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CT arthrography of the intra-articular long head of biceps tendon: Diagnostic performance outside the labral-bicipital complex

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KEYWORDS
Biceps long head;
CT arthrography;
Tendinopathy;
Rotator cuff tears;
Arthroscopy

Abstract

Purpose: The purpose of this study was to determine the performance of CT arthrography for the diagnosis of intra-articular long head of biceps (LHB) tendon intrinsic lesions using arthroscopy findings as standard of reference.

Material and methods: CT arthrography studies of 98 patients (55 men, 43 women; mean age 54.8 ± 12.7 [SD] years [range: 16—77 years]) were retrospectively evaluated by two radiologists independently. Per operative arthroscopic images and surgical reports were retrospectively reviewed by a shoulder-specialist surgeon. Based on the analysis of arthroscopic images and the surgical reports, the LHB tendon was classified as normal (continuous with uniform tendon thickness), tendinopathy/partial rupture (focal change in tendon thickness and contour irregularities) and total rupture (total loss in tendon continuity). Imaging results were compared to those of surgery that served as standard of reference. Interobserver agreement was assessed.

Results: At arthroscopy, the LHB tendon was classified as normal in 38/98 (38.8%) patients, tendinopathic in 51/52 (52%) and totally ruptured in 9/98 (9.2%). The sensitivity and specificity of CT arthrography for the diagnosis of LHB tendinopathy were respectively 74% (95%CI: 60%—85%) and 93% (95%CI: 80%—99%) for reader 1 and 79% (95% CI: 67%—89%) and 95% (95% CI: 83%—99%) for reader 2. The sensitivity and specificity for the diagnosis of LHB tendon total ruptures were 100% (95%CI: 66%—100%) and 93% (95%CI: 86%—98%) for both readers. Interobserver agreements for the identification of the LHB tendon tendinopathy and total ruptures were excellent (kappa values of 0.94 and 0.96, respectively).

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Conclusion: CT arthrography demonstrates good sensitivity and excellent specificity for the detection of intra-articular LHB tendinopathy and tear.

Introduction

Pathologic processes of the long head of the biceps (LHB) tendon are a frequent cause of shoulder pain [1—4]. Symptoms are predominantly anterior and clinical examination usually reveals non-specific findings, particularly in patients with chronic painful shoulders [2,5,6]. Lesions of the LHB tendon occur in particular during external rotation and arm elevation [7,8]. There are due to micro traumatisms, which lead to tendinopathy and eventually tendon ruptures [1,6]. LHB tendon intrinsic lesions are rarely isolated and are strongly associated with rotator cuff lesions [8—11]. Pre-operative diagnosis of LHB tendon intrinsic lesions is important because when present, LHB tenotomy sometimes coupled with tenodesis can be recommended [3,6,7,12].

The diagnosis of LHB tendon intrinsic lesions is sometimes difficult. On MRI, analysis is hindered at the entrance to the bicipital groove, a frequent site not only for magic angle effects but also for true tendinopathy [13,14]. The LHB tendon is prone to anisotropy artifacts on ultrasound and the performance of this method for the evaluation of the intra-articular portion of this tendon, which is also the most frequent site of LHB pathology, is limited [15]. CT arthrography, already widely used for rotator cuff assessment in some European countries can also be used for LHB tendon for its a high spatial resolution, short acquisition and relatively resistance to artifacts [2,11,16,17].

The value of CT arthrography in the identification and characterization of LHB tendon intrinsic lesions is poorly studied as most studies focused on superior labrum anterior posterior lesions (SLAP) and LHB tendon instability. Nourissat et al. reported a 71% sensibility and 100% specificity of CT arthrography for the diagnosis of LHB tendon tears [6]. However, the authors included in the analysis lesions of the labral-bicipital complex, which may have overestimated the performance of CT arthrography for the diagnosis LHB injuries [10,18]. De Maeseneer et al. reported 31% sensitivity and 95%specificity for the identification of LHB tendon intrinsic lesions on CT in 12 pathological tendons [13].

