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S ORIGINAL ARTICLE

The use of shoulder ultrasound in a one-stop clinic: diagnostic accuracy for rotator cuff tear and biceps tendon pathology

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ABSTRACT

Background Ultrasonography is useful in diagnosing rotator cuff tears in one-stop shoulder clinics. The present study aimed to investigate one-stop shoulder clinic ultrasonographic accuracy when diagnosing rotator cuff tears and their size, as well as long head of biceps (LHB) tendon pathology.

Methods One hundred and twenty-two patients who underwent shoulder arthroscopy following pre-operative ultrasonography in a one-stop shoulder clinic were analyzed retrospectively.

Results Partial thickness cuff tears were detected with a sensitivity and specificity of 65.0% and 94.0%, respectively, and full thickness tears at 94.8% and 93.8%, respectively. Full thickness tears were further analyzed as small tears, (<1 cm), with a sensitivity and specificity of 50.0% and 96.6%, respectively; moderate (1 cm to 3 cm), at 88.5% and 93.8%, respectively; and large/massive tears (>3 cm) at 73.1% and 99.0%, respectively.

LHB pathology diagnosis sensitivity and specificity was 62.5% and 100%. Further analysis revealed a sensitivity and specificity of LHB dislocation of 83.3% and 100%, respectively, and rupture of 61.1% and 99.0%, respectively.

Conclusions This is the first study to report shoulder ultrasonographic accuracy at a one-stop clinic when investigating cuff tear size and LHB pathology. Ultrasonography at a one-stop clinic is a cost-effective accurate method of managing patients with shoulder pathology.

INTRODUCTION

Shoulder disorders can be severely debilitating for both the patient and society [1]. It is therefore vital that, for an effective treatment plan to be instigated, an accurate diagnosis must be made. A thorough history and clinical examination are extremely important, although an essential adjunct to this is imaging.

Diagnostic ultrasound has been shown to be of great value in one-stop shoulder clinics in previous studies [2–4] because it is a fast, inexpensive, non-invasive method of investigation of shoulder pathology. This means that multiple scans may be performed during each one-stop clinic, with a diagnosis sought and management plan commenced all at one sitting. However, other studies have focussed upon rotator cuff tears, specifically looking at partial or full thickness tears, rather than the size of the tear, or other shoulder problems.

The present study aimed to investigate whether an ultrasound scan of the shoulder performed at a one-stop clinic could accurately diagnose the specific common shoulder problems of rotator cuff tears, including the size of the tear, and long head of biceps (LHB) tendon pathology. Shoulder arthroscopy was considered as the gold standard.

MATERIALS AND METHODS

Between January 2005 and July 2009, 280 shoulder ultrasound examinations were performed by a specialist ultrasonographic radiographer (A.G.) in the outpatient department at a one-stop shoulder clinic. Of these patients, 122 underwent shoulder arthroscopy performed by a single specialist shoulder surgeon (A.R.), in whom a rotator cuff tear or LHB pathology had been diagnosed, and for whom arthroscopic surgery was indicated. In all patients, the decision to operate was founded upon the basis of clinical data, and sometimes after an appropriate trial of conservative management.

Of the 122 patients, 32 were male (26.2%), and the mean age was 45.0 years (range 19 years to 76 years). Forty-nine had left shoulder pathology (40.2%), and the mean time elapsed between ultrasound and surgery was 22.6 weeks (range 1 week to 50 weeks).

Ultrasound technique

A Philips HDI 5000 Ultrasound machine (Philips Healthcare, Best, The Netherlands) with a high frequency L12-5 mHz linear probe was used to perform all the shoulder ultrasound examinations. The high frequency probe enables good near-field resolution, which is essential when examining superficial structures. A liberal amount of coupling gel is placed on the transducer to improve the transducer-surface contact.

The supraspinatus tendon (SST) was visualized with the arm in internal rotation and extension by asking the patient to place their hand behind their back, exposing the SST from the overlying acromion. This is examined in the transverse and longitudinal planes. To check for impingement, the transducer was rotated through 90° and the arm is abducted upwards, the SST should slide freely but, in impingement, it can be seen to bunch under the acromion.

