Comparative Study between Multi-slice Computed Tomographic Arthrography and Arthroscopy in the Evaluation of Rotator Cuff Tears*

Estudo comparativo entre artrotomografia computadorizada multi-slice e artroscopia na avaliação das lesões do manguito rotador

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Rev Bras Ortop 2019;54:579–586.

Abstract

Objective To compare the imaging findings of anatomical alterations using multi-slice computed tomographic arthrography in the evaluation of rotator cuff tears in the shoulder, correlating them with the arthroscopy (the gold standard diagnostic test) findings.

Materials and Methods A longitudinal, prospective, comparative study of diagnostic accuracy performed in the period between June 2016 and June 2017 in patients of both sexes, aged between 40 and 70 years, with shoulder rotator cuff tendon tears and therapeutic need to undergo shoulder arthroscopy. Patients with contraindication to magnetic resonance imaging were included. After multi-slice computed tomographic arthrography, all patients underwent arthroscopy.

Results To obtain the results, the following parameters were determined: sensitivity, specificity, accuracy, positive predictive value, negative predictive value, and Kappa coefficient, and contrast between the imaging method and arthroscopy.

Conclusion In the impossibility of performing magnetic resonance imaging (the gold standard imaging technique), multi-slice computed tomographic arthrography is an imaging examination capable of evaluating/diagnosing rotator cuff tears.

Keywords
- arthrography/methods
- rotator cuff
- shoulder injuries/classification
- arthroscopy

* *Study developed at Hospital Português da Bahia, Salvador, BA, Brazil. Originally published by Elsevier Ltda.*

received
October 16, 2017
accepted
December 14, 2017

DOI https://doi.org/10.1016/j.rbo.2017.12.020.
ISSN 0102-3616.

Resumo

Objetivo Comparar os achados por imagem das alterações anatômicas da artrotomografia computadorizada *multi-slice* na avaliação das lesões do manguito rotador do ombro e correlacioná-los com os achados da artroscopia (exame diagnóstico padrão-ouro).

Materiais e Métodos Estudo longitudinal, prospectivo, comparativo de acurácia diagnóstica, feito de junho de 2016 a junho de 2017, em pacientes de ambos os sexos, com idades entre 40 e 70 anos, com lesão dos tendões do manguito rotador do ombro, e que tinham necessidade terapêutica de fazer artroscopia do ombro. Foram incluídos pacientes com contraindicação à realização de ressonância magnética. Após a artrotomografia computadorizada *multi-slice*, todos os pacientes foram submetidos a artroscopia.

Resultados Para a obtenção dos resultados, os seguintes parâmetros foram considerados: sensibilidade, especificidade, acurácia, valor preditivo positivo, valor preditivo negativo, coeficiente Kappa, e contraposição do método de imagem com a artroscopia.

Conclusão Na impossibilidade da realização da ressonância magnética (exame de imagem padrão-ouro), a artrotomografia computadorizada *multi-slice* se mostra um exame de imagem capaz de avaliar/diagnosticar as lesões do manguito rotador.

Palavras-chave
- artrografia/métodos
- manguito rotador
- lesões do ombro/classificação
- artroscopia

Introduction

Lesions that affect the rotator cuff are among the most frequent causes of shoulder pain, which are likely to generate marked functional impotence.[1–3] These lesions represent a spectrum of diseases ranging from acute tendonitis to extensive injury, compromising all of the anatomical components of the shoulder. In addition to its high prevalence, which ranges from 7% to 40%, it is also known that this disorder increases in direct proportion with advancing age.[4]

The rotator cuff acts to dynamically stabilize and balance the humeral head with respect to the glenoid, while the axial muscle group (deltoid and pectoralis major etc.) acts to move the humerus: rupture of the rotator cuff can easily lead to loss of function of the shoulder [5,6] in varying degrees.

The age, symptoms and level of activity of the patient directly influence the treatment, as well as the presence of other associated abnormalities, such as labral, cartilage and bone lesions.[7–9]

In the assessment of the rotator cuff, magnetic resonance imaging (MRI) is considered the gold standard in comparison with other imaging methods. It is an examination that captures electromagnetic waves for the definition of images of the human body.[10] Some sequences during the examination, however, make the MRI relatively time-consuming, which becomes a serious problem in the case of patients with claustrophobic "traits" or indeed claustrophobia. In addition, metal implants may be a contraindication for this test. Altered functioning of cardiac pacemakers or even displacement of brain clips and orthopedic implants are examples of this type of concern.