The purpose of this study was to determine the performance of CT arthrography for the diagnosis of intra-articular LHB tendon intrinsic lesions using arthroscopy findings as standard of reference.

Material and methods

Study population

The hospital information system of our institution was searched by a radiologist for patients who underwent shoulder CT arthrography followed by arthroscopy from January 2014 to December 2016. A total of 106 consecutive patients were initially identified. The images from these studies were retrospectively evaluated. All these patients presented with painful shoulders and had been addressed by orthopedic surgeons of our institution for the evaluation of suspected rotator cuff tears. Per operative arthroscopic images and surgical reports were retrospectively reviewed by an orthopedic shoulder specialist surgeon with seven years of clinical experience. Patients with prior shoulder surgery were not included. Eight patients were excluded due to poor opacification of the glenohumeral joint cavity insufficient to allow a precise delineation of LHB tendon or the rotator cuff tendons articular surface.

The study population included 98 patients. There were 55 men and 43 women with a mean age of 54.8 ± 12.7 (SD) years (range: 16—77 years). Fig. 1 shows inclusion of patients in the study.

Because in our institution fully anonymized retrospective studies on clinical images do not require ethics committee approval, Institutional Review Board exemption was granted.

CT arthrography

Glenohumeral contrast material injection was performed through an anterior approach by a radiologist under fluoroscopic guidance in aseptic conditions. Approximately 10 cc of iodinated contrast material (iohexol, Omnipaque 300® or iodixanol Visipaque270®; -, General Electric Healthcare) were injected using a 22 G needle, followed by passive shoulder mobilization to assure a homogenous intra-articular contrast distribution.

All CT examinations were performed with 320 detector-row scanner (Aquilion One®, Canon Medical Systems Corporation). The following acquisition parameters were used: A 12—14 cm z-axis coverage was used including the acromioclavicular and glenohumeral joints; 120—135kVp, 200 mAs (tube output varied depending on patient body habitus), 0.75s tube rotation speed, 512×512 matrix with a 24 cm field-of-view. The dose length product (DLP) and the CT dose index (CTDIvol) varied from 209—379 mGy*cm and 17.4—27.1 mGy respectively. Patients were imaged supine with the arm in slight external rotation (about 40°). The contralateral arm was positioned overhead to avoid additional radiation exposure. The images were reconstructed in the axial, coronal, sagittal and oblique planes in 0.5 mm every 0.25 mm using a bone kernel. A 400L/2000 W window setting was used.

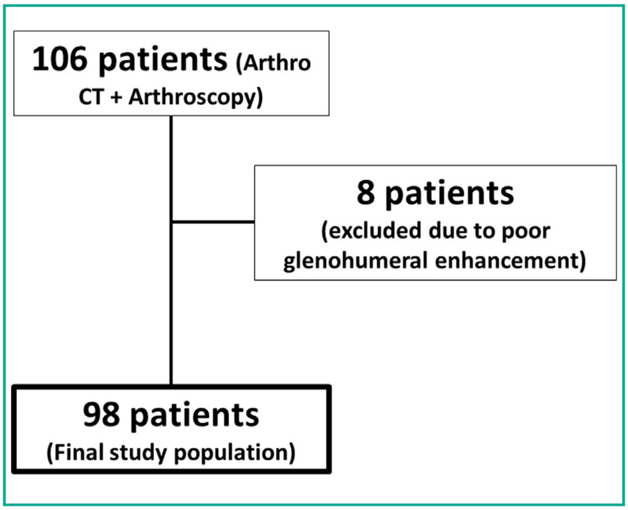

Figure 1. Patient inclusion flowchart.

Image analysis

CT arthrography images were analyzed independently by two radiologists with seven (reader 1) and two (reader 2) years of clinical experience in musculoskeletal imaging. The readers were blind to arthroscopic results. All images were evaluated on a PACS workstation (Synapse® v4.1.600, Fujifilm). Based on the analysis of arthroscopic images and surgical reports, LHB tendon was classified as normal, tendinopathic or totally ruptured. The LHB tendon was classified as normal when it showed a uniform thickness, regular contours and no hyperemia. LHB was classified tendinopathic (including partial ruptures) when hyperemia, focal atrophy or hypertrophy, fissures and delamination were present on arthroscopic images. LHB tendon was classified as totally ruptured when a complete loss of tendon continuity was identified.