The infraspinatus tendon was visualized in the longitudinal plane with the arm in a flexed and adducted position by asking the patient to put the hand of the side being examined on the contralateral shoulder.

The bipennate subscapularis tendon was visualized with the arm externally rotated, as the tendon is stretched to its maximum extent, and can be examined in the transverse and longitudinal plane from its insertion into the lesser tuberosity to the point it becomes hidden by the coracoids process.

The LHB was examined in the longitudinal and transverse plane, and is identified in the intertubercular (bicipital) groove on the anterolateral aspect of the humerus with the arm in a neutral position (palm facing upwards) and the elbow flexed to 90°. The patient was then asked to externally rotate the arm to allow assessment of subluxation of the LHB from its position in the groove.

Rotator cuff tears seen at arthroscopy were measured from anterior to posterior at the footprint. Full thickness tears were diagnosed when a hyperechoic area was detected through the entire substance of the tendon, or an absence of the tendon substance with visualized margins, or a bald humeral head. Any gap seen between the retracted tendons was also measured. Partial thickness tears were diagnosed when a focal hypoechoic defect within the tendon could be visualized, either on the articular or bursal side of the tendon, or if a mixed hyperechoic/hypoechoic area could be visualized within the tendon.

Arthroscopic technique

Partial thickness tears were documented in terms of location (tendon involved and surface affected: articular or bursal) and the size (depth) of tear as per Ellman's classification, where a tear 3 mm in depth is classified as grade 1; 3 mm to 6 mm deep as grade 2 and >6 mm (>50% thickness) as grade 3. Grades 1 and 2 involve <50% thickness of tendon [5].

Full thickness tears measured according to American shoulder and elbow surgeons' classification [6]: <1 cm = small ; 1 cm to 3 cm medium; 3 cm to 5 cm = large and >5 cm = massive.

All intra-operative measurements were made in the normal fashion of using standard arthroscopic probe markings: 5-mm markings on the stem and 3 mm being the length of the bent tip of probe.

RESULTS

All results are summarized in Table 1.

Rotator cuff tears

The patients with cuff tears found at arthroscopy were divided into partial thickness tears and full thickness tears.

Of the 20 patients with a partial thickness tear found at arthroscopy, 13 were detected at ultrasound (65%). Of the seven not seen at ultrasound, six were recorded as having no cuff tear on ultrasonography. Of these, four were found at arthroscopy to be <50% partial thickness articular surface tears at arthroscopy, and two were >50% partial thickness tears. The final patient was recorded as a small full thickness tear on ultrasound but found to be a partial thickness tear on arthroscopy.

Sixty-five patients were found to have a full thickness tear at arthroscopy, of which 60 were picked up at ultrasound (92.3%). Of the five missed, a partial thickness tear was recorded at ultrasound in three, and an intact cuff was recorded in the remaining two.

Those with full thickness tears were further divided into the size of the tear: small (<1 cm), moderate (1 cm to 3 cm) and large/massive (>3 cm).

Six small cuff tears were found at arthroscopy, of which three (50%) were detected at ultrasound. Of the remaining three, two were described as partial thickness tears, and one as no cuff tear at ultrasound.

Twenty-six moderate cuff tears were found at arthroscopy, of which 23 (88.5%) were detected at ultrasound. Of the remaining three, one was described as a small tear, one as a large tear, and one as having no tear at ultrasound.

Table 1 A summary of the results obtained in the present study

Diagnosis	TP	TN	FP	FN	Acc	Sens	Spec	PPV	NPV
Rotator cuff tear									
Partial thickness	13	96	6	7	84.4	65.0	94.0	68.4	88.1
All full thickness	60	53	4	5	94.3	92.3	93.0	93.8	91.4
Small	3	112	4	3	94.3	50.0	96.6	42.9	97.4
Moderate	23	90	6	3	92.6	88.5	93.8	79.3	96.8
Large/massive	19	95	1	7	93.4	73.1	99.0	95.0	93.2
Impingement	32	81	1	8	92.6	80	98.8	97.0	91.0
LHB pathology	20	86	0	12	86.9	62.5	100	100	87.8
Dislocation	5	116	0	1	99.2	83.3	100	100	99.1
Rupture	11	103	1	7	93.4	61.1	99.0	91.7	93.7

TP, true positive; TN, true negative; FP, false positive; FN, false negative; Acc, accuracy (TP + TN/total); Sens, sensitivity (%); Spec, specificity (%); PPV, positive predictive value (%); NPV, negative predictive value (%).

Twenty-six large or massive tears were found at arthroscopy, of which 19 (73.1%) were detected at ultrasound. Of the seven missed, five were described as moderate at ultrasound, and one as partial thickness, and one as no tear.

Long head of biceps pathology

Looking at all LHB tendon pathology, ultrasound correctly identified 20 patients of the 32 seen at arthroscopy (62.5%). This includes LHB dislocation or rupture (partial or full).

Examining the results more specifically, LHB dislocation was correctly detected in five of six patients, with the one dislocation missed being reported as a LHB partial rupture. No false positive results were reported.

LHB rupture was correctly identified in only 11 of 18 patients (61.1%), with the one false positive result from above, where the ultrasound reported a rupture but arthroscopy found a dislocation. This left seven patients with bicipital ruptures diagnosed at arthroscopy but unseen at ultrasound.

DISCUSSION

The accuracy of any investigation of shoulder pathology is important because it can affect the treatment the patient receives. The methodological advantages of ultrasound to diagnose shoulder pathology has been previously documented as being cheap, quick and easy to perform, preferred by patients, and with few contraindications [7,8].

The accuracy of shoulder ultrasound when looking specifically at rotator cuff tears has reported a sensitivity of detection of full thickness tears of 67% to 100%, and a specificity of 85% to 97% [3,9–18]. For partial cuff tears, previous studies show a sensitivity of 46% to 93% and a specificity of 50% to 100% [3,9–19].

Documented disadvantages of ultrasound diagnosis of shoulder pathology include the operator-dependence and long learning curve required for this investigative method [8,20,21]. Recent studies have attempted to investigate this, examining the accuracy of shoulder ultrasound in the outpatient setting in a one-stop clinic [2,4,22,23], where ultrasonography is often performed by the orthopaedic surgeon of little experience. These studies reported good accuracy, with sensitivity of detection of full thickness tears of 88% to 96.2%, with a specificity of 94.3% to 95.4%, and for partial cuff tears a sensitivity of 70% to 95.4% and a specificity of 84.6% to 96.1%.

The present study therefore compares favourably with all of the above results, with a sensitivity and specificity of predicting a full thickness tear of 92.3% and 93.0%, respectively, and, for a partial thickness tear, 65.0% and 94.0%, respectively.

The size of the tear found at arthroscopy compared to that reported at ultrasound has not been widely reported, and as such, the evidence has been presented in a number of ways: Weiner and Seitz [13] reported the sensitivity of ultrasound in the staging of the tears into normal, partial, small (<1 cm), large (1 cm to 3 cm) and massive (>3 cm) tears at 91%, with a specificity of 94%. Teefey et al. [15] divided the analysis of the size and extent of the tears into those involving only the supraspinatus tendon and <1.5 cm wide, those involving the supraspinatus and infraspinatus and >1.5 cm wide, and those with a tear of the subscapularis tendon. They found ultrasound correctly predicted the extent of the tear in 89%, with the remaining cases underestimating the extent of the tear by 1 cm to 1.5 cm. Al-Shawi et al. [4] divided the full thickness tears into categories in a similar manner to our own study: small (<1 cm), moderate (1 cm to 3 cm) and large/massive (>3 cm). They reported results of estimation of tear size to be more 'accurate' for large/massive tears (96.5%) than for moderate (88.8%) and small tears (91.6%).