An optional imaging examination in the diagnosis of rotator cuff lesions of the shoulder does not exist so far. Thus, the aim of the present study is to compare the efficacy of multi-slice computed tomographic arthrography (MSCTA), and the findings resulting from it regarding anatomical changes, with the arthroscopic findings in the evaluation of shoulder rotator cuff lesions. The study focused on a group of patients for whom the MRI was relatively or absolutely contraindicated.

Materials and Methods

A longitudinal, prospective, comparative study conducted from June 2016 to June 2017 with patients of both sexes, aged between 40 and 70 years, with a history and clinical findings of rotator cuff tendon injury (positive for the Jobe, Patte and Gerber tests), who had clinical and therapeutic need to undergo shoulder arthroscopy because they did not respond to the conservative treatment (analgesic and anti-inflammatory medication, physiotherapy, hydrotherapy, infiltration etc.).

Patients from the Orthopedics Service of our institution for whom the MRI was contraindicated were included, as well as patients whose physician had requested a computed tomographic arthrography (CTA) of the shoulder as an optional method of evaluation.

The exclusion criteria were: patients who underwent previous surgical procedures in the affected shoulder; and those with inability to fill out the clinical questionnaire or to comprehend the free and informed consent form (FICF), or who were not accompanied by a responsible person capable of doing so. We also excluded patients with allergies, claustrophobia, active hyperthyroidism, severe heart failure, high-grade pulmonary insufficiency, asthma, renal failure, autoimmune diseases, multiple myeloma, nephropathies with diabetes mellitus, or other serious conditions unrelated to the purpose of the study.

All patients eligible for the study were adequately informed of its objectives, risks and benefits, and they entered the protocol after being fully aware of their desire and after signing the FICF. The research began only after the protocol was evaluated and approved by the Ethics in Research Committee of the institution.

The patients were referred to the computed tomography sector for MSCTA examinations according to a clinically standardized protocol. Subsequently, all patients with indication for arthroscopic surgical treatment underwent arthroscopy in the conventional manner, without the interference of the researchers in the indication or protocol of the procedures. The orthopedic evaluation was performed by means of history research and clinical findings of rotator cuff injuries according to the criteria adopted by the attending physician. The clinical diagnostic findings were recorded in the same examination sheets that were used to plan the treatment of the rotator cuff lesion on the shoulder of the studied patient. The MSCTA of each patient was performed on a single day with the conventional technique using the Optima (GE, Chicago, IL, US) device with 128 multi-detectors. Prior to the method, the patients were submitted to arthrography as follows: a) identification of the exact point where the intra-articular needle would be introduced by fluoroscopy; b) asepsis and antisepsis of the shoulder to be examined with 2% chlorhexidine (for degermation) and 0.5% chlorhexidine (alcohol solution); c) local anesthesia with 2% xylocaine introduced through a 30×7 mm needle; d) introduction of a 18 or 20 Ga spinal anesthesia needle 7 cm long until reaching the glenohumeral joint guided by fluoroscopic vision; e) injection in the glenohumeral joint of 10 to 12 ml of solution with 5 ml of contrast medium diluted in 100 ml of 0.9% saline guided by fluoroscopy of computed tomography by the anterior route; f) referral of patients for imaging.

After the arthroscopy, all images of the MSCTA were analyzed again by a radiologist with more than 10 years of experience in musculoskeletal radiology, who had no access to the medical history or the results of the arthroscopy. In order to prevent flaws, the authors analyzed all of the MSCTA results separately, without patient identification.

The arthroscopies were performed in the conventional manner according to the technique, protocol and decision of the attending physician. Three small cuts were made to open the arthroscopic portals (anterior, lateral and posterior) on the shoulder of the patient. The camera to film and visualize of the surgery was located in the posterior portal, and the anterior and lateral portals served to introduce the surgical material necessary for the correction of the lesions. After the procedure, the authors of the study had access to the videos of the arthroscopies to analyze the existing anatomical lesions in each patient with their own protocol record.

