. *J Shoulder Elbow Surg* 2003;12(6):550-4.
- Buck FM, Grehn H, Hilbe M, et al. Magnetic resonance histologic correlation in rotator cuff tendons. *J Magn Reson Imaging.* 2010;32:165-72.