The present study only found six small (<1 cm) tears at arthroscopy, which showed a disappointing sensitivity of 50%, as a result of such small numbers. However, the moderate and large/massive tears did show more accurate results, although they did not follow the pattern of Al-Shawi et al. [4]. This logically draws the conclusion that smaller tears are more difficult to accurately measure than larger tears. The apparent difficulty in distinguishing between full-thickness and partial thickness tears has been commented upon previously [7,15], although van Holsbeeck [19] and Wiener and Seitz [13] have shown good results in this area. All other studies [2–4,9–12,14–18,20,21] have shown detection of partial thickness tears to be less accurate that detection of full thickness tears at ultrasonography. The importance of diagnosing that a cuff tear is present, and the extent of the tear, is vital for the management of the patient. It allows for a plan for treatment to be established between the surgeon and patient.

Pathology involving the LHB is an important cause of shoulder discomfort, and is commonly linked to rotator cuff pathology [24]. The detection of biceps tendon pathology by ultrasound and comparison with the arthroscopic findings has been analyzed in a small number of studies [8,14,15,25]. Sensitivity of LHB rupture has been reported at 75% to 100%, with a specificity of 98.9% to 100%. LHB dislocation has been reported at a sensitivity of 83.3% to 100% and specificity of 96.4% to 100%.

Again, the present study used small numbers to evaluate the accuracy of ultrasound, with only 18 patients found to have LHB rupture at arthroscopy. Seven of these were not picked up at ultrasound, and were in fact reported as normal.

Data from Hospital Episode Statistics show that, in 2008 to 2009 in the English National Health Service (NHS), there were around 18.7 million first outpatient attendances. Trauma and orthopaedics was the specialty with the highest proportion of first attendances, a position that it has held since 2005 to 2006. The speciality accounted for 13% of attendances in 2008 to 2009 [26]. According to the Outpatient Attendance Tariff 2009 to 2010 prices used in the English NHS [27], a one-stop shoulder clinic could save approximately £82 per patient (Table 2). This is based on the premise that, in a one-stop clinic, a patient would be assessed by a member of the surgical team, before attending the ultrasound suite for a shoulder ultrasound scan, and then returning to the clinic with the ultrasound results for analysis and management decisions with the surgical team; this is in comparison to a new patient attendance for assessment by a member of the surgical team, then referral for an outpatient ultrasound scan, before returning to a review clinic at a later date to receive the ultrasound scan results and management decisions with the surgical team.

Table 2 Outpatient attendance tariff 2009–2010 prices: comparison of a one-stop clinic with a standard outpatient attendance

One stop clinic		Standard out-patient attendance	
Procedure	Cost per patient (£)	Procedure	Cost per patient (£)
Multiprofessional new patient clinic	158	Multiprofessional new patient clinic	158
Ultrasound >20 minutes	85	Ultrasound >20 minutes	85
		Multiprofessional review clinic	82
Total	243	Total	325

Although this calculation does not take into account all running costs of a clinic and ultrasound suite, as well as staffing and space issues, it gives a gives an indication of the financial cost-saving potential of a one-stop clinic, as well as the time saved by having the ultrasound performed at the same hospital visit, which must be more convenient for the patent.

The strengths of the present study are the high number of patients involved, and that a number of shoulder problems were analyzed within this large cohort. A limitation of the study is the retrospective analysis of the accuracy of shoulder ultrasound, which only looks at patients then going for arthroscopic surgery. The study could also be criticised because the specialist ultrasonographic radiographer was not blinded to the results of the clinical examination and the surgeon was not blind to the results of clinical examination or ultrasound, which may introduce bias. However, in normal clinical practice, this does not occur, and all ultrasound scans and arthroscopies provided printed photographic evidence of pathology for independent verification. There were also a very small number of patients with any sort biceps tendon pathology ($n = 32$), which makes analysis of the data inaccurate.

In conclusion, there are now many studies that support the use of ultrasound in a one-stop clinic to accurately diagnose shoulder pathology. The present study supports these, and adds that the size of cuff tear may be accurately estimated using ultrasound in this manner. Our study also shows the cost-saving potential of a one-stop shoulder clinic.

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