We considered arthroscopy the gold standard examination, and the following parameters were determined: sensitivity, specificity, accuracy, positive predictive value, negative predictive value, and Kappa coefficient, with contrast of the MSCTA with the arthroscopy. For this purpose, 2×2 double-entry tables were made, with frequencies and percentages of the pairs of variables formed and their respective marginal and total values; thus, for each table, the aforementioned summary measures were calculated. The Kappa coefficient classifies the degree of agreement as: null (values lower than 0), bad (0–19), reasonable (20–39), moderate (40–59), substantial (60–79) and almost perfect (80–100).[11]

Table 1 Sociodemographic and clinical variables of patients

Characteristics	n (%) or mean (standard deviation)
Sex	
Male	15 (50%)
Female	15 (50%)
Age	57.00 (8.28)
Weight	68.00 (5.56)
Height	1.64 (0.06)
Cardiovascular disease	16 (53,3%)
Use of pacemaker	9 (30%)
Other comorbidities	19 (63.3%)
Claustrophobia	18 (60%)
Presence of metal implants	16 (53.3%)
Operated dominant limb	18 (60%)
Diagnostic time	
Up to six months	2 (6.7%)
More than 6/less than 12 months	12 (40%)
More than 12 months	16 (53.3%)

The sociodemographic and clinical variables of the patients, as well as the findings of the MSCTA and arthroscopy, are summarized in ►**Tables 1–5**.

By chance, the gender distribution in this study was the same, with 15 men and 15 women with an average age of 57 years, mean weight of 68 kg, and average height of 1.64 m. The dominant limb of the patients was operated in 60% of the cases, and the diagnosis of the lesion, in most cases, took more than 12 months to be established (53.3%).

Table 2 Lesions found in the computed tomographic arthrography and in the arthroscopy

CTA	With arthroscopic lesion	Without arthroscopic lesion	*p*-value
Rotator cuff			
With lesion	27	0	
Without lesion	7	4	
Supraspinatus			
With lesion	26	0	< 0.001
Without lesion	7	5	
Infraspinatus			
With lesion	15	0	< 0.001
Without lesion	4	19	
Subscapular			
With lesion	13	0	
Without lesion	3	22	

Abbreviation: CTA, computed tomographic arthrography.

Table 3 Characteristics of the lesions found in the computed tomographic arthrography and in the arthroscopy

Lesions	CTA n (%)	Arthroscopy n (%)
Supraspinatus		
Intact	4 (13.3%)	0
Complete	12 (40%)	15 (50%)
Transfixing	9 (30%)	6 (20%)
Partial bursal	1 (3.33%)	5 (16.7%)
Partial intrasubstantial	0	0
Partial articular	4 (13.3%)	4 (13.3%)
Infraspinatus		
Intact	15 (50%)	13 (43.33%)
Complete	6 (20%)	8 (26.67%)
Transfixing	1 (3.33%)	1 (3.33%)
Partial bursal	0	1 (3.33%)
Partial intrasubstantial	0	0
Partial articular	8 (26.67%)	7 (23.33%)
Subscapular		
Intact	17 (56.67%)	15 (50%)
Complete	5 (16.7%)	4 (13.3%)
Transfixing	1 (3.33%)	1 (3.33%)
Partial bursal	0	0
Partial intrasubstantial	0	1 (3.33%)
Partial articular	7 (23.33%)	9 (30%)

Abbreviation: CTA, computed tomographic arthrography.

Table 4 Findings associated with rotator cuff injuries in the MSCTA and in the arthroscopy

Findings	MSTCA	Arthroscopy
long head of the biceps tendon (lesion)	7	8
Anchor of the biceps (lesion)	0	0
Labrum (lesion)	3	3
Cartilage (lesion)	2	2
Bone structures (lesion)	11	11
Joint capsule (lesion)	0	0
Loose body (intra-articular)	0	0

Abbreviation: MSCTA, multi-slice computed tomographic arthrography.

Among the clinical variables observed in the patients were claustrophobia (60%), cardiovascular diseases (53.3%), metal implants (53.3%), and diverse comorbidities (63.3%).

Results

The most common abnormality visualized in the arthroscopy was injury of the supraspinatus muscle tendon, which was also evident in the MSCTA of every patient in the study; among these abnormalities, the most commonly found was complete supraspinatus lesion, which was evident in 12 and in 15 patients by MSCTA and arthroscopy, respectively (►**Fig. 1**).

Regarding the second most common abnormality – infraspinatus muscle tendon injury – the lesion most commonly found was partial articular lesion, which was evident in eight patients by MSCTA, and in seven patients by arthroscopy.

Rotator cuff lesions were detected by arthroscopy in 27 patients, and by MSCTA in 20 patients.

