Prevalence and characteristics of asymptomatic tears of the rotator cuff
AN ULTRASONOGRAPHIC AND CLINICAL STUDY

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We undertook clinical and ultrasonographic examination of the shoulders of 420 asymptomatic volunteers aged between 50 and 79 years. MRI was performed in selected cases. Full-thickness tears of the rotator cuff were detected in 32 subjects (7.6%). The prevalence increased with age as follows: 50 to 59 years, 2.1%; 60 to 69 years, 5.7%; and 70 to 79 years, 15%. The mean size of the tear was less than 3 cm and tear localisation was limited to the supraspinatus tendon in most cases (78%). The strength of flexion was reduced significantly in the group with tears (p = 0.01).

Asymptomatic tears of the rotator cuff should be regarded as part of the normal ageing process in the elderly but may be less common than hitherto believed.

Tears of the rotator cuff are a well-known cause of chronic pain and dysfunction in the shoulder, but it has been shown that some tears are, and possibly remain, asymptomatic. Studies on cadavers1-4 and, more recently, using MRI5-9 or ultrasonography10-13 have tried to assess the prevalence of asymptomatic tears in the general population. In the cadaver studies, however, clinical details were not available and tears which were symptomatic were included. Those based on MRI have been on small series in younger age groups, and most lacked correlation with the clinical findings. Ultrasonography allows examination of large groups and is reported to be reliable in the detection of full-thickness tears.14-24 However, such studies are uncommon and present varying results for prevalence, the influence of age and the clinical findings. There have been few data on the characteristics of asymptomatic rotator-cuff tears, such as their size, location, involvement of the biceps tendon and bursal or glenohumeral effusion. Such information may give better understanding of the factors which are important in the development of symptoms.

Our aim in this clinical and ultrasonographic study was to assess, prospectively, the prevalence and characteristics of full-thickness tears of the rotator cuff in asymptomatic subjects aged between 50 and 79 years, and to relate these findings to clinical examination.

Patients and Methods
The study had ethical approval. Between September 2005 and January 2008, we performed clinical and ultrasonographic examination of the shoulders of 420 subjects with asymptomatic shoulders in the age groups 50 to 59, 60 to 69 and 70 to 79 years. Each group consisted of 140 individuals and all gave informed consent. They had earlier been treated at our hospital for conditions unrelated to the shoulder such as meniscal tears, hallux valgus, hammer toe, Morton’s neuroma and carpal tunnel syndrome. They were included on the basis of a written statement, which confirmed the absence of acute or earlier pain and subjective dysfunction in one (120 subjects) or both shoulders (300 subjects), along with a score of at least 90 points in the self report section of the American Shoulder and Elbow Surgeons form (ASES).25 The choice of 90 points was based on age-related baseline values from studies of individuals with no history of shoulder symptoms.26-28 Clinical examination was performed by one examiner (SM) and consisted of measurement of the active range of movement (ROM) for abduction, flexion and external rotation with a goniometer, and of internal rotation by noting the highest anatomical landmark reached by the subject’s thumb, such as the gluteal region, sacrum, vertebral spine L5, L3 or T12 and the interscapular region. Strength was assessed using a handheld spring balance with the elbow extended with the subject sitting on a swivel stool with the shoulder in 90° of abduction and then in 90° of flexion. The ‘break-test method’29 was used in which the subject resisted the examiner’s downward force until it overcame the subject’s isometric contraction. The mean of two
consecutive measurements was used for analysis and a form listing the findings was completed immediately afterwards.

Bilateral ultrasonographic examination was then performed by the same examiner who had previously carried out 2000 such examinations of the shoulder. His ability to detect full-thickness tears of the rotator cuff in symptomatic shoulders had been shown to have a sensitivity of 100% and a specificity of 97%.19 Real-time ultrasonography was performed according to a standard protocol,19 using a Sonoline Antares scanner (Siemens Medical Systems, Erlangen, Germany) equipped with a linear-array transducer of 8.5 to 11.5 MHz. Diagnostic criteria for full-thickness tears included absence of the rotator cuff, hypo- or anechoic discontinuity and contour concavity at the superior border of the tendon of the rotator cuff in two planes.30-32 In subjects with bilateral tears only one shoulder was used for analysis of tear characteristics. Partial-thickness tears were not included because of the lack of reliable diagnostic criteria for their detection.

The measurement of the maximum size of the tear was made on lateral transverse and longitudinal views. The distance between the margins of the tear on the lateral transverse view or between the margin of the tear and the greater tuberosity on the lateral longitudinal view was determined.33

The particular tendon involved was observed on anterior (subscapularis) and lateral transverse views (supra- and infraspinatus), using the biceps tendon as a landmark. Tears extending posteriorly for less than 1.5 cm from the intra-articular portion of the biceps tendon were recorded as tears of supraspinatus. Those extending for more than 1.5 cm were recorded as involving supra- and infraspinatus and those located anterior to the biceps tendon as tears of subscapularis.34

Assessment of the biceps tendon was performed on ante- rior transverse and longitudinal views. A tear was diagnosed if the tendon could not be identified in the intertubercular sulcus or elsewhere in front of the humerus. A dislocation was diagnosed when the tendon was seen anterior or medial to the lesser tuberosity.23 The amount of any subacromial-subdeltoitd bursal effusion and effusion of the biceps tendon sheath was assessed on anterior transverse views and graded subjectively as normal (distension < 1 mm), slightly increased (1 mm to 2 mm) or clearly increased (> 2 mm).

