The detection of full thickness rotator cuff tears using ultrasound

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We have examined the accuracy of 143 consecutive ultrasound scans of patients who subsequently underwent shoulder arthroscopy for rotator-cuff disease. All the scans and subsequent surgery were performed by an orthopaedic surgeon using a portable ultrasound scanner in a one-stop clinic. There were 78 full thickness tears which we confirmed by surgery or MRI. Three moderate-size tears were assessed as partial-thickness at ultrasound scan (false negative) giving a sensitivity of 96.2%. One partially torn and two intact cuffs were over-diagnosed as small full-thickness tears by ultrasound scan (false positive) giving a specificity of 95.4%. This gave a positive predictive value of 96.2% and a negative predictive value of 95.4%. Estimation of tear size was more accurate for large and massive tears at 96.5% than for moderate (88.8%) and small tears (91.6%). These results are equivalent to those obtained by several studies undertaken by experienced radiologists.

We conclude that ultrasound imaging of the shoulder performed by a sufficiently-trained orthopaedic surgeon is a reliable time-saving practice to identify rotator-cuff integrity.

Ultrasound imaging has become an essential adjunct to clinical examination when assessing a patient with suspected rotator-cuff pathology. The advantages of portable shoulder ultrasound are that the surgeon, in a one-stop clinic, can immediately evaluate the integrity of the rotator cuff. This allows an efficient and effective plan of treatment to be initiated. Ultrasound of the shoulder is non-invasive, has virtually no side effects and allows the rotator cuff to be visualised dynamically during rotation and elevation of the shoulder. It is cost effective and time efficient and allows the patient to see their own pathology, leading to better understanding of the disease process and a constructive discussion on the merits of treatment.

The aim of this study was to investigate whether an orthopaedic surgeon can develop both the technical skills involved in acquiring ultrasound images and interpreting pathological findings with a similar degree of accuracy as trained musculoskeletal radiologists.

Patients and Methods

A prospective consecutive record was made of all ultrasound scans of the shoulder performed by one orthopaedic surgeon (TB) between 2001 and 2004. The clinics were in two hospitals using a portable scanner (Sonosite 180plus with 8 MHz to 10 MHz small parts linear array probe; Sonosite, Bothwell, Washington). A total of 364 patients were scanned. Despite a trial of conservative therapy, 132 patients continued to have symptoms sufficient to warrant surgical intervention. They subsequently underwent arthroscopy of the shoulder. A further 11 patients had MRI, but did not require surgery and this group of 143 patients forms the index group for this study. The remaining 221 patients, many of whom had detectable pathology of the rotator cuff, either improved with conservative management including cortisone injection and physiotherapy, did not have sufficient symptoms to require surgery, or refused surgery. They did not undergo arthroplasty of the shoulder or MRI scanning and were excluded from the study. The mean age of the patients was 57 years (31 to 82).

Ultrason sound examination technique. An abbreviated three-plane rotator cuff scan was carried out instead of the 12 planes recommended in most radiological texts. The first plane was an axial scan to demonstrate the lesser tuberosity, the subscapularis muscle and tendon (longitudinal), the bicipital groove and the long head of biceps (horizontal). The second was an oblique coronal scan to show the greater tuberosity and the supraspinatus muscle and tendon (longitudinal).
cuff interval and the long head of biceps in their transverse plane. The findings were recorded in detail with drawings of each plane for schematic representation of the pathology. An assessment was made of the bone (normal/irregular), the articular cartilage (normal/positive cartilage reflection sign), cuff pathology (rim-rent tear/cleft/de-lamination/focal absence/absent cuff) and the presence of an effusion (nil/effusion/flattening of bursa/bursal concavity).

The diagnosis of a full thickness supraspinatus tear was made in the presence of a focal hypoechoic deficit or complete absence of the tendon as shown by a bald humeral head. Other indirect signs of a tear such as bursal concavity, effusion around the biceps, bony irregularity or a positive cartilage reflection sign were also looked for. For purposes of comparison, five categories were chosen to describe the state of the rotator cuff on ultrasound, MRI or at surgery. These were an intact cuff, a partial-thickness tear, a small full-thickness tear (< 1 cm), a moderate full-thickness tear (1 to 3 cm) and a large/massive tear (> 3 cm). A description of the state of the biceps was not a goal of this paper, but the presence or absence of the long head of biceps, a perched biceps, subluxation, dislocation, hypertrophy and tendon sheath effusions were noted. All patients had a standard shoulder arthroscopy and subacromial bursoscopy. All the arthroscopies were performed by TB using standard techniques.11 Patients with a full-thickness tear of the rotator cuff underwent open or mini-open repair, whereas patients with a partial-thickness tear or an intact cuff with impingement signs had an arthroscopic subacromial decompression.