With arthroscopy, supraspinatus lesions were detected in 26 patients, infraspinatus lesions in 15, and subscapular lesions in 13, while the MSCTA showed the same lesions in 20, 11 and 10 patients respectively.

The lesions were differentiated between complete, transfixing, partial bursal, partial intrasubstantial, and partial articular lesions.

Regarding the supraspinatus tendon lesions detected by MSCTA, they were complete in 12 patients; transfixing in 9; partial bursal in 1; and partial articular in 4.The infraspinatus tendon lesions were distributed as follows: complete lesion in six patients; transfixing lesion in one; and partial articular in eight patients. As for the subscapularis tendon lesions, they were complete in five patients; transfixing in one; and partial articular in seven patients (►**Figs. 2** e **3**).

In the arthroscopy, the supraspinatus tendon lesions were complete in 15 patients; transfixing in 6; partial bursal in 5; and partial articular in 4 patients. Regarding the infraspinatus tendon lesions, they were complete in eight patients; transfixing in one; partial bursal in one; and partial articular in seven patients. As for the subscapularis tendon lesions, they were complete in four patients; transfixing in one; partial intrasubstantial in one; and partial articular in nine patients.

As for the findings associated with rotator cuff lesions, labral lesions (three patients), cartilage lesions (two patients) and bone lesions (eleven patients) were also identified in both the MSCTA and arthroscopy. Concerning the associated lesion of the long head of the biceps tendon, in the arthroscopy this lesion was identified in eight patients, while in the MSCTA it was identified in seven patients.

Intrasubstantial partial lesion of the supraspinatus and infraspinatus tendons was not found by MSCTA or by arthroscopy. This lesion was identified only once in the subscapularis tendon by arthroscopy.

Injuries to the biceps anchor and the joint capsule, as well as the presence of articular loose bodies, were not observed by arthroscopy or MSCTA.

In the present study, for the purpose of calculating sensitivity and specificity, it was necessary to take a sample from a distinct group of eight patients with pathologies other than rotator cuff lesions and who also underwent MSCTA and arthroscopy.

Thus, our specificity (non-diseased patients) is not reflected at all because of the selection bias. However, the sensitivity (sick patients) represents reality perfectly.

Discussion

There are few scientific studies comparing MSCTA and arthroscopy in the evaluation of rotator cuff lesions, which makes it difficult to correlate the findings. Thus, we sought to

Table 5 MSCTA – sensitivity, specificity, positive predictive value, negative predictive value, accuracy and Kappa coefficient (%)

Variable	Rotator cuff	Supraspinatus	Infraspinatus	Subscapular
Sensitivity	79.41 (%)	78.78 (%)	78.95 (%)	81.25 (%)
Specificity	100 (%)	100 (%)	100 (%)	100 (%)
PPV	100 (%)	100 (%)	100 (%)	100 (%)
NPV	36.36 (%)	41.67 (%)	82.61 (%)	88.00 (%)
Accuracy	81.57 (%)	81.57 (%)	89.47 (%)	92.11 (%)
Kappa	44.44 (%)	49.51 (%)	78.94 (%)	83.39 (%)

Abbreviations: MSCTA, multi-slice computed tomographic arthrography; NPV, negative predictive value; PPV, positive predictive value.

