Clinical Article

Sonographic evaluation of the arthroscopically repaired rotator cuff

J de Beer MBChB, MMed(Ortho)
Cape Shoulder Institute, Cape Town, South Africa
Anne Karelse MD
Orthopaedic Surgeon specialised in shoulder surgery
University Hospital of Ghent, Belgium

Reprint requests:
Dr JF de Beer
P O Box 15741
7506 Panorama
Tel: (021) 911-1017
Email: shoulder@iafrica.com

Abstract

Ultrasound is gradually achieving more acceptance by orthopaedic surgeons as a diagnostic imaging tool for rotator cuff and biceps tendon pathology.

Two hundred and ten patients with arthroscopic rotator cuff repairs were examined clinically and with ultrasound at early (3 weeks) and late follow-up (average 22 months; range: 12 to 49).

A high correlation between clinically intact cuffs and sonographically intact rotator cuffs after repair is shown. This article gives an overview of relevant sonographic signs of rotator cuff tears, and it gives a detailed description of the sonographic signs of an intact rotator cuff after repair. Ultrasound appears to be a valuable examination for the orthopaedic surgeon to evaluate the postoperative integrity of (arthroscopically) repaired rotator cuff tendons.

Introduction

Better knowledge of the sonographic signs of rotator cuff tears, the technique of scanning and the positioning of the patient, together with the improved quality of the scanning equipment, increases the accuracy of the examiner in evaluating shoulder pathology. Orthopaedic surgeons are progressively making more use[1] of high-resolution ultrasound for the detection of rotator cuff disease and non-rotator cuff abnormalities.[1-5]

Recently multiple studies report the excellent sensitivity, specificity and high accuracy[6-14] for the detection and characterisation of both partial and full-thickness rotator cuff tears. The sensitivity and the specificity seem to be dependent on the type of pathology.[5,11-13] Ultrasound and MRI are shown to have a comparable accuracy when it comes to detection of partial and full thickness rotator cuff tears.[12] Today ultrasound is validated as an accurate imaging tool for pre-operative as well as postoperative evaluation of the rotator cuff. In the case of an enduring painful shoulder after surgery it can be used to exclude or to diagnose a persistent or recurrent tear.[15-17]

The purpose of this study is to evaluate the clinical relevance of well-defined sonographic signs in the early (and late) postoperative period of arthroscopically repaired rotator cuffs.

Materials and methods

Scanning technique

Techniques of shoulder ultrasound and the order of imaging of the relevant structures are extensively described in the literature.[5,11] The authors use a Siemens Sonoline G 50 ultrasound scanner and a 12 MHz linear transducer (Soma Technology, Inc). Patients are evaluated in a sitting position with the arm slightly extended and the elbow flexed. The examiner stands behind the patient and supports the patient's forearm with the free hand, so slight passive movements of this arm can be accomplished when necessary. The scanner is placed in a sagittal position, which is in line with the fibres of the supraspinatus tendon and its insertion onto the greater tuberosity. The scanner is moved anteriorly until it reaches the bicipital groove and the subscapularis tendon.

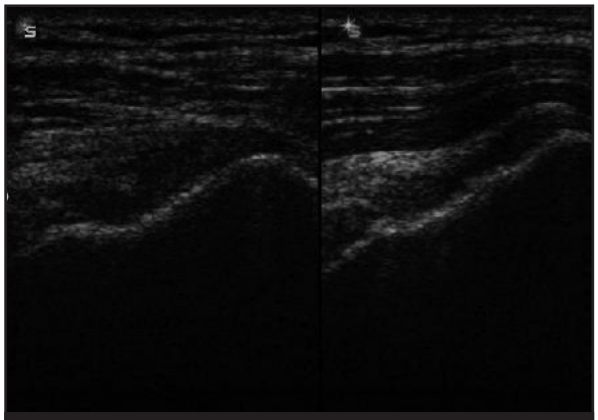

Figure 1: Ultrasound (US) shoulder; longitudinal image. The sagging rope sign is visible on the right image (left image; infraspinatus tendon, right image; supraspinatus tendon).

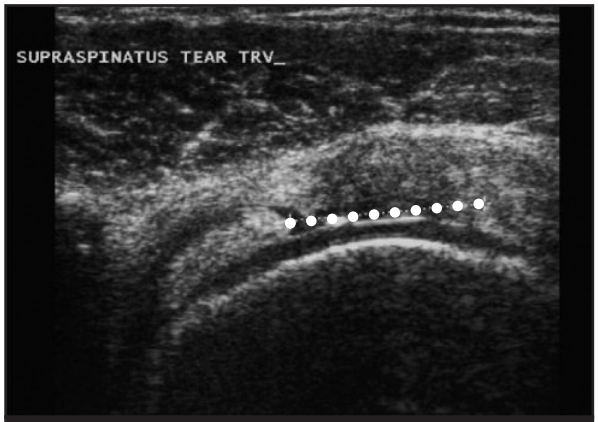

Figure 2: US shoulder; transverse image. Note the hypoechoic gap between the biceps tendon medially (left) and the infraspinatus tendon, compatible with a large full thickness tear of the supraspinatus tendon.

With the transducer moving back posteriorly the infraspinatus and teres minor tendon are visualised.

While viewing the rotator cuff, the arm is gently abducted and adducted to determine the integrity of the attachment of the tendons to the bone. By rotating the scanner 90 degrees the rotator cuff tendons are viewed in the transverse plane. A bilateral examination should always be performed. It helps in defining the patient's individual anatomy and it allows the patient to become acquainted with the examination on the painless shoulder first.

Sonographic definition of the signs of rotator cuff tears pre-operatively

The sonographic signs considered important in diagnosing partial and full thickness rotator cuff tears vary.

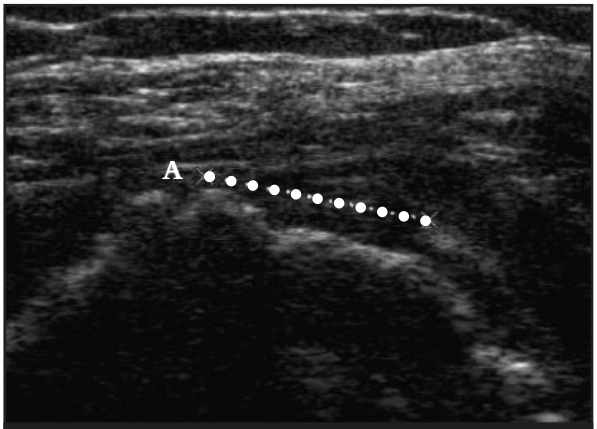

Figure 3: US shoulder; longitudinal image. Retracted full thickness tear of the supraspinatus tendon. Note the irregularity of the greater tuberosity.

In general the defect must be reproducible on both longitudinal and transverse views.

1. The complete absence of tendon tissue between the deltoid muscle and the humeral head clearly represents a full-thickness tear. In this situation the tendon is often completely retracted under the acromion.
2. The 'sagging rope' sign, implying the deltoid muscle occupies the defect in the rotator cuff so that the bursal side of the cuff gives a thinner, flatter or even concave appearance, suggests a complete tear (*Figure 1*).
3. The lack of continuity of the tendon attaching to the lateral edge of the footprint suggests a complete tear.
4. A focal hypoechoic defect in the tendon with retraction of the tendon ends is an indication of a full-thickness tear (*Figures 2 and 3*).
5. A hypoechoic defect at the articular or bursal surface of the tendon, or mixed hypo- and hyperechoic regions within the tendon are suggestive of a partial tear.
6. In the case of a tear of the subscapularis tendon, the tendon can be retracted under the coracoid and in some circumstances the biceps tendon can be found subluxed or dislocated (*Figure 4*).

The findings of secondary signs like a subdeltoid bursal effusion or thickened bursal tissue, cortical irregularities of the greater tuberosity and glenohumeral joint effusion[4,18] support the diagnosis of a tear. So does tenderness caused by pressure on the spot elicited while imaging, especially when this is absent in the other shoulder. The extent of the tear is determined on longitudinal and transverse views by recording the involvement of the different tendons and if possible by measuring the defect. The integrity and condition of the biceps tendon is always noted.

In general the defect must be reproducible on both longitudinal and transverse views

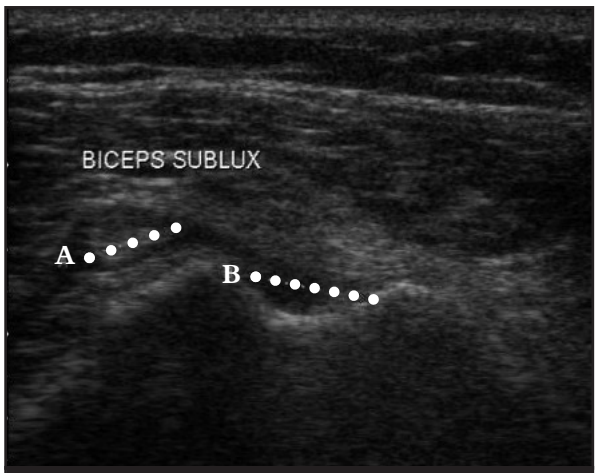

Figure 4: US shoulder; transverse image. Note the biceps tendon dislocated medially (from B to A).

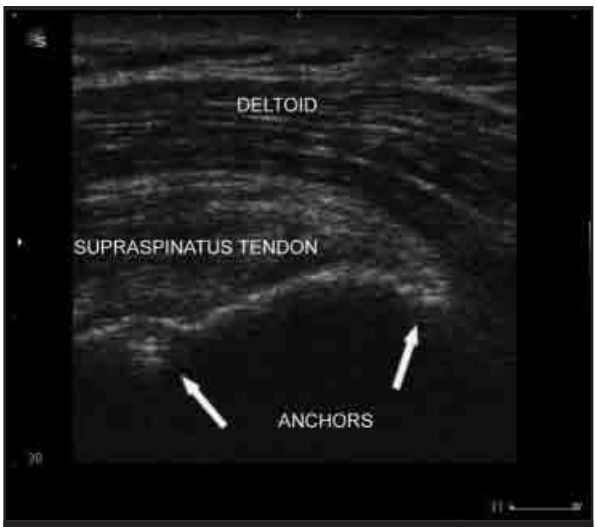

Figure 5: US shoulder; longitudinal image. Repaired tendon 3 weeks postoperatively. Note the bulky tendinous tissue reattached to the footprint, and a medial and lateral anchor in the greater tuberosity.

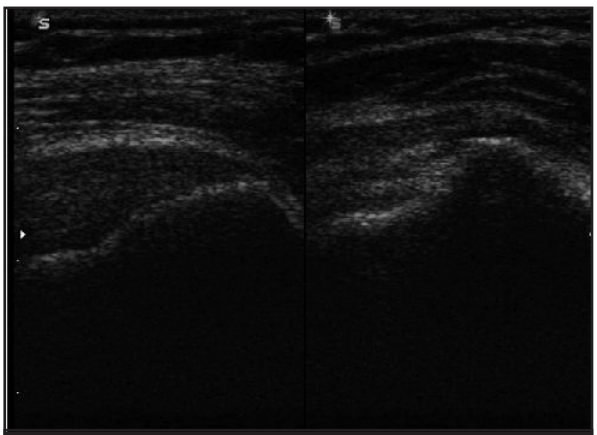

Figure 6: US shoulder; longitudinal image, 6 months postoperatively. Normal cuff (left shoulder) and repaired tendon (right shoulder).

Sonographic definition of the signs of rotator cuff tears postoperatively

1. The longitudinal view of the repaired tendon (most often the supra- and/or infraspinatus tendon) should give an appearance of a bulky tendinous structure between the deltoid and the humeral head, which is clearly attached to the greater tuberosity (*Figure 5*).
2. This structure should move synchronously with the underlying humeral head when the shoulder is passively moved. To accomplish this, the free arm of the examiner moves the arm of the patient gently into a 10 to 20 degrees abducted position and back to neutral.
3. The deltoid muscle is lifted by the repaired tendon but the sagging rope sign as described above can be still visible, often to a lesser extent than before the repair (*Figure 6*).
4. The anchors are recognised as hyperechoic structures in the greater tuberosity (or lesser tuberosity if it concerns a subscapularis repair), more or less perpendicular to the cortex (*Figure 7*).
5. In 'footprint reconstruction' of the rotator cuff it is possible to recognise one or more anchors just lateral to the edge of the articular cartilage (medial row) and on the lateral edge of the footprint (lateral row) (*Figure 7*).
6. It is important to be able to view the reattached tendinous tissue and one or more anchors on one image (*Figure 5*).
7. Often there is a hyperechoic structure visible in and superior on the repaired tendon representing suture material.

A subdeltoid bursal effusion representing residual arthroscopic fluid and/or haematoma is noticed. After three months this should have disappeared.

Study setup

We reviewed 210 patients with painful full-thickness rotator cuff tears (traumatic and acute) in whom no conservative treatment was effective. All tears were diagnosed preoperatively by clinical examination and ultrasound. The average duration of symptoms at the time of surgery was 14 months (range: 1 to 130). The average age was 59 years (range: 19 to 83) with 131 males and 107 females; and 62% of patients were operated on their dominant extremity. All patients underwent an ultrasound examination pre-operatively by the senior author (JdB).

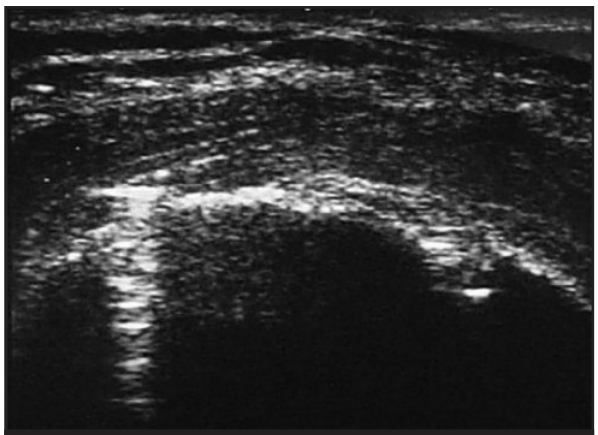

Figure 7: US shoulder; longitudinal image. Anchors of 'footprint reconstruction' visible. Note the interruption of the cortex above the anchors.

All tears were repaired by the same surgeon (JdB) and a footprint reconstruction was achieved by double row fixation. A sling was applied for 6 weeks postoperatively after which active mobilisation was initiated. The average follow-up period was 22 months (range: 12 to 49).

A standard follow-up protocol of clinical and sonographic examination at set postoperative dates (3 weeks and at final follow-up) was used.

Pre-operatively and at final follow-up Constant-Murley scores and Visual Analog Scores were done by an independent examiner. The sonographic signs described in the methods were meticulously studied in all patients pre- and postoperatively. This study focuses on the postoperative signs. A repair is considered intact if: 1) we see a bulky tendon; 2) which can be moved synchronously with the humeral head; and 3) is attached to a visible anchor in the footprint. If these three signs cannot be visualised the repair is assumed not to be intact.

Results

At 3 weeks post surgery 90.5% (190 cases) of the repairs appeared to be intact on ultrasound; in 6.2% (13 cases) the repair was not intact, and in 3.3% (seven cases) it was unknown (not written down in folder).

At final follow-up (average: 22 months) ultrasound showed 83% (174 cases) of the repairs to be intact, an absent tendon in 15% (32 cases), and unknown in 2% (four cases).

This implies that in 92% of the cases with an intact repair at 3 weeks post-surgery, the cuff was still intact at final follow-up.

The Visual Analog Pain Score dropped from 7.4 (range: 3 to 10) pre-operatively to 0.7 (range: 0 to 3) after surgery. The Constant Score improved by an average of 29.6 points, i.e. from 60.7 pre-operatively to 90.

Arthroscopic surgery is becoming the mainstay in treatment of rotator cuff pathology

The patients with an intact repair at ultrasound had a highly significant improvement in strength and range of motion after surgery, in comparison to failed repairs. The pain scores decreased comparably in both groups.

Discussion

Arthroscopic surgery is becoming the mainstay in treatment of rotator cuff pathology.[19-24] It has been proven that the result of a successful rotator cuff repair is significantly better for pain and strength compared to a conservative approach.[25-30] The success of this surgical treatment correlates strongly to the quality of the rotator cuff repair. Double row fixation techniques are superior to single row.[31-37] If the repair is insufficient the postoperative recovery will be retarded with the possibility of an inferior result. In these cases is can be necessary to consider a revision repair. Early diagnosis is preferable in these cases.

The evaluation of rotator cuff pathology can be done by sonography, MRI (arthrogram) or CAT scan (arthrogram).

Yamaguchi *et al*[11] studied the sonographic results and the arthroscopic findings in 100 symptomatic shoulders. He reports a sensitivity of 100%, a specificity of 85% and an accuracy of 96% in detecting full thickness tears. In his study ultrasound is seen to be slightly less sensitive for detecting partial tears of the rotator cuff. This is comparable to several other reports.[11-13] Biceps tendon abnormalities are frequently associated with rotator cuff tears. Dislocations of the biceps tendon are easily recognised on ultrasound, but there is less sensitivity for ruptures of the biceps tendon. Ziegler[5] presents the results of 282 sonograms compared to findings at arthroscopy and shows a sensitivity, specificity, positive and negative predictive value of 94.1%, 96.1%, 96.6% and 93.2%, respectively, for partial thickness tears, and 95.9%, 94.3%, 92.9% and 96.8%, respectively, for full-thickness tears.

His study demonstrates the value of this investigation in the hands of an orthopaedic surgeon.

Ultrasound can accurately predict the localisation and extent of the tear (on transverse and longitudinal views, respectively) with sensitivity increasing as the size of the tear increases. Yamaguchi *et al*[12] compare the outcome of ultrasonography and MRI with the findings at arthroscopy used as the standard in 71 patients. A comparable accuracy for ultrasound and MRI in identifying and measuring the size of partial and full-thickness tears is found. Kraft *et al*[16] show in their study that post-surgical MRI and ultrasound findings show a distinct discrepancy to clinical results, and based on clinical findings, postoperative MR-imaging shows a slightly higher sensitivity than ultrasound.

Modern high-quality equipment, standardised techniques and imaging protocols make ultrasound increasingly attractive. The possibility of a static and dynamic evaluation of the tissues with the shoulder in different positions, the convenience for the patient and the low risk are among the advantages of sonography. It is an inexpensive, fast, and easily accessible method[38] and has the potential to be performed in the setting of the orthopaedic clinic.[5] There is however a long learning curve, and a good knowledge of relevant anatomy and pathology is required. The experience of the sonographer, the technique used and the positioning of the patient are important factors in achieving a good result.[39-41]

MRI, on the contrary, is less operator-dependent and the images can be reviewed more easily. There is a better evaluation of surrounding structures such as labrum, capsule, bone and muscle. The determination of muscle atrophy in view of reparability of rotator cuff tears is a main advantage over ultrasound. But, in addition, MRI is expensive and time-consuming, and it has to be scheduled. Patients find it uncomfortable and sometimes intolerable.

If an investigator has similar experience with MRI and ultrasound, the preference for either one of these tests should not be based on the accuracy of the imaging modality, but rather on patient tolerance, costs and the importance of detecting non-rotator cuff pathology, e.g. labral, capsular or bone lesions. A significant advantage of ultrasound over MRI is that these images are not distorted by the presence of intraosseous hardware.

A CAT scan/arthrogram is an invasive technique that is hardly applicable in the early postoperative period due to ethical reasons.

This study used the sonographic technique to diagnose a rotator cuff tear pre-operatively, and to evaluate the quality of the tendon repair postoperatively. In 92% of the cases with an intact repair at 3 weeks post-surgery, the cuff was still intact at final follow-up. Only a few cases with unsatisfactory outcomes had an intact repair on the initial ultrasound and deteriorated afterwards (8%). Figures of absent tendons at early follow-up and at a later stage might imply that these rotator cuffs had not healed after repair, rather than having reruptured.

If there was any doubt about the integrity of the repair at the early stage, it implied a worse prognosis, and this information was kept in consideration for further management. But if favourable signs of bulky tendinous tissue moving with the humeral head, and visible anchors were present at early (3 weeks) follow-up we consider this repair as secure and expect a satisfactory result.

Conclusion

In our experience ultrasound is extremely valuable in preoperative and postoperative evaluation of the rotator cuff. It is easily accessible and can be performed during the orthopaedic consultation as it takes only a few minutes. We recommend its use routinely in the follow-up for the evaluation of arthroscopically repaired rotator cuffs. If the integrity of a repair is shown at ultrasound at early follow-up, a favourable result can be expected.

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