B. C. Hanusch, L. Goodchild, P. Finn, A. Rangan

From James Cook University Hospital, Middlesbrough, England

The aim of this study was to determine the functional outcome and rate of re-tears following mini-open repair of symptomatic large and massive tears of the rotator cuff using a two-row technique.

The 24 patients included in the study were assessed prospectively before and at a mean of 27 months (18 to 53) after surgery using the Constant and the Oxford Shoulder scores. Ultrasound examination was carried out at follow-up to determine the integrity of the repair. Patient satisfaction was assessed using a simple questionnaire.

The mean Constant score improved significantly from 36 before to 68 after operation (p < 0.0001) and the mean Oxford Shoulder score from 39 to 20 (p < 0.0001). Four of the 24 patients (17%) had a re-tear diagnosed by ultrasound. A total of 21 patients (87.5%) were satisfied with the outcome of their surgery. The repair remained intact in 20 patients (83%). However, the small number of re-tears (four patients) in the study did not allow sufficient analysis to show a difference in outcome in relation to the integrity of the repair.

Large and massive tears of the rotator cuff are associated with significant morbidity and functional deficit. Gartsman et al. has shown that the impact of such a tear on a patient’s life is similar to that of major medical conditions such as acute myocardial infarction. The onset of symptoms is often insidious in this group with a long-standing history of shoulder pain and gradual reduction in function as a sign of a chronic tear.

The management of these large and massive tears is controversial, and the published outcomes have been inconsistent. Some patients achieve good function after conservative treatment, but these results deteriorate with time. Others maintain good function after surgery despite a re-tear. Surgical repair of tears of the rotator cuff has been shown to be beneficial, but the results are less favourable and less predictable in large and massive tears. In particular, the rate of re-rupture after repair is significantly higher in this group. The chronic nature of these tears, with tendon retraction, bursal scarring, muscle atrophy and fatty degeneration, can make surgical repair difficult.

The operative technique has evolved from open to arthroscopically assisted mini-open, and in recent years, all-arthroscopic repair. The results of open repair of large and massive tears are well documented, and an increasing number of studies have been published on all-arthroscopic repairs. However, there are few investigations of the functional outcome and the rate of re-tear after mini-open repair, and these have included tears of all sizes with only few patients having large and massive tears. We are not aware of any previous study which has investigated the outcome and integrity of the repair after mini-open repair of large and massive tears.

The aim of this prospective study of a case series of consecutive patients was to investigate the functional outcome and rate of re-tears after mini-open repair of large and massive tears of the rotator cuff using a two-row technique.

Patients and Methods

We reviewed prospectively 24 patients with a large or massive tear of the rotator cuff who had surgical repair between 2002 and 2006. Inclusion criteria were the presence of a large or massive tear, identified by imaging and confirmed intra-operatively, which was repaired using a mini-open approach and a two-row technique. A total of 26 patients fulfilled the inclusion criteria at the time of surgery; 24 patients, 12 men and 12 women, attended a follow-up clinic at a mean of 27 months (18 to 53). Two patients were lost to follow-up and were not included in the analysis.
The mean age of the patients at surgery was 60 years (42 to 74), and in 17 of 24 patients (71%) the dominant arm was affected. One patient had previously undergone a subacromial decompression for impingement symptoms without evidence of a tear of the rotator cuff at the time of surgery. The mean time between the onset of symptoms and surgery was 18 months (2 to 120). In eight patients (33%) the onset of symptoms was acute, six after a fall, one following a ‘jerking movement’ of the arm, and one associated with a dislocation of the shoulder. In 11 patients (46%) the onset of symptoms was gradual, and five (21%) identified an acute event that worsened their existing symptoms.

The indication for surgery was a symptomatic tear of the rotator cuff, confirmed by either ultrasound or MRI, following acute injury or with persistent symptoms after six months of non-operative treatment, which included physiotherapy, subacromial injections and anti-inflammatory medication.