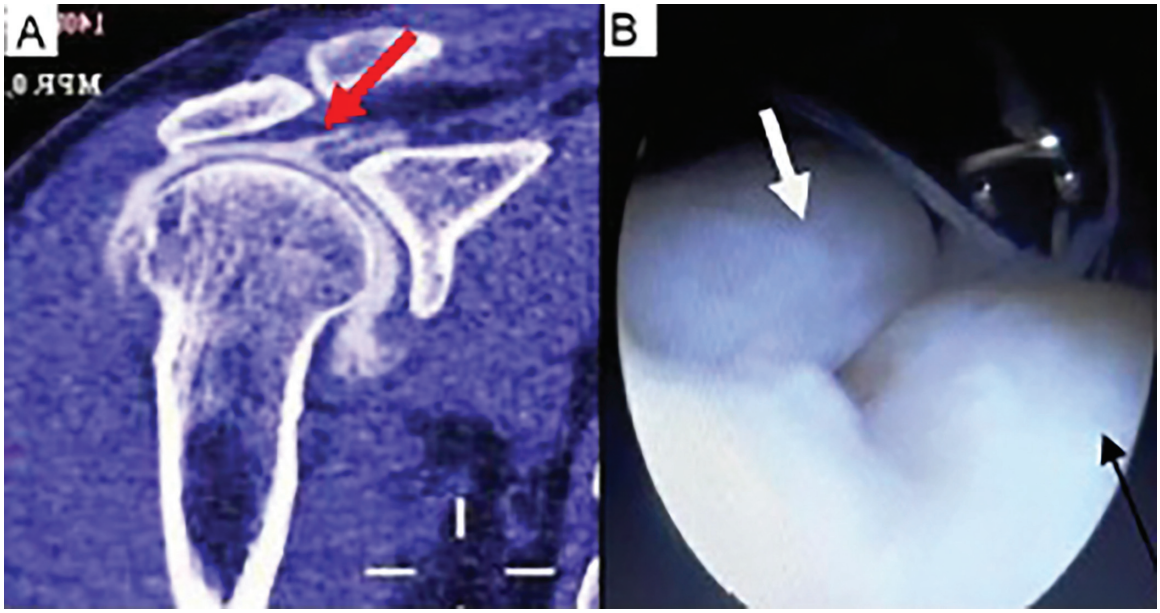

Fig. 1 Complete supraspinatus tendon injury (red arrow). A, coronal cut of the multi-slice computed tomographic arthrography (MSCTA); B, subacromial arthroscopic vision (white arrow - supraspinatus tendon; black arrow - major humerus tuberosity).

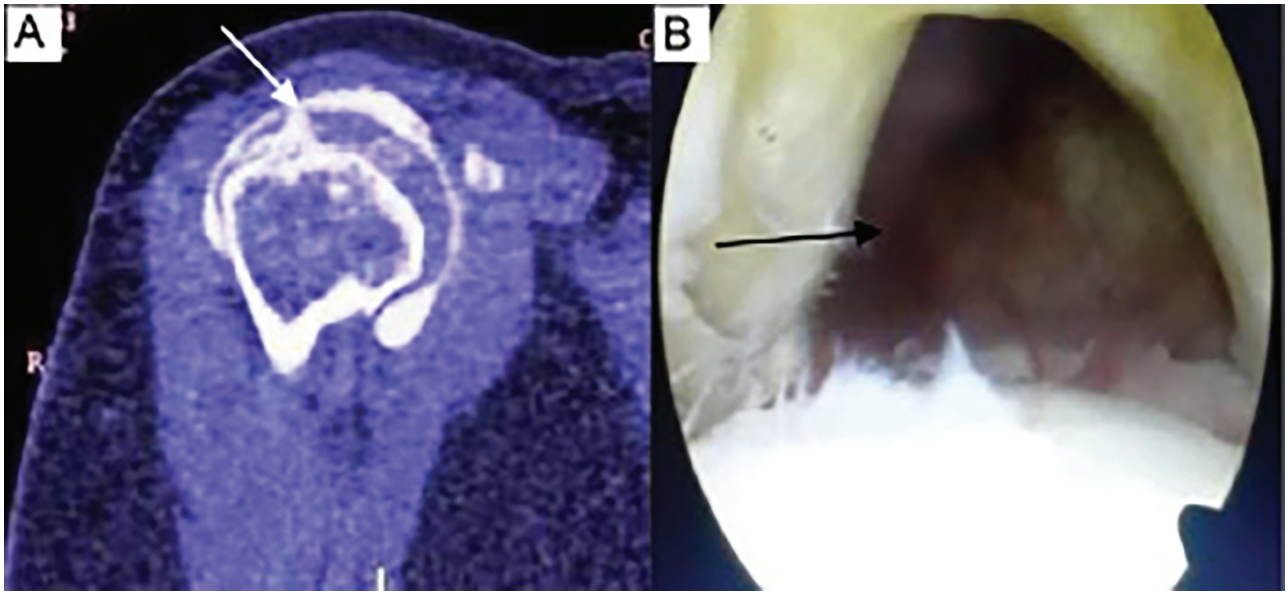

Fig. 2 Transfixing lesion of the supraspinatus tendon. A, sagittal section of the MSCTA (arrow); B, intra-articular arthroscopic view (arrow).