An image interpretation training session with both readers was performed with 20 shoulder CT arthrography studies not included in the study population. Native axial i and multiplanar mages were available for analysis. On CT arthrography images, the LHB was divided in 4 portions in the following order: proximal insertion (labral-bicipital complex), horizontal portion, transition portion at the level of the LHB pulley and vertical portion in the bicipital groove (Fig. 2) [10,19,20].

Lesions of the proximal insertion were excluded from the analysis because these lesions are associated with glenoid labrum injuries, which have a different physiopathology than more distal intrinsic tendon injuries. On CT arthrography images the LHB tendon was classified as normal when a uniform thickness varying from three to eight millimeters in diameter and regular contours were seen; tendinopathic (including partial ruptures) when focal changes in tendon thickness (> 8 mm or < 3 mm in diameter), irregular contours and insinuation of contrast medium within the tendon substance was identified; and totally ruptured when a complete loss in tendon continuity was identified.

The presence of supraspinatus, infraspinatus and subscapularis tendon tears was evaluated both on imaging and on arthroscopy. On arthroscopy, supraspinatus and infraspinatus tears were classified as partial or complete according to the tendon fiber continuity status. The subscapularis tendon was classified binary manner as normal (continuous tendon) or ruptured (partial or complete loss in tendon fiber continuity).

Similarly, on CT arthrography, supra and infraspinatus tendon tears were classified as partial tendon tears or full thickness tears (partial or complete). Partial articular sided tears were characterized by irregularity of articular tendon contours and insinuation of contrast within the tendon substance, while full thickness tears were characterized by a clear passage of contrast medium from the gleno-humeral joint to the subacromial subdeltoid bursa. Subscapularis tendon was classified as normal or ruptured (partial and complete). Tendons with regular contours and no intratendinous contrast insinuation were considered as normal.

Statistical analysis

Quantitative data were expressed as mean ± standard deviation (SD) and range. Imaging and arthroscopic findings were compared and the latter was used as the standard of reference. Sensitivity, specificity and accuracy for the identification of LHB tendinopathy and total ruptures were calculated along with their 95% confidence intervals (CI) with the the Clopper-Pearson method. The presence of LHB tendon was correlated to the presence of rotator cuff (supraspinatus, infraspinatus and subscapularis) tears. Kappa values were calculated to evaluate interobserver agreement of LHB tendon classification on CT arthrography. Interobserver agreement was graded as follows: Kappa < 0 = poor; 0.01—0.2 = slight; 0.21—0.4 = fair; 0.41—0.6 = moderate; 0.61—0.8 = substantial and 0.81—0.99 = excellent.

Results

The mean delay between CT arthrography and arthroscopy in the study population was 87.7 ± 22 (SD) days [range: 20—180 days]. After imaging evaluation, the retained indications for arthroscopy in the study population were rotator cuff repair for 67/98 patients (68%), acromioplasty for 93/98 patients (95%) and tenotomy for 50/98 patients (51%).

On arthroscopy, 38/98 LHB tendons (38.8%) were classified as normal (Fig. 3), 51/98 (52%) as tendinopathic (Fig. 4) and 9/98 (9.2%) as totally ruptured (Fig. 5). On CT arthrography there were 56 normal LHB tendons, 27 tendinopathies and 15 total ruptures for reader 1 and 52 normal tendons, 31 tendinopathies and 15 total ruptures for reader 2. The interobserver agreement for the identification of the LHB tendon tendinopathy and total ruptures were excellent (Kappa values of 0.94 and 0.96, respectively).

The sensitivity and specificity for diagnosis of LHB tendinopathy were respectively 74% (95% CI: 60%—85%) and 93% (95% CI: 80%—99%) for reader 1 and 79% (95% C: 67%—89%) and 95% (95% CI: 83% to 99%) for reader 2. The sensitivity and specificity for the diagnosis of LHB total ruptures were 100% (95% CI: 66%—100%) and 93% (95% CI: 86%—98%) for both readers (Table 1).