All patients were independently assessed pre-operatively and at their follow-up appointment by an experienced physiotherapist specialising in shoulder rehabilitation. During this assessment the Constant score and Oxford Shoulder Score were recorded in every patient. Subjective measures such as the level of pain and activities of daily living as part of the Constant score and the Oxford Shoulder Score, were recorded as stated by the patient. The range of movement was measured using a goniometer, and strength was tested with a digital myometer (Nottingham Mecmesin Myometer, Atlantech, Harrogate, United Kingdom). Strength testing was carried out with the arm in 90° of abduction. Patients who were unable to abduct their arm to 90° received a strength score of 0 as described by Constant and Murley.

During the post-operative assessment patients were also asked to complete a questionnaire on their demographics, the onset of symptoms and return to work. Patient satisfaction was assessed on a four-point scale: very satisfied, satisfied, not satisfied, displeased.

An ultrasound examination of the shoulder was carried out by an independent radiographer experienced in ultrasound imaging of the shoulder to assess the integrity of the repair. The examination was carried out as real-time imaging using a Philips HDI 5000 scanner and a variable high-frequency linear array transducer, 12 MHz to 5 MHz, or 7 MHz to 4 MHz for larger patients. The tendons of supraspinatus, infraspinatus, subscapularis and long head of biceps were visualised in the transverse and longitudinal plane in all patients. The subacromial and subdeltoid bursa and the bony surfaces were assessed for irregularity. A complete re-rupture was diagnosed when a focal defect in the tendons of the rotator cuff was found with a variable degree of retraction of the tendon, or when the cuff could not be visualised because of complete retraction under the acromion. A partial re-rupture was recorded when there was a distinct defect on the articular side of the tendon of the rotator cuff.

All operations were carried out under general anaesthesia with the patient in a beach-chair position. Anterior, posterior and lateral arthroscopic portals were established. After assessing the glenohumeral joint for additional pathology, an arthroscopic subacromial decompression and acromioplasty was performed in all patients. The tear of the rotator cuff was measured with a probe in the anteroposterior direction at the point of insertion of the tendons, and its size recorded as large (3 cm to 5 cm) or massive (> 5 cm). The retracted tendons were mobilised arthroscopically and the footprint prepared. The lateral incision was then extended vertically to a maximum of 5 cm distal to the acromion to protect the axillary nerve. The deltoid was split in the line of its fibres to allow direct access to the tear. The tendons were approximated side to side to achieve margin convergence with simple mattress sutures using no 1 Ethibond. The reconstructed cuff was fixed to the bony footprint using two rows of absorbable Panalok RC suture anchors with absorbable Panacryl sutures (Ethicon, Johnson & Johnson, Westwood, Massachusetts). Simple mattress sutures were used for the medial row and modified Mason-Allen sutures for the lateral row. Two to three suture anchors were used in each of the rows.

Post-operatively all patients followed a standard protocol of rehabilitation. The arm was placed in a sling for four weeks, during which only gravity-assisted flexion for personal hygiene was allowed. At four weeks pendular exercises and passive movement were commenced. At six weeks patients began active assisted exercises, and after eight weeks graded strengthening exercises were introduced.

**Statistical analysis.** A sample size calculation was carried out based on detecting a ten-point difference between the pre- and post-operative Constant scores, which was seen as clinically significant. In order to detect this difference at the 5% significance level with a power of 80%, 21 patients were needed.

Data were tested for normality and the post-operative Constant and Oxford Shoulder Scores were found to be skewed. Therefore, non-parametric tests were used for the analysis. Pre- and post-operative data were compared using Wilcoxon’s signed ranks test, and data between groups were analysed using the Mann-Whitney U test. The association between different outcome variables was analysed with Spearman’s correlation coefficient. A result was considered statistically significant if the p-value was < 0.05. The statistical analysis was carried out using SPSS version 13.0 (SPSS Inc, Chicago, Illinois).