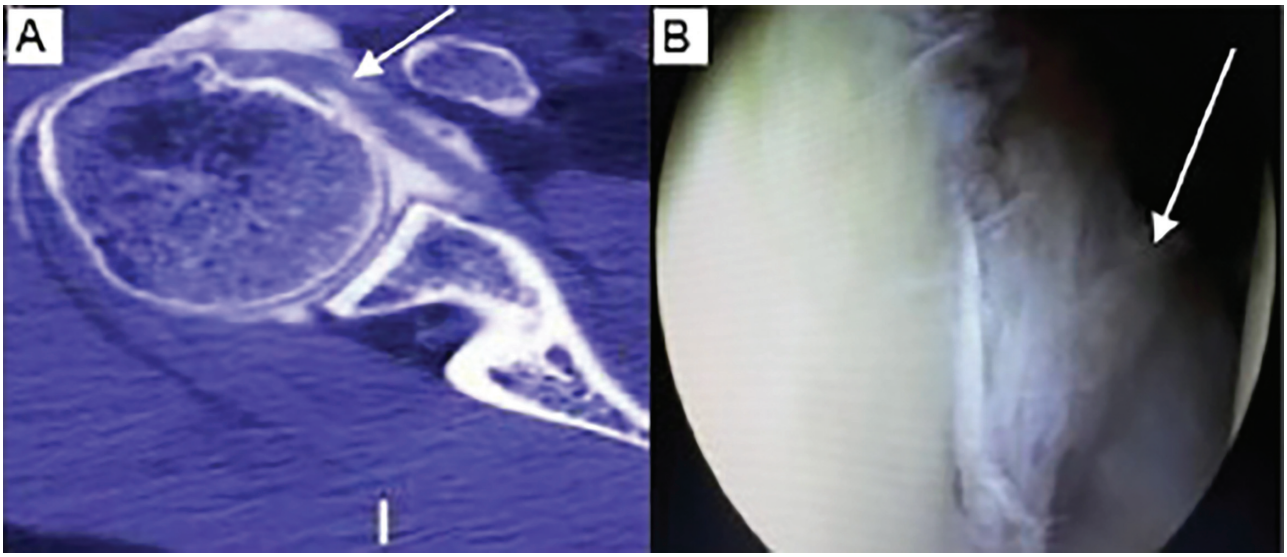

Fig. 3 Partial lesion of the subscapular tendon. A, axial section of the MSCTA (arrow); B, intra-articular arthroscopic view (arrow).

revise several studies that discussed some anatomical structures correlated with the present study.

Rotator cuff lesions have an unknown incidence in the general population, with a high prevalence that increases with age and at around 60 years reaches an incidence close to 60%.[6,12] In our study, the mean age of the patients was 57 years.

The dominant limb is the most frequently affected limb in rotator cuff lesions, probably due to its greater demand when compared to the opposite side.[13] We observed in our study that 60% (18 patients) of the cases affected the dominant side of the patient, which corroborates the findings in the literature.

Although our patients had a significant number of comorbidities, just as in the studies in the literature, those were not considered a negative factor for the indication of the surgical procedure and the subsequent postoperative rehabilitation.[14,15]

As for other lesions (labral, cartilaginous, and bone lesions, as well as lesion of the long head of the biceps tendon) associated with those of the rotator cuff, we observed in our study that the MSCTA was able to identify them with the same precision as arthroscopy. Many authors understand that rotator cuff injury and instability with associated lesions are closely related, especially in individuals older than 60 years of age.[16–19] Although we did not have any cases of associated shoulder instability among our patients, associated lesions were identified.

Even with all of the advances achieved in the field of musculoskeletal imaging, to date there is neither an established consensus regarding which imaging technique provides the best diagnostic results and follow-up of patients with shoulder rotator cuff injury, nor a standardization of the available methodologies when it is impossible to perform an MRI, which is currently considered the best imaging method for the diagnosis of this kind of lesion.

However, it is known that CTA and magnetic resonance arthrography (MRA) have been frequently used in the preoperative assessment of rotator cuff lesions.[20–22]

The advantage of MRA over the conventional MRI is that the contrast fluid introduced into the joint distends it, separates the structures, and promotes a better detailing of the intracapsular structures of the shoulder, as well as a better appreciation of its complex anatomy and anatomical variations; besides that, the contrast medium enhances the structures of the joint and, consequently, enables a more clear identification of the lesions. One disadvantage is to transform a non-invasive examination into a minimally invasive, although universally tolerated, examination.[23]

In a comparative study, Farley et al[24] evaluated by MRA 36 patients with partial or complete lesions of the rotator cuff, which were confirmed by the arthroscopic route. Based on the radiological observation, the diagnosis was true positive in 12 patients, true negative in 16, false positive in 3, and false negative in 5 patients. The isolated sensitivity of the MRA was of 71%, the specificity was of 84%, and the accuracy was of 78%. In our study, based on the MSCTA, we achieved findings with a better result: a sensitivity of 79.41%, a specificity of 100%, and an accuracy of 81.57%.

