Résumé

Échographie des tendons de la coiffe en mode harmonique : les clivages sont-ils enfin visibles ?

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Objectifs. Pour certains, les clivages restent un des points faibles de l'échographie. Le but de cette étude est de démontrer la visibilité et décrypter la séméiologie des clivages des tendons supra et infra-épineux en mode harmonique.

Matériels et méthodes. Il s'agit d'une étude prospective de 52 patients suspects de lésions tendineuses ayant bénéficié d'une échographie avant un arthroscope, un bursoscope ou une arthro-IRM. L'examen est réalisé avec une sonde 7-15 MHz en mode harmonique tissulaire (« pulse substraction »). Un clivage était évoqué devant la mise en évidence d'une ligne hypoéchogène intratendineuse, prolongeant une rupture partielle ou transfixiante. Les performances de l'échographie concernant les clivages étaient corrélées aux examens opacifiés.

Résultats. Dix cas de clivages étaient décrits en échographie contre 18 visibles sur les examens arthrographiques. Les faux négatifs étaient en rapport avec des patients peu échogènes (n = 4), des tendons trop rétractés (n = 2) ou opérés (n = 2). La sensibilité était de 55 % et la spécificité de 94 %, la valeur prédictive positive de 83 %, la valeur prédictive négative de 80 % pour le dépistage des clivages. Les performances de l'échographie étaient moins bonnes pour les clivages associés à des ruptures transfixiantes (5/11) en comparaison aux clivages associés aux ruptures partielles (5/6).

Conclusion. Nous démontrons que les clivages sont maintenant visibles en échographie grâce aux sondes hautes fréquences et au mode harmonique tissulaire. Toutefois, la sensibilité reste insuffisante surtout en cas de lésion transfixiante évoluée, en postopératoire et pour les patients peu échogènes.


IRM. Scanner.

Abstract

Purpose. For some, cleavage tears remain a pitfall of sonography (US). The purpose of this study is to demonstrate the visibility of intratendinous tears of the supraspinatus and infraspinatus tendons and describe their imaging features on tissue harmonic US.

Materials and methods. Prospective study of 52 patients with suspected cuff pathology who underwent US prior to CT-arthrography, CT-bursography or MR arthrography. The US examinations were performed using 7-15 MHz transducers with tissue harmonic mode (pulse subtraction). An intratendinous tear was suggested by the presence of a hypoechogenic intratendinous line, extending from a partial or full thickness tear. Results from US were correlated to contrast material enhanced CT or MR findings.

Results. Ten cases of cleavage tears were detected on US compared to 18 on arthrographic examinations. False negative results occurred in poor US candidates (n=4), excessively retracted tendons (n=2) or postsurgical cuffs (n=2). Sensitivity was 55% and specificity was 94%, with PPV of 83% and NPV of 80% for the detection of intratendinous tear. The accuracy of US was lower for intratendinous tear associated with full thickness tears (5/11) compared to intratendinous tears associated with partial thickness tears (5/6).

Conclusion. We demonstrate that cleavage tears are now visible on US using high-frequency transducers and tissue harmonic mode. However, the sensitivity remains too low, especially in patients with full thickness tear, postsurgical patients and patients that are poor candidates to US.

Key words: Shoulder. US. Tendons. Tear. Arthrography. MRI. CT.

Harmonic sonography of rotator cuff tendons: are cleavage tears visible at last?

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Ultrasonography (US) has become the first line imaging study in patients with asymptomatic rotator cuff. It allows rapid and low-cost triage of patients and referral for complementary cross-sectional imaging with arthrography in patients with tendon pathology. Intratendinous horizontal tears are reportedly undetectable on US. This represents a major pitfall of US for some authors.

Current US systems allow better visualization of intratendinous lesions due to improved transducer technology and tissue harmonic imaging (1). These technological advances have enabled the detection of new imaging features suggestive of intratendinous horizontal tears. The purpose of this study is to demonstrate the visibility of intratendinous horizontal tears on US by comparing it with cross sectional arthographic examinations (CT arthrogram, CT bursogram, and MR arthrogram).