There were 15 false negatives for reader 1 and 12 for reader 2 for the detection of LHB tendinopathy. In eight

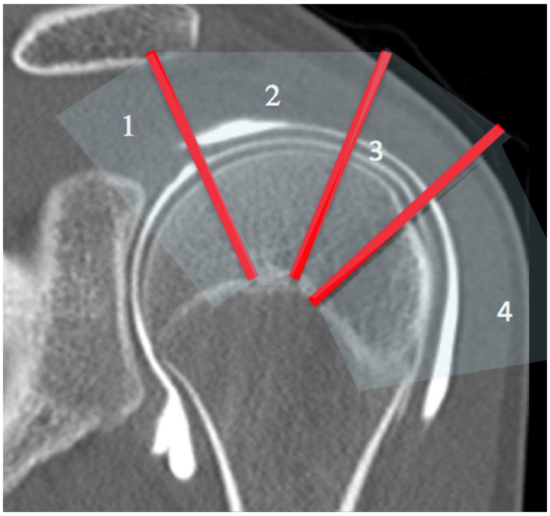

Figure 2. CT arthrography image of a 40-year-old man in an oblique coronal plane shows the different anatomic portions of the long head of the biceps tendon: proximal insertion (zone 1), horizontal portion (zone 2), biceps pulley (zone 3) and vertical portion (zone 4).

of these patients for reader 1 and seven for reader 2 the thickness of LHB tendon was in the lower limits of normal (3 mm). In five patients for reader 1 and four patients for reader 2, the LHB tendon thickness was in the upper limits of normal. In the last two false negatives studies of the appearance of the LHB was normal in CT arthrography, and in arthroscopy both tendons had intra tendon fissures or hyperemia with no abnormality of size (Fig. 6). There were three false positives in reader 1 and two for reader 2 for the detection of LHB tendinopathy. In one patient for both readers, the LHB diameter was difficult to evaluate due to the presence of intra-articular debris at the bicipital groove. The other two patients were related to focal variation in tendon diameter.

In 6 patients for both readers, the LHB was diagnosed as ruptured on CT arthrography whereas only tendinopathy with partial tearing was seen in arthroscopy. CT arthrography image review showed amorphous images in the topography of the LHB groove. These images were interpreted as debris with a discontinuous tendon by both readers (Fig. 7).

In the study population there were 67 patients with degenerative rotator cuff tears (supra, infraspinatous and