**Results**

**Functional outcome.** There was a statistically significant improvement in all shoulder scores after operation (Table I). The mean relative Constant score (CSrel) was calculated using the reference tables of normalised values by Yian et al to adjust the score for age and gender.

Analysis of the pre-operative shoulder scores showed a statistically significant difference between men and women for the Constant score (p = 0.004, Mann-Whitney U test) and
the Oxford Shoulder score ($p = 0.022$, Mann-Whitney U test). Even after adjusting for age and gender, the difference in the relative Constant score was still significant ($p = 0.046$, Mann-Whitney U test), with women showing a poorer functional status before surgery.

This difference was also seen in the post-operative Constant score ($p = 0.02$, Mann-Whitney U test) and the strength subscore ($p = 0.01$, Mann-Whitney U test). No difference was observed for the relative Constant score and the pain, activity and range of movement subscores, as well as the Oxford Shoulder score and its pain and function subscores.

The size of the tear did not influence the functional outcome, with no statistically significant difference in any of the pre- or post-operative scores between patients with large or massive tears.

The integrity of the repair also had no impact on functional outcome. However, the patients with a re-rupture were few and included the patient with the best functional outcome in the study. After removing this outlier from the analysis, patients with a re-rupture had a statistically significantly lower Constant score ($p = 0.027$, Mann-Whitney U test) and higher Oxford Shoulder score ($p = 0.043$, Mann-Whitney U test) than those with an intact repair. These results must be viewed with caution, however, owing to the low sample size in one of the groups.

We also found no association between functional outcome and the patient variables of arm dominance, acute or chronic onset, and pre-operative duration of symptoms.

**Intra-operative findings.** Large tears were found in 17 patients (71%) and massive tears in seven (29%). Table II shows the tendon involvement found intra-operatively.

The long head of biceps showed degenerative changes in nine patients, with a partial tear with fraying of the superior labrum without detachment of the biceps tendon (SLAP type 1) in four. A chronic rupture of the long head of biceps was found in one patient. There were early osteoarthritic changes of the glenohumeral joint in six patients.

The rotator cuff tear was successfully repaired in all patients. Three also underwent a biceps tenotomy and tenodesis, and three had the labral tear debrided.

**Repair integrity.** At the ultrasound examination at follow-up four patients (17%) had a re-rupture. In two the supraspinatus tendon had retracted under the acromion, and in the remaining two there was a full-thickness defect without retraction.

**Patient satisfaction.** Of 24 patients, 21 (87.5%) were satisfied or very satisfied with the outcome of the surgical procedure. Three patients (12.5%) were not satisfied, and none was displeased with the result.

Patient satisfaction correlated significantly with the post-operative Constant score ($p = 0.001$, Spearman’s correlation coefficient) and the Oxford Shoulder score ($p = 0.001$, Spearman’s correlation coefficient). A better functional outcome was associated with a higher degree of satisfaction. The three patients who were not satisfied also had significantly higher pain subscores in the Constant score ($p = 0.014$, Mann-Whitney U test) and the Oxford Shoulder score ($p = 0.025$, Mann-Whitney U test) than those who were satisfied with the outcome.

No correlation was found between satisfaction and the integrity of the repair. Only one of the patients with a re-rupture was not satisfied with the outcome, the remaining three being very satisfied with the result of the surgery.

Prior to their injury, ten patients were retired. Of the 14 patients in employment before injury, eight returned to their previous job, three retired, and three had not returned to any form of employment at the time of follow-up.