The information from the index group of 143 patients who had collected data prospectively from their ultrasound scans and subsequently underwent arthroscopy or MRI were analysed by a surgeon (AA) who had not been involved in their management at any stage in order to avoid surgical bias. This method of comparing ultrasound scans against arthroscopic findings is similar to previous studies.1,4,6,8,12-16

Results

There were 78 patients with full-thickness supraspinatus tears confirmed at surgery or by MRI. Three moderate size tears were missed on ultrasound and were thought to represent partial-thickness tears, giving three false negatives and a sensitivity of 96.2%. Three cuffs (one intact and two with partial-thickness tears) were over-diagnosed as full-thickness tears on ultrasound, giving three false positives with partial-thickness tears (96.5%) than for moderate (88.8%) and small tears (91.6%).

Discussion

When assessing a patient presenting with pain in the shoulder and signs of impingement, the priority is to define whether the rotator cuff is intact or torn. If there is a tear it is necessary to define which tendon is torn and how extensive the tear is. This information allows a strategy for treatment to be agreed between the patient and the surgeon. It allows discussion as to whether surgery is needed, and the consequences of such a procedure; whether it will be arthroscopic or open, as a day-case or an inpatient, the degree of post-operative immobilisation, the schedule of rehabilitation, the time of return to work, the success of that type of surgery and the risks involved. Portable ultrasound in the hands of the surgeon allows this discussion to take place at the initial consultation. This study set out to answer the question as to whether an untrained orthopaedic surgeon is capable of obtaining a similar degree of accuracy with a portable ultrasound scanner as a fully-trained musculoskeletal radiologist using a more expensive static departmental ultrasound machine.

Before the advent of portable ultrasound scanners examinations were performed by radiologists1-8 in the radiology suite. This usually required a second visit to the hospital, and then a further consultation with the surgeon before a plan of treatment could be made.15,16 Inevitably this led to a delay in treatment with consequent retraction of the muscle, contraction of the capsule and stiffness of the shoulder17 with prolonged suffering, greater disability, more time off work and poorer surgical results.

The emergence of inexpensive high definition portable ultrasound scanners has allowed orthopaedic surgeons to perform these scans in the clinic at the first point of contact. These scanners use linear array probes running at wavelengths of 8 MHz to 13 MHz. This permits visualisation not only of the reflective interface between the bursa and the top surface of the rotator cuff and that of the bottom surface of the rotator cuff and the bone of the greater and lesser tuberosities, but it also allows visualisation of the collagen bundles in the tendon tissues, the articular hyaline cartilage, and even the fibrocartilagenous tidemark at the tendon-bone interface of the footprint of insertion of the rotator cuff. This degree of high definition allows interpre-
tation of quite subtle changes in the morphology of the cuff. The portable scanners cost from £3700 to £36 000, the majority being in the range of £12 000 to £20 000, making them affordable to an orthopaedic department, or even an individual orthopaedic surgeon. The original portable scanners were designed to be used in the battlefield, are lightweight, can be transported in a backpack and are resistant to moderate abuse. This new generation of portable scanners are being used by many hospital departments, including in accident and emergency for the investigation of abdominal trauma, in anaesthetic departments for vascular access and local anaesthetic blocks, in obstetric departments, vascular laboratories and by cardiologists.

Ultrasound has been shown to be an effective tool for determining the presence of a full-thickness tear in the hands of trained radiologists with an accuracy of between 81% and 95%. Errors in detection and measurement are small in the hands of experienced radiologists. Errors are often clinically irrelevant such as a grading error, mistaking a deep partial-thickness tear for a pinhole full-thickness tear, or a small error in measurement, mistaking a large tear for a massive tear due to inability to follow the retracted tendon under the acromion. Such errors do not change the clinical management of the patient. Inter-observer error between experienced radiologists is low, with full agreement on categorisation in 92% of scans.

There are very few studies on the accuracy of surgeons in performing ultrasound scans. Iannotti et al assessed the accuracy of a surgeon interpreting office-based ultrasonography for the diagnosis of rotator cuff tears, but the scans were performed by a physician-assistant or nurse-clinician who had undergone six hours of formal training and 30 supervised scans, and not by the surgeon. The surgeon reported on these scans and 98 patients subsequently underwent rotator cuff surgery. The sensitivity was 88% for full thickness tears and 70% for partial thickness tears. However, this study can be criticised in that the scans were not performed by the surgeon who may have been biased in his interpretation of the scan having just performed a careful clinical examination of the patient.

The study by Hedtmann and Fett demonstrates that surgeons are capable of reasonable accuracy in the diagnosis of rotator-cuff tears. In their review 239 patients were scanned and then arthroscoped for rotator-cuff disease. Both surgeons correctly identified 103 of 104 full-thickness tears with an accuracy of 98.7%. However, both surgeons had been formally trained and surgeon A had performed 10 000 scans and surgeon B 1500 scans before the study started. Static scanners were used and the authors concluded that pre-operative ultrasound scanning was reliable in diagnosing full-thickness tears, with a sensitivity of 99%, and calcific deposits, but less so for partial tears, with a sensitivity of 79%. They stated that the experience of the examiner plays an important role and that permanent continuous training is a prerequisite to ensure reliability of ultrasound diagnosis of disorders of the shoulder.

Ziegler documented his results showing the ability of an orthopaedic surgeon to use portable ultrasound scanning in his office. He studied 282 sonograms in patients who subsequently underwent surgery to the rotator cuff. When the cuff was assessed for damage, ultrasound showed a sensitivity of 99.6%. The sensitivity for full thickness tears was 95.9% and he showed far better results for looking at partial-thickness tears than other workers, with a sensitivity of 94.1%. The results were not independently verified.

Our study can be criticised in a number of ways. The surgeon may have been influenced in his interpretation of the scans by the clinical examination of the shoulder that he had just performed. However, this is the real-life situation of ultrasound scanning in a one-stop clinic and the bias could therefore not be avoided. A total of 221 patients, many of whom had abnormalities of the rotator cuff on ultrasound scanning, either improved with conservative management such as cortisone injection or physiotherapy, had symptoms that were not severe enough to warrant arthroscopy of the shoulder or MRI, or had sufficient symptoms but refused surgery on the grounds that they could not take sufficient time off work to rehabilitate. This meant that the scans in this group of patients could not be checked, both for pragmatic and ethical reasons against arthroscopy of the shoulder.

This study shows that a surgeon with no formal training, who had performed approximately 200 scans prior to the start of this study, using an inexpensive portable ultrasound scanner in an outpatient clinic, can achieve a level of competence close to that of formally-trained radiologists using expensive static scanners in a dedicated radiology department. Only 3 of 78 full thickness tears were missed. Two of these were longitudinal splints of supraspinatus and one was a tear at the musculotendinous junction that was approximated at rest. These results compare well with radiological studies which showed a range of sensitivities between 57% and 100%, Estimation of the size of the tears was, as expected, more accurate for the larger than for the smaller. The tendency was more on the side of oversizing rather than undersizing tears. The same was true for diagnosing partial-thickness tears. More were diagnosed than missed which is comparable with most other studies. Such errors rarely have clinical relevance and would not affect management or outcome.

High definition scanners using wavelengths of 8 MHz to 12 MHz give detailed pictures of the morphology of the underlying structures. However, the higher the wavelength used the more rapid the attenuation of the signal. This means that detail will fall off rapidly in individuals who are very obese, or have bulky deltoid muscle. Competition in this sector of ultrasound scanning means that rapid advances continue to be made in post-acquisition data handling by the computer, improving the picture display. At the same time this competition is driving prices down.
To date, ultrasound scanning has been the province of trained sonographers and radiologists, despite the fact that the original papers on shoulder ultrasound on both sides of the Atlantic were co-authored by orthopaedic surgeons.\textsuperscript{1,20-22} The advent of portable scanners meant that it was inevitable that medical staff in the specialities of urology, gynaecology, obstetrics, gastrointestinal medicine, vascular laboratories, breast surgery, thoracic surgery, cardiology, cranial surgery, emergency surgery, intensive care, anaesthesia and musculoskeletal disease would all use portable ultrasound as an extension of their clinical examination skills within their own departments or one-stop clinics. This has led the Royal College of Radiologists to issue a directive\textsuperscript{23} on ‘Ultrasound Training Recommendations for Medical and Surgical Specialities’. This document can be downloaded and should be read by all surgeons who want to start using shoulder ultrasound. The Royal College of Radiologists recommends that surgeons should attend a course on the theory of ultrasound including aspects of physics, safety, techniques, reading, filing and reporting. They then suggest that training should involve attendance at one clinic per week for three to six months supervised by a grade 2 practitioner, a minimum of 250 examinations recorded in a log book and a competency assessment. However, the most important recommendation is that all practitioners should recognise their own limits. Like all investigations ultrasound should not be relied upon in isolation and if equivocal the findings will need to be confirmed by MRI or shoulder arthroscopy.

Based on our positive experience we recommend this practice to other orthopaedic surgeons.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References