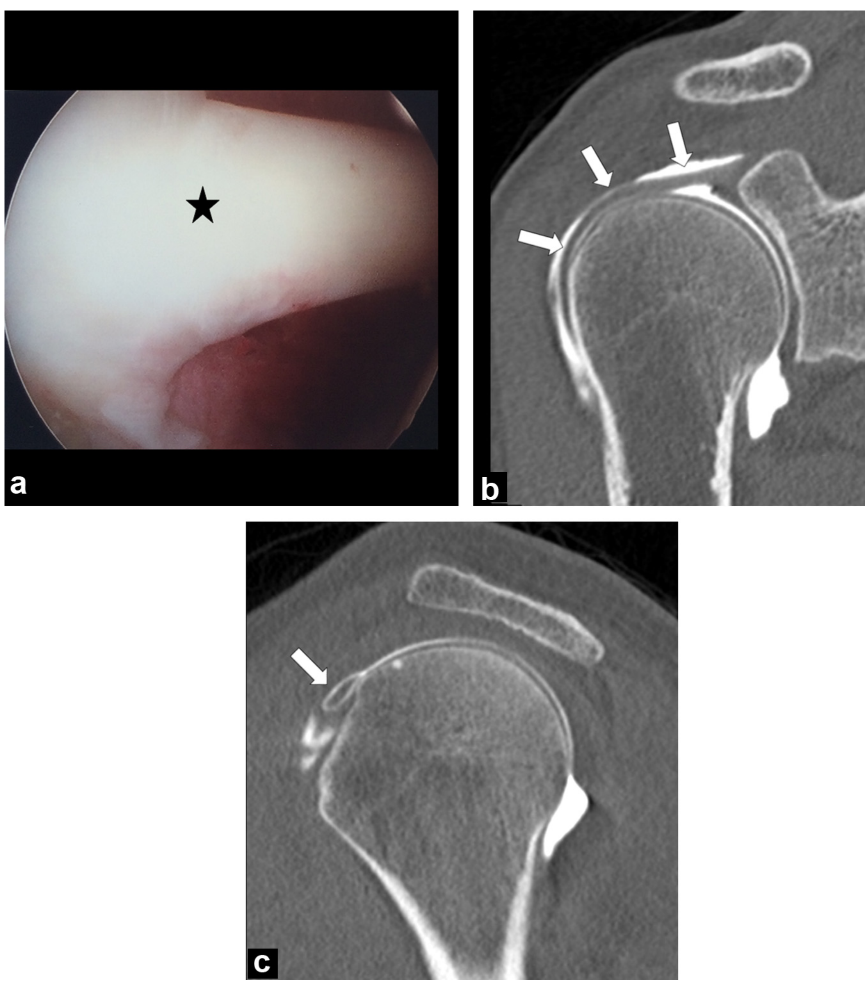

Figure 3. 45-year-old man with no clinical signs of the long head of the biceps (LHB) tendon pathology and normal LHB tendon at arthroscopy. A) Arthroscopic view shows normal LHB tendon with normal aspect of the proximal insertion of LHB tendon (star), which appears as a whitish uniform structure with smooth contours. B and C) CT arthrography images in an oblique coronal (B) and oblique sagittal (C) planes show a normal LHB tendon with regular contours and uniform thickness (arrows).