Materials and methods

This is a prospective study of 52 patients. All patients underwent US evaluation of the supraspinatus and infraspinatus tendons for suspected rotator cuff pathology.
All US examinations were performed by a single operator using a 7-15 MHz multifrequency linear array probe (Aplio, Toshiba) and tissue harmonic imaging (pulse subtraction). Intratendinous horizontal tears were defined as the presence of a thin hypoechoic band within the tendon substance along the long axis of the tendon originating from a complete or partial thickness tear. This hypoechoic band should be visible on two imaging planes (coronal and sagittal). We have also noted the presence of a hyperechoic band of increased trough transmission (fig. 1). The examinations were performed using the Crass and modified Crass positions (2). For the Crass position, the arm is placed behind the back with elbow flexed and palm of the hand facing back (with fingers pointing to the contralateral scapula). This position allows better evaluation of the infraspinatus tendon. The modified Crass position is useful to better evaluate anterior structures (supraspinatus tendon and rotator interval) with the patient’s hand resting on the posterior iliac crest. The US images were stored on a picture archival system. All patients then underwent, within 0 to 92 days (mean: 27 days), a cross sectional arthrographic examination that was considered the gold standard. Contrast material was injected in the glenohumeral joint of all patients prior to CT arthrography in 43 cases and MR arthrography in 9 cases. The procedure was complemented by subacromial-subdeltoid (SASD) bursal injection of contrast only when US suggested partial bursal surface tendon tear, without communication between the glenohumeral joint and SASD bursa. CT arthro-bursography was then obtained (8 patients). MR arthrography, performed in 9 patients, always included fat-suppressed FSE T1W images in the axial, coronal and sagittal planes, along with a coronal fat-suppressed FSE T2W images. The cross sectional arthrographic examinations were reviewed by senior radiologists; none was reviewed by the radiologist who performed the US. The correlation was considered positive when an intratendinous horizontal tear was opacified (18 cases), irrespective of its location (supraspinatus or infraspinatus).

**Results**

A total of 18 intratendinous horizontal tears were confirmed on cross sectional arthrographic examination. Twelve were associated with complete tears (fig. 2) and six were associated with partial thickness tears. Of these 18 lesions, 10 were detected on tissue harmonic US imaging, 5 in association with partial thickness tears and 5 in association with complete tears (table I).

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<th>Table I</th>
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<td>Accuracy of US for the detection of intratendinous tears based on the different types of tendon tears. With partial thickness tendon tears, US is nearly as accurate as cross sectional arthrography.</td>
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<td>Intratendinous tear</td>
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<td>Cross sectional arthrography</td>
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There were 8 false negative results on tissue harmonic US imaging, with 7 of these in association with complete tears and 1 in association with a partial thickness tear. These occurred in the following setting:
- 4 obese patients that were poor US candidates (3 complete and 1 partial thickness tears);
- 2 complete tears with marked tendon retraction;
- 2 complete tears in patients with previous cuff surgery.
There were 2 false positive results. One case corresponded to a non-communicating lesion (visible only on US and MR) with no opacification on cross sectional arthrographic examination. The other case corresponded to a complete tear where the SASD bursa was misinterpreted as an intratendinous horizontal tear.
A hyperechoic band of increased trough transmission underlining the intratendinous horizontal tears was present in 7 of 10 cases.
The sensitivity, specificity, positive predictive value and negative predictive value of tissue harmonic US imaging for the detection of intratendinous horizontal tears were 55%, 94%, 83%, and 80% respectively.

**Discussion**

The pulse subtraction mode corresponds to further advances of tissue harmonic US imaging. Harmonic US imaging eliminates a significant number of artifacts compared to fundamental US imaging providing images with better contrast resolution and improved tissue interface discrimination. Initially, tissue harmonic imaging was only available on curvilinear abdominal transducers. As such, there were 3 main obstacles to its routine use for soft tissue imaging. The first was the need for “wide band” high frequency linear transducers which was resolved with the availability of 7-15 MHz transducers, allowing reception of all echo signals at twice the transmit frequency (harmonic frequency). The second was the low amplitude of the harmonic signal. This was resolved by the introduction of pulse subtraction harmonic imaging. By transmitting two consecutive pulses into the body, with the phase of the second inverted relative to the phase of the first, it is possible to suppress the fundamental signal whereas added harmonic signal is...
amplified (fig. 3). The third obstacle was the reduced image frame rate due to the transmission of the 2 pulses, which was resolved by improved electronics. Currently, it is possible to perform tissue harmonic US imaging with pulse subtraction and obtain signal and frame rate comparable to the fundamental mode. Our study describes new US imaging features for intratendinous horizontal tears of the rotator cuff. The results show excellent specificity and positive predictive value for a positive diagnosis making tissue harmonic US imaging with pulse subtraction technique a reliable imaging modality. The sensitivity remains nonetheless too low, especially in poor US candidates (obese, previous cuff surgery) and patients with chronic retracted complete cuff tear. We have elected to evaluate all patients, irrespective of surgical indications. It is likely that the sensitivity would be improved if only small lesions were considered: 5 of 6 intratendinous horizontal tears in association with partial thickness cuff tear were detected. In routine practice, early diagnosis of intratendinous horizontal tears is only relevant in such circumstances since patients with chronic retracted complete tear or obese patients usually are not surgical candidates. This is confirmed by results from Daguet (3) with sensitivity of 78% on a population of surgical candidates (who did undergo surgery). US also provided useful information allowing referral of patients for cross sectional arthrographic examination. Advanced superficial tendon lesions were evaluated by CT arthro-bursography or MR arthrography to evaluate both tendon surfaces. Intratendinous horizontal tears were seen in association with articular (fig. 4) or bursal (fig. 5) surface tears. Two false positive cases were identified, one of which seemingly corresponding to an intratendinous horizontal tear without articular or bursal surface extension, explaining the absence of contrast opacification (fig. 6). We have elected to use intratendinous horizontal tear opacification as the gold standard, which may be questionable since only T2W MR imaging allows evaluation of isolated intratendinous lesions. It is also known (4) that some articular surface fissures with intratendinous horizontal tear are only opacified at CT arthrogram or MR arthrogram on images obtained in the ABER position (abduction external rotation).

We have used a conventional protocol for evaluation of the supraspinatus and infraspinatus tendons with Crass and modified Crass positions (2, 5). Some authors recommend arm adduction with external rotation to facilitate detection of the edges of intratendinous horizontal tears of the infraspinatus (3). We have not specifically assessed the extent of intratendinous horizontal tears, but it seems that the correlation is good. A single experienced sonographer performed all US examinations, which introduces a bias; interobserver reproducibility remains to be assessed. In addition, we have performed all US examinations using tissue harmonic imaging with only a few comparison exams. This precludes comparison between results on fundamental imaging and tissue harmonic imaging in our series. However, some of our cases suggest that tissue harmonic imaging would facilitate detection of intratendinous horizontal tears that are barely visible on fundamental US imaging (fig. 7).
Conclusion

Intratendinous horizontal tears of the supraspinatus and infraspinatus tendons are now detectable using high frequency transducers and tissue harmonic imaging with pulse subtraction with markedly improved tissue interface discrimination. This is one of the first studies demonstrating these features. The sensitivity in an unselected population remains insufficient to replace cross sectional arthrographic examinations in the preoperative work-up. However, if only less extensive lesions with surgical indications are considered, this US technique seems more accurate. We believe that tissue harmonic imaging should always be used for evaluation of the rotator cuff, especially when a tendon lesion is present.
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References