In order to control for false-positive findings, MRI was performed on subjects with an ultrasonographically detected full-thickness tear. It was also carried out on 81 subjects who did not fulfil our criteria for full-thickness tears, but had ultrasonographic appearances which were described as diagnostic for partial-thickness tears. Such criteria included focal heterogenous tendon hypoechochogenicity, incomplete hypoechoic clefts and pitting or irregularity of the bony surface of the greater tuberosity.30,31 Since ultrasonographic distinction between partial and small full-thickness tears is difficult16 we considered this group to be at risk for overlooked full-thickness tears and MRI was therefore performed as a control for false-negative ultrasonographic findings using a 1.5 T scanner (Siemens Medical Systems). Five sequences, all with a slice thickness of 3.5 mm to 4 mm, field of view of 17.5 to 18.0 and one number of excitations were obtained as follows: 1) oblique sagittal T1-weighted spin echo (TR/TE, 513/13 ms; matrix, 192 × 256); 2) oblique sagittal T2-weighted turbo spin echo (TR/TE, 2930/74 ms; matrix 218 × 256); 3) oblique coronal; 4) axial proton density-weighted turbo spin echo with fat saturation (TR/TE, 2800/40 ms; matrix 230 × 256); and 5) oblique cor onal dual echo turbo spin echo (TR/TE, 2500/13 to 81; matrix 205 × 256). All images were interpreted by one of two musculoskeletal radiologists (RT, AL), blinded as to the clinical and ultrasonographic findings. A full-thickness tear was diagnosed as a discontinuity or gap in the tendon or increased signal intensity on T2-weighted images, extending from the articular to the bursal surface.23,35,36

Statistical analysis. The prevalence of tears was calculated per subject. In those with bilateral findings, the shoulder which, by chance, was examined first was used for all further analysis. The 95% confidence interval (CI) for prevalence was derived from the binominal distribution.37 A chi-squared test for trend was used to assess the association between the prevalence of a tear and the age group.

Measurement of the range of movement (ROM) and ASES points were expressed as mean values for subjects with and without tears of the rotator cuff. Interaction between tear/no-tear and age on shoulder strength, adjusted for gender and between tear/no-tear and gender on shoulder strength, adjusted for age was tested by a two-way analysis of covariance (ANCOVA). One-way ANCOVA with age and gender as covariates was performed to test the effect of tear/no-tear on shoulder strength. The relationship between the size of the tear and strength was investigated using the Pearson product-moment correlation coefficient.

Results

Ultrasoundographic screening detected asymptomatic full-thickness tears of the rotator cuff in 32 subjects (7.6%, 95% CI 5.3 to 10.6). The prevalence increased with age (Table I). This association was highly significant (chi-squared test, p < 0.0005).

MRI of subjects with ultrasonographic evidence of a tear was carried out in 30 of 32 subjects. Two were excluded, one because of claustrophobia and the other because of the presence of a pacemaker. MRI confirmed the ultrasonographic finding of a full-thickness tear in 28 subjects, but found only a partial-thickness tear in two. The possibility for a false-negative ultrasonographic result was assessed in a subgroup of 81 individuals considered to be at risk for overlooked full-thickness tears by ultrasonography. In this group, MRI detected two patients with a full-thickness tear, 45 with a partial-thickness tear and 34 with no tear.
There was no difference of clinical relevance between the tear and no-tear groups in respect of the ROM and ASES points (Table II). Strength testing showed reduced mean values for abduction and flexion strength in those with full-thickness tears. Testing for interaction between tear/no-tear and age on shoulder strength (adjusted for gender) and between tear/no-tear group and gender on shoulder strength (adjusted for age) by two-way ANCOVA was negative. Testing of the effect of tear/no-tear on shoulder strength with age and gender as covariates by one-way ANCOVA showed statistical significance for flexion strength only (Table II).

Unilateral asymptomatic tears were discovered ultrasonographically in 21 subjects, 17 of which were on the dominant side. All the subjects were right-handed. Bilateral asymptomatic tears were found in 11. For the 32 asymptomatic tears, the mean tear size by ultrasonography was 12.9 mm (sd 8.8) in the anteroposterior plane and 13.1 mm (sd 9.5) in the mediolateral plane. The size was classified as small (< 1 cm) in 12 subjects, medium (1 cm to 3 cm) in 18, large (3 cm to 5 cm) in one and massive (> 5 cm) in one. The tears were localised to the supraspinatus tendon in 25 subjects (78%). Four tears extended less than 5 mm into the infraspinatus, one into subscapularis and one in both. In one case a complete tear of the supraspinatus, infraspinatus and subscapularis tendons was found. A tear of the long head of the biceps was diagnosed in the three cases in which subscapularis was affected.

