Evaluation of chronic tears of the rotator cuff by ultrasound

A NEW INDEX

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The diagnosis of chronic lesions of the rotator cuff is challenging. We have developed a new index to improve the sonographic diagnosis of chronic tears of the cuff.

In a pilot study, we examined 50 asymptomatic healthy volunteers by ultrasound to establish the diameter of the rotator cuff in relation to the tendon of the long head of biceps. Subsequently, the index was calculated in 64 patients who had had shoulder pain for more than three months caused by clinically diagnosed lesions of the rotator cuff. The compensatory hypertrophy of the biceps tendon was quantified sonographically in relation to the diameter of the cuff.

Comparison with the contralateral shoulder revealed a significantly higher biceps rotator-cuff ratio ($p < 0.05$) for patients with torn rotator cuffs. A ratio greater than 0.8 was considered pathological (index positive); the mean ratio in the control group was 0.43. The sensitivity of a positive index was 97.8%, the specificity 63.2%, the positive predictive value 86.3%, and the negative predictive value 92.4% in comparison with surgical findings.

Use of the index improves sensitivity in the diagnosis of chronic tears of the cuff by ultrasound.

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The diagnosis of tears of the rotator cuff by ultrasound is still uncertain. Some descriptions, such as inhomogeneity,¹ fibrocartilaginous metaplasia of tendon tissue² or calibre jump, indicate that the sensitivity of sonographic diagnosis of problems in the shoulder is still uncertain. Sonomorphological descriptions of lesions of the rotator cuff include

both hypo- and hyperechogenic ones¹ or a central echogenic band.³ With increasing age, structural modifications of the rotator cuff show an inhomogeneous pattern indicative of disintegration of collagen.² Middleton et al³ reported sonographically-detectable effusions into the tendon sheath of the long head of biceps of patients with tears of the rotator cuff and other soft-tissue abnormalities.

A partial tear of the rotator cuff may present with no more than nocturnal pain or a minor functional loss. Even with modern diagnostic facilities such as MRI, difficulties of definition are seen after scar formation and the compensatory hypertrophy of muscles of the shoulder girdle.

Arthrography has been used in the diagnosis of acute, complete ruptures of the rotator cuff,⁴ but it is an invasive procedure with a high rate of delayed morbidity^{4,5} and it is expensive. Conventional radiological findings include a narrowing of the acromiohumeral interval, decalcification of the greater tuberosity or a reversal of the normal convexity of the inferior surface of the acromion. These appearances are not specifically diagnostic of tears of the rotator cuff.⁶

Patients and Methods

In a pilot study we examined 50 asymptomatic healthy volunteers (25 women and 25 men) by ultrasound to establish standard values for the diameter of the rotator cuff in relation to the long tendon of biceps. The mean age of the group was 32 years (19 to 52) and 46 (91.6%) were right-handed. A commercially available real-time 7.5MHz linear scanner (Siemens) was used. The sonographic protocol was standardised by scanning the infraspinatus, supraspinatus and biceps tendon in longitudinal and transverse planes. The supraspinatus tendon was identified using the biceps tendon as a landmark. No abnormalities of the biceps tendon were seen. It was measured sonographically in relation to the diameter of the rotator cuff which was determined as a mean of three measured values, at intervals of 1 cm, in the transverse scans of the tendons of supraspinatus and infraspinatus. The diameter of the biceps tendon was calculated from the mean of three values measured 1, 3 and 5 cm proximal to the tendon-muscle junction (Fig. 1), which was identified from the central echogenicity of muscle and tendon.

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Fig. 1a

Fig. 1b

Transverse sonographs with measured values of a) the normal supraspinatus tendon and b) the normal biceps tendon.

Table I. Details of measurements (mm; mean $\pm$ sd) in the 50 healthy volunteers

Right side			Left side		
Biceps tendon	Rotator cuff	Index	Biceps tendon	Rotator cuff	Index
2.8 $\pm$ 0.5	6.7 $\pm$ 0.67	0.43 $\pm$ 0.065	2.8 $\pm$ 0.49	6.4 $\pm$ 0.64	0.44 $\pm$ 0.07

The index was calculated in 64 patients who had suffered shoulder pain for longer than three months and in whom a chronic tear of the rotator cuff had been diagnosed clinically. It was compared with the asymptomatic contralateral side. The mean age of the patients was 56 years (43 to 79). The right and left sides were affected with equal frequency (31 left and 33 right). Most individuals (59:99%) were right-handed. The mean duration of the complaint was 11 months (4 to 24). The compensatory hypertrophy of the biceps tendon was quantified sonographically in relation to the diameter of the rotator cuff. Radiographs were obtained in two planes in each patient. The sonographic diagnosis in the patients was confirmed or excluded operatively.

Our criteria for exclusion were tenosynovitis or rupture of the biceps tendon, non-identification of the rotator cuff by sonography (which is intrinsically associated with a complete tear of the rotator cuff) and a 'drop arm' sign. Since we compared both sides, the contralateral side acting as a control, patients with symptoms in the contralateral shoulder were also excluded.

Results

For the healthy volunteers, the mean diameter of the rotator cuff was 6.25 mm. We found no significant differences between men and women. There was no significant difference between the dominant and non-dominant side in the control group. In 46 (92%) of the right-handed volunteers, the diameter of the supraspinatus tendon was the same on each side ($p > 0.05$). On the longitudinal scans the mean

diameter of the biceps tendon, in healthy shoulders, was 2.8 mm (2.0 to 3.9 mm) as shown in Table I.

Clinical findings. All 64 patients complained of shoulder pain on movement. At operation, 45 of the 64 had tears of the rotator cuff. Night pain was a diagnostic sign in 43 of the patients with tears. Subacromial impingement was found in 60 patients (94%) and in 42 (93%) of those with tears. Crepitus was a feature in 49 of the 64 patients (77%), and 33 (73%) of those with tears. A weakness in abduction was seen in 31 (48%) of all patients and in 23 (51%) of those with lesions of the cuff. The range of movement was reduced in 26 patients with abduction to 100° and internal rotation to 50°.

Pathological index. Patients with a chronic lesion of the rotator cuff had a higher index on sonographic measurement of the long tendon of biceps and the rotator cuff (Fig. 2); 51 showed a ratio higher than 0.8. This value was defined as the pathological index ($p < 0.05$). The mean index in patients with a complete tear was 1.09, and for those with partial tears, 0.99.

Comparing each side, the mean ratio in the healthy volunteers was 0.43 (Table I). There was no variation in the index for gender or age; the correlation coefficient for age was -0.27 and that for gender was 0.34. In the patient group, the sensitivity of a positive index was 97.8% (44/45), the specificity 63.2% (12/19), the positive predictive value 86.3% (44/51) and the negative predictive value 92.4% (12/13) in comparison with the surgical findings (Table II).

Sonomorphological findings. The most frequent appearance was a focal discontinuity in the homogeneous echo-

Fig. 2a

Fig. 2b

Transverse sonographic scans with measured values of a) the supraspinatus tendon with focal thinning, hyperechogenic zone and a thickened bursa and b) a hypertrophic biceps tendon.

Table II. Details of measurements (mm; mean $\pm$ SD; range) of tears of the rotator cuff in the 64 patients

Affected side			Contralateral side		
Biceps tendon	Rotator cuff	Index	Biceps tendon	Rotator cuff	Index
5.3 $\pm$ 1.00 (3.7 to 7.8)	5.3 $\pm$ 0.95 (3.0 to 7.0)	1.02 $\pm$ 0.30 (0.74 to 2.44)	3.5 $\pm$ 0.66 (2.4 to 3.8)	6.8 $\pm$ 0.71 (5.0 to 8.1)	0.51 $\pm$ 0.73 (0.41 to 0.72)

genicity of the cuff, with no thinning. This was observed 47 times; 36 of these patients had a tear. In 35 patients, focal thinning of the cuff was observed, but 12 patients with a tear did not show this sign. A central echogenic band³ within the region of the rotator cuff was seen in 11 patients, in seven of whom a lesion was present.

Operative findings. Tears were found in 45 shoulders; 31 showed partial-thickness tears measuring between 1 and 2 cm in diameter and 14 had full-thickness scarred tears with a mean diameter 1.4 cm (1 to 3). All tears were near the insertion of the supraspinatus tendon, and in seven patients were seen to extend to the tendon of infraspinatus. A partial-thickness tear was defined as disruption of the fibres involving at least one-quarter of the tendon thickness.⁷ The long head of the biceps was hypertrophied in every patient as revealed by sonography. In the other patients we found a thickened inflamed subacromial bursa and a degenerative condition of supraspinatus caused by impingement, but no tear of the tendon.

Discussion

The value of ultrasound for investigation of the shoulder is still uncertain.⁸ Since Seltzer et al⁹ described the sonographic appearance of tears of the rotator cuff in 1979, there has been considerable progress in the precision of the investigation. Changes in the biceps tendon which accompany a lesion of the cuff are well understood.^{1,3} Additionally, modifications in the usually hyperechogenic structure

of the biceps tendon have been observed. Some authors describe a direct correlation between the diameter of the biceps tendon and the extent of the tears.^{1,3} Our results confirm this association; the measurement of our index is not dependent on the absolute size of the rupture but on a ratio. In scarred tears of the cuff, reliability remains a problem of standardised sonographic examination.^{1,10,11}

The technique cannot be used for complete or very extensive tears or when the long head of the biceps has ruptured. There is, however, no need to use the index for such lesions because sonographic diagnosis is better made morphologically. Together with other authors¹ we regard the criterion of echogenicity to be inadequate. Our results show that even focal thinning is not sufficiently reliable to reveal every tear by sonography. The biceps/rotator index helps to increase sensitivity in the diagnosis of chronic lesions of the cuff. The method is simple, non-invasive, reliable and cheap.

Biomechanical aspects. The presence of muscular hypertrophy may obscure the clinical signs of a tear of the rotator cuff, but may assist a sonographic diagnosis. Hypertrophy of the long biceps tendon, which contributes to abduction of the shoulder,¹² develops within a few months. In partnership with the cuff, the long head of biceps stabilises the humeral head by holding it down.^{13,14} Leffert and Rowe¹⁵ observed the increased size of the tendon in the presence of rupture of the cuff and considered that it represented increased function to compensate for the loss of the cuff. On the other hand Neer¹⁶ showed that in stage I of

impingement, the supraspinatus tendon may be thickened by oedema and haemorrhage. Since this would give a lower index, the minimum duration of complaint in this study was chosen as three months.

In contrast, EMG studies have yielded conflicting results. McCann et al¹⁷ observed activity in the biceps in shoulder rehabilitation exercises, whereas Yamaguchi et al¹⁸ did not observe any activity in patients with tears of the cuff.

The clinical diagnosis of partial tears of the cuff is difficult. The most common symptom in our patients was night pain and subacromial impingement, which other authors have reported.^{1,7} These are, however, general symptoms, which by themselves do not give a diagnosis. Many of these patients are managed under a 'catch-all' diagnosis of bursitis or frozen shoulder.⁷

Arthrography, an invasive procedure, should be carried out only in uncertain cases. Non-invasive procedures, such as sonography and MRI, offer no diagnostic reliability. MRI has a low sensitivity and specificity for partial tears of the rotator cuff.¹⁹ With increasing experience the sensitivity of sonography in the diagnosis of lesions of the cuff and biceps tendon is comparable with arthrography and MRI. Using the biceps-tendon-rotator-cuff index, the validity of sonographic diagnosis is further increased.

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