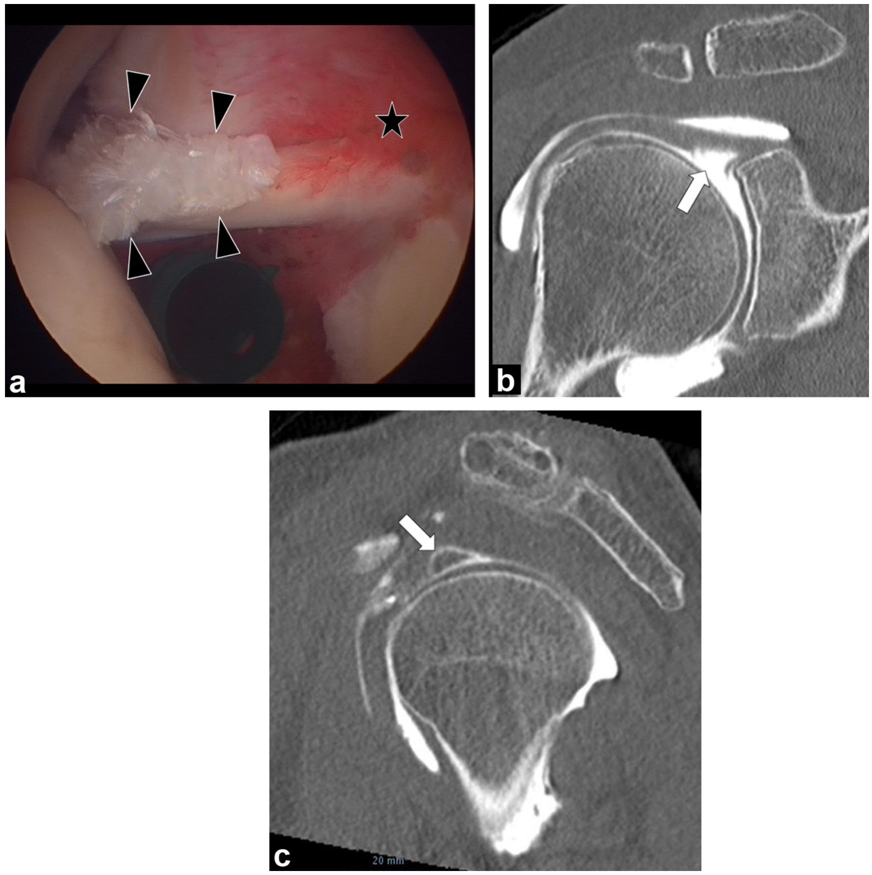

Figure 4. 60-year-old man with chronic shoulder pain and long head of the biceps (LHB) tendinopathy. A) Arthroscopic view shows a frayed appearance of the proximal insertion of the LHB tendon (arrowheads) with diffuse hyperemia (star) consistent with of LHB tendinopathy. B and C) CT arthrography images in the oblique coronal (B) and oblique sagittal (C) planes show pathologic LHB tendon with contour irregularity and thinning adjacent to the proximal insertion (arrows).

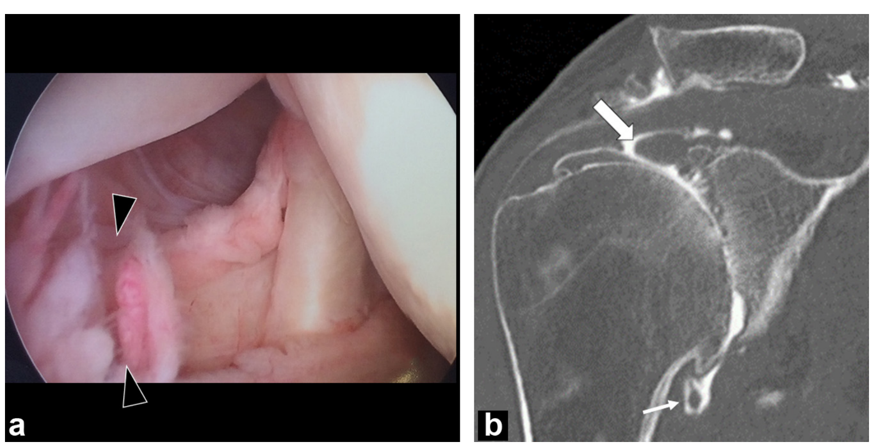

Figure 5. 70-year-old woman with total rupture of the long head of the biceps (LHB) tendon. A) Arthroscopic view shows complete discontinuity at the proximal insertion of the biceps tendon (arrowheads) consistent with total rupture of the LHB tendon. B) CT arthrography image in an oblique coronal plane shows the LHB tendon stump with a complete loss in the continuity (large arrow). Note the advanced glenohumeral degenerative joint disease with diffuse cartilage loss and an intraarticular foreign body (thin arrow).

subscapularis added) on arthrography. In 50/67 patients (75%), rotator cuff tears were associated with a pathologic LHB tendon (tendinopathy or total rupture). Among the 51 patients with a pathologic LHB on CT arthrography there were 41 patients (80%) with associated rotator cuff pathology. In 35 out of 51 patients (69%) a pathologic LHB tendon was associated with a supraspinatus tear (22% partial articular sided and 47% full thickness tears), in 33 out of 51 patients (65%) with an infraspinatus tear (32% partial articular sided tears and 33% full thickness tears) and in 16 out of 51 patients (31%) with a subscapularis tear.

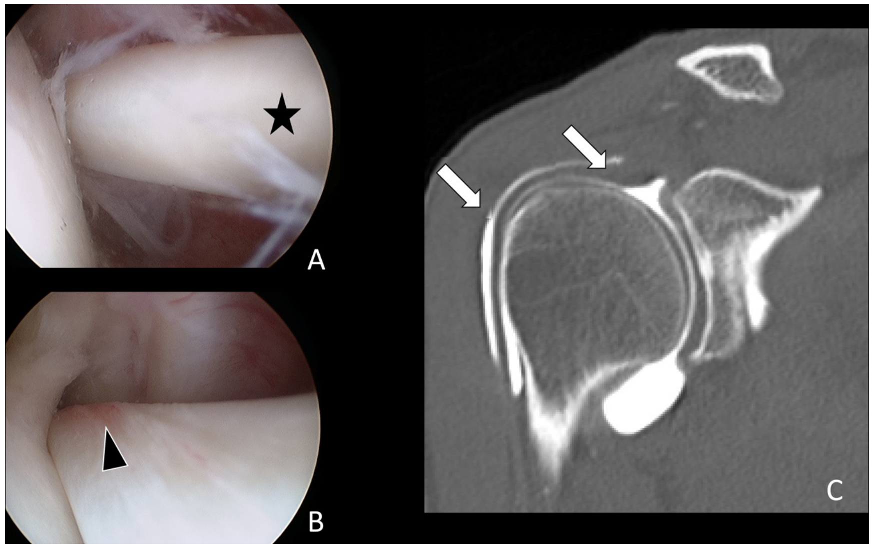

Figure 6. A and B) Arthroscopic view of a LHB tendon in a 47 year-old man with no clinical signs of biceps tendon pathology . LHB tendon appears continuous, with a regular caliber (star) and discrete zone of tendon hypermia (arrowhead) C) CT arthrography image of the same patient in an oblique coronal plane showing the proximal LHB tendon with regular contours and uniform thickness .

Table 1 Diagnostic performance CT arthrography for the identification of LHB tendinopathy (including partial ruptures) and total ruptures.

	Tendinopathy		Total rupture	
	Reader 1	Reader 2	Reader 1	Reader 2
TP	42	46	9	9
TN	38	38	83	83
FP	3	2	6	6
FN	15	12	0	0
Sensitivity	74%[60—85]	79%[67—89]	100%[66—100]	100%[66—100]
Specificity	93%[80—99]	95%[83—99]	93% [86—98]	93% [86—98]
Accuracy	82%[73—89]	86%[77—92]	94% [87—98]	94% [87——8]

TP: true positive; TN: true negative; FP: false positives; FN: false negative; CI: confidence interval. Numbers in brackets are 95% confidence intervals.

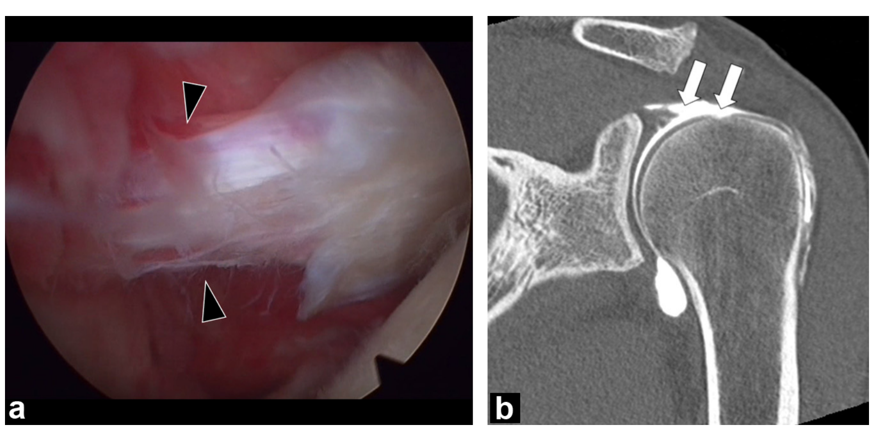

Figure 7. 50-year-old man with advanced long head of the biceps (LHB) tendinopathy. A) Arthroscopic view shows intense fraying and thinning (arrowheads) of the LHB tendon that remains continuous. B) CT arthrography image in an oblique coronal plane shows proximal LHB tendon insertion zone. Only the tendon stump can be seen with no identifiable continuous fibers (arrows).

Discussion

Our results indicate that CT arthrography offers good sensitivity and excellent specificity for the diagnosis of LHB tendinopathy. The sensitivity was slightly better for the identification of total ruptures (sensitivity and specificity of 100% and 93% respectively). Moreover, the interobserver agreement for LHB lesion characterization with CT arthrography is excellent (kappa > 0.94). These findings are consistent with those of prior studies that showed sensitivity and specificity varying from 57—71% and 93—100%, respectively, indicating that the search for LHB tendon intrinsic lesions on CT arthrography should be systematic, with potential implications in patient management.

Despite the good diagnostic performance, the evaluation of the LHB tendon on CT arthrography is not always straightforward. As expected, the sensitivity of CT arthrography in the diagnosis of tendinopathies is lower than for the diagnosis of total rupture. This can be explained at least in part by studies of LHB tendinopathy with small variations in tendon thickness and the lack of contrast insinuation in intra-substance partial tears. False positive studies of LHB total ruptures were also found when amorphous tissue was present at the LHB groove which turned out to represent continuous tendon fibers on arthroscopy. Finally, other factors not evaluated in this study, such as suboptimal patient positioning (excessive internal rotation) and the presence of synovial thickening or intra articular debris precluding contrast distention of the LHB tendon sheath can hinder LHB tendon evaluation on CT arthrography. Radiologists interpreting shoulder CT arthrography should be made aware of these limitations.

The performance of CT arthrography for the identification of LHB tendon intrinsic is similar to that reported for MR arthrography. However, this method shows a much wider variation for the diagnosis of biceps tendon lesions with sensitivities and specificities ranging from 25 to 91% and from 56% to 96%, respectively [13,17,21,22]. For the detection of tendinopathy the reported variation is even wider (9.1% to 80% and 69.8% to 98% for sensitivity and specificity respectively) [14,21,23—27]. This variation in performance may be due to difficulties in interpreting the signal anomalies at the entry of the bicipital groove related to magic angle and partial volume effects. The frequency of anatomical variants of the LHB may also contribute [28]. In this context, CT arthrography with a similar and less variable diagnostic performance seems as a valid alternative to MR imaging for the evaluation of LHB pathology.

LHB tendon intrinsic lesions are rarely isolated and were associated with rotator cuff tears in 80% of patients. These lesions were more frequent in supra and infraspinatus tendons (> 65% of patients). This is likely related to the fact that LHB lesions are also associated with sub-acromial and anterosuperior shoulder mechanical strain, which are a part of the physiopathology of rotator cuff tears [29—31]. Additionally, some authors suggest rotator cuff tears could be favored by the loss of antero-superior glenohumeral stabilization provided by the LHB tendon [24]. The increased awareness of this association can help identify rotator cuff and LHB tendon tears when evaluating shoulder CT arthrograms.

Various limitations of this study have to be acknowledged. The instability of the LHB, which is a common pathology, was not evaluated as imaging evaluation was not dynamic and arthroscopic dynamic tendon testing is not accessible retrospectively. Tendinopathy and partial tears of all types (hypertrophy, atrophy, fissuring, delamination) were evaluated as a single group. This was done to avoid small subgroups and due to the fact that surgical treatment of tendinopathy and partial tears is the same (tenotomy and tenodesis). There was no correlation between CT arthrography findings and MR imaging. However, the performance of the latter technique has already been thoroughly studied in the literature. Although the delivered dose remained within an acceptable range, compared to MR imaging, ionizing radiation remains a limitation of CT arthrography. Finally, image findings did not correlate with clinical symptoms or surgical outcome. Further studies are needed to address these issues.

In conclusion, CT arthrography offers high specificity and good sensitivity for the diagnosis of intrinsic LHB tendon pathology. Radiologists should be aware that the LHB tendon evaluation can be made difficult by moderate thickness changes, intra-substantial tears and by fibrous residues in the tendon path. In light of these findings LHB assessment should be active and systematic when evaluating shoulder CT arthrography.

Authors contribution

Pedro Augusto Gondim Teixeira: conceptualization; data curation; formal analysis; investigation; methodology; resources; supervision; validation; visualization; roles/writing - original draft; writing - review & editing.

Pierre Jaquet: conceptualization: data curation; formal analysis; investigation; resources; visualization; roles/writing - original draft.

Omar Bakour: data curation; formal analysis; investigation.

Adrien Jacquot: conceptualization; data curation; formal analysis; visualization.

Daniel Molé: conceptualization; supervision; validation.

François Sirveaux: conceptualization; supervision; validation.

Alain Blum: conceptualization; data curation; formal analysis; investigation; methodology; resources; supervision; validation; visualization; roles/writing - original draft; writing - review & editing.

Disclosure of interest

The authors declare that they have no competing interest.

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