The subacromial-subdeltoid bursa and biceps tendon sheath were assessed ultrasonographically as normal in 21 (65.6%) and 15 (47%) subjects, respectively. A slightly increased effusion was found in nine and six and a clearly increased effusion in two and 11 subjects, respectively. The relationship between the size of tear in the mediolateral or anteroposterior planes on one side and abduction or flexion strength on the other side was assessed by analysis of correlation. A moderate negative strength of relationship was found for the association of the size with shoulder strength (Table III).
Discussion

The prevalence of asymptomatic tears of the rotator cuff in our study was lower than that in most comparable reports. In agreement with the study of Schibany et al and the results of MRI-based studies, we found that asymptomatic tears were very uncommon in subjects younger than 60 years but increased in prevalence with age. A higher prevalence has been reported in other ultrasonographic and MRI-based studies. When comparing these results with ours, the following differences in study design should be noted. Our use of a higher frequency transducer (8.5 to 11.5 MHz compared with 7.5 MHz) gave better image resolution. The low number of subjects older than 60 years in the other studies may have lessened the validity of their findings. We alone attempted to verify positive and negative ultrasonographic results by MRI and good agreement between the techniques supported the reliability of our findings.

A lower prevalence has been given by the results of cadaver studies which have the advantage of a high diagnostic validity but the disadvantage of the likelihood that some tears are asymptomatic. Therefore, the prevalence of asymptomatic tears in cadaver studies should be higher than the true prevalence. In a review of several cadaver studies, Reilly et al found that the prevalence of asymptomatic full-thickness tears was 12.7%. This makes the higher values from other studies difficult to explain. When considering the younger mean age between these and cadaver studies, the discrepancy was even greater. In our study, the theoretical expectation of a slightly lower prevalence in vivo was realised. In our two oldest age groups, with a comparable mean age of 69.9 years, the prevalence was 10.3%.

In agreement with our inclusion criteria, the clinical results from measuring the ROM and the ASES score showed no clinically significant differences between torn and intact cuffs, as was also found by Schibany et al, who reported a slight reduction in the Constant-Murley score (84.3 vs 89.5 of maximum 100 points) and the Constant ROM score (37.3 vs 37.8 of maximum 40 points) between the two groups. Our differences for strength between the groups were considerable but reached statistical significance for strength of flexion only. Tempelhof et al found increasing loss of strength with the size of tear of the affected compared with the non-affected side. Schibany et al found significant differences between torn and intact cuffs for the Constant power score (15.2 vs 11.5 of maximum 25 points, p < 0.01) indicating that asymptomatic tears caused measurable changes in shoulder strength. The ultrasonographic or MRI characteristics of asymptomatic tears are generally agreed. Asymptomatic tears are typically limited to the supraspinatus tendon, as in 25 of 32 tears in our study, in all 13 of the series of Schibany et al and in 92 of 96 of that of Tempelhof et al. Involvement of the subscapularis and biceps tendon was not described in any of the earlier studies but was present in three of our cases. The tear size was small to moderate (< 3 cm) in 30 of 32 cases in our study, and in 80 of 96 cases in that of Tempelhof et al. They did not find any effusion in the subacromial-subdeltoid bursa, but it was present in 11 of 32 of our cases and in all 14 in the study of Needell et al. In 17 of our 32 cases and in all 14 of Needell et al an effusion was seen in the biceps sheath.

In studies analysing the prevalence of conditions of the rotator cuff, both shoulders must be considered and this had implications for our study design. The calculation of prevalence and analysis of tear characteristics should be performed on the basis of independent observations, and since the right and left shoulders are interdependent, the prevalence was calculated by subject rather than by shoulder. Also, in cases of bilateral asymptomatic tears, only one tear was analysed.

Several limitations in our study design warrant discussion. Our group may have differed from the general population since all the subjects had been treated at our hospital. However, they had only one or very few attendances, and were treated for minor orthopaedic conditions remote from the shoulder. We were unaware of any evidence which might link those conditions with the rotator cuff. We therefore believe that our study group represented the general population without shoulder problems.

MRI in all subjects with negative ultrasonographic findings might have supported the reliability of our results but was considered to be too costly and time-consuming. MRI of those subjects who were defined ultrasonographically to be at risk of overlooked tears seemed to be an acceptable compromise. Neither ultrasonography nor MRI is currently used as the optimum standard for the evaluation of the rotator cuff in research protocols, and surgical exploration may have given a different result, but this is not practicable in asymptomatic subjects.

Ultrasonography and MRI can only perform a static evaluation of an evolving condition. We cannot assume that the shoulders which we studied will remain asymptomatic but only that the finding of a torn rotator cuff did not relate to previous or current symptoms.

Asymptomatic tears of the rotator cuff were found less frequently in our study than in most comparable reports. In the majority of our cases the tear was less than 3 cm in size and localisation was limited to the supraspinatus. The reason as to why these tears are, and possibly remain asymptomatic, is not yet understood. Therefore, therapeutic decisions must be made on the basis of clinical examination and not on imaging findings alone.

Supplementary material

A further opinion by Dr G. Porcellini is available with the electronic version of this article on our website at www.jbjs.org.uk

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References