According to Rhee et al,[25] the combined use of shoulder arthrography with magnetic resonance imaging and computed tomography offers distinct advantages over conventional imaging (without the use of the articular contrast medium). Contrast medium and joint distension have improved the assessment of various joint structures and helped distinguish subtle abnormalities and normal anatomical variants. We understand that this advantage enables a better diagnostic definition and a more accurate surgical planning.

Because it is a relatively new imaging modality, MSCTA can also show changes in the articular cartilage in the shoulders through thin sections and high photon flow (200-750 mAs). The result is the possibility of obtaining diagnostic and multi-planar images, and three-dimensional shoulder reconstructions.

Although it is considered the gold standard imaging technique in the evaluation of the rotator cuff, the MRI may be contraindicated in some situations, such as in the presence of pacemakers and metallic artifacts, and in cases of claustrophobia. Our observations are also corroborated by

other authors, who understand that the CTA with multi-detectors is a valid option in patients for whom the MRI is contraindicated.[26,27]

Charousset et al[28] confirm the value of the CTA in the diagnosis of rotator cuff lesions, and they reached a considerable sensitivity and specificity for the lesions of the supraspinatus and infraspinatus muscle tendons. In our work, in general, we reached a specificity of 100% and a sensitivity of 79.41% for the rotator cuff lesions, while for the lesions of the supraspinatus and infraspinatus tendons, we reached a sensitivity of 78.78% and 78.95% respectively. In addition, the MSCTA has shown advantages in the postoperative period, such as the non-production of significant artifacts in the presence of metallic surgical material.[29–32] In some cases, the presence of metal in or around the shoulder joint may limit the effectiveness of the conventional MRI or of the MRA, in spite of the techniques that may enhance the MRI.[33–36]

High-resolution MSCTA of the shoulder enables the visualization and diagnosis of rotator cuff joint injuries. However, regarding partial lesions (bursal, interstitial), the examination was not effective.[37,38] In our study in particular, we also noticed a greater difficulty in the diagnosis of partial lesions. This impression was confirmed when we identified that, while the partial supraspinatus tendon lesion was identified by MSCTA only in 3.33% of the cases, this type of lesion was found by arthroscopy in 16.7% of the cases.

In complete rotator cuff lesions (full thickness), the values found for sensitivity, specificity, predictive values and accuracy are as high in the MSCTA as in the MRA. However, the sensitivity for partial lesions is very low.[39,40] In the present study, the accuracy of the MSCTA in the diagnosis of rotator cuff lesions (81.57%), in general, showed a moderate degree of agreement (Kappa coefficient). However, when evaluating the accuracy of the MSCTA with specification of the affected tendon separately, we observed an even better result with an even greater degree of agreement: the accuracy in the supraspinatus tendon injury was of 81.57%; in the infraspinatus tendon injury, it was of 89.47%; and in the subscapularis tendon lesion, it was of 92.11%, with concordance degrees of 49.51% (moderate), 78.94% (substantial) and 83.39% (almost perfect), respectively.

It is worth mentioning that the MSCTA has the great advantage of being a procedure of lower cost and quicker accomplishment, with less discomfort for the patient when compared to the MRI.

The present research has some limitations. Even though it is considered a gold standard exam, arthroscopy is an operator-dependent method – regardless of the fact that the orthopedic doctor had more than 10 years of experience in arthroscopic shoulder surgery. Another bias was the fact that in the present study all operated patients had rotator cuff lesions, and this compromised the specificity findings, which in our study was of 100%. To minimize this limitation, we chose to identify a group in our historical data that had been negative for rotator cuff lesion in the arthroscopic evaluation, but that had been diagnosed in the radiological evaluation by MSCTA, which was considered a key group in the evaluation and determination of the statistical findings.

Conclusion

In the impossibility of performing the MRI (the gold standard imaging test), the MSCTA is an imaging examination that enables the evaluation and diagnosis of rotator cuff lesions. Thus, with this exam, the attending physician can better plan the strategy of the therapeutic approach.

Conflicts of Interest
The authors have none to declare.

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