**Complications.** There were no surgical or post-operative medical complications.

**Discussion**

The best treatment for large and massive tears of the rotator cuff remains controversial. It is widely acknowledged that surgical repair of such tears significantly reduces pain and improves shoulder function, but the size of the tear and the poor quality of the tissues often make successful repair difficult. Many authors have described good functional outcomes and pain relief with subacromial decompression and debridement alone. Many authors have described good functional outcomes and pain relief with subacromial decompression and debridement alone.21-23 Mellilo, Savoie and Field, however, showed in a long-term follow-up study that the initial good results deteriorated significantly with time, and concluded that this was not acceptable. Vad et al1 and Moser et al12 could not find a statistically significant difference between decompression and repair, but reported

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**Table I. Pre- and post-operative shoulder scores**

<table>
<thead>
<tr>
<th>Shoulder score†</th>
<th>Mean</th>
<th>Median</th>
<th>Range</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS pre-operative</td>
<td>36</td>
<td>38</td>
<td>21 to 49</td>
<td>8.1</td>
<td>&lt; 0.0001†</td>
</tr>
<tr>
<td>CS post-operative</td>
<td>68</td>
<td>73</td>
<td>28 to 92</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>CSrel pre-operative</td>
<td>42</td>
<td>44</td>
<td>26 to 54</td>
<td>8.1</td>
<td>&lt; 0.0001†</td>
</tr>
<tr>
<td>CSrel post-operative</td>
<td>78</td>
<td>85</td>
<td>35 to 99</td>
<td>18.3</td>
<td></td>
</tr>
<tr>
<td>OSS pre-operative</td>
<td>39</td>
<td>39</td>
<td>27 to 48</td>
<td>6.1</td>
<td>&lt; 0.0001†</td>
</tr>
<tr>
<td>OSS post-operative</td>
<td>20</td>
<td>16</td>
<td>12 to 38</td>
<td>8.4</td>
<td></td>
</tr>
</tbody>
</table>

* CS, Constant score; CSrel, relative Constant score; OSS, Oxford Shoulder Score
† Wilcoxon’s signed ranks test

**Table II. Tendon involvement found intra-operatively in 24 shoulders**

<table>
<thead>
<tr>
<th>Tendon involvement</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraspinatus</td>
<td>15 (62.5)</td>
</tr>
<tr>
<td>Supraspinatus and infraspinatus</td>
<td>5 (20.8)</td>
</tr>
<tr>
<td>Supraspinatus and subscapularis</td>
<td>1 (4.2)</td>
</tr>
<tr>
<td>Supraspinatus, infraspinatus and subscapularis</td>
<td>3 (12.5)</td>
</tr>
</tbody>
</table>
a trend towards a better outcome in patients who had a repair.

The potential advantages of arthroscopic methods over open repair are reduced deltoid morbidity, faster rehabilitation, and the ability to assess and treat intra-articular pathologies. However, the all-arthroscopic approach is technically difficult and has a steep learning curve.

The functional outcome of open repair of large and massive tears of the rotator cuff has been reported widely, but the results of a mini-open approach are not available in isolation for this particular group of patients in the English literature. They are reported as subgroups in studies which include tears of various sizes, and often the number of patients in the group are small, or no individual analysis of outcome by size of tear has been carried out.

Baysal et al prospectively reviewed 84 patients with tears of all sizes, including 17 with large and massive tears, who underwent mini-open repair, and reported a statistically significant improvement in shoulder scores and range of movement. They found no difference in outcome between different tear sizes at one year, but noticed a trend towards improved outcome in smaller tears. Hersh and Sgaglione also found significant improvement in pain and function in 22 patients with tears of all sizes. They concluded that size of tear did not predict outcome, but their numbers were small, with only five patients each having large and massive tears. Posada et al investigated deterioration over time in 60 patients with all sizes of tear, including 37 which were large and massive. They noted no decline in functional outcome, but had only 53% good or excellent results for patients with massive tears, compared to 88% and 90% for patients with medium-sized and large tears.

Recent studies comparing mini-open with all-arthroscopic repair have shown no statistically significant difference in functional outcome between the two groups. However, none of these were randomised controlled trials, and data were often collected retrospectively.

The functional outcomes in our 24 patients with large and massive tears are similar to those recorded for open or arthroscopic repair. We showed a statistically significant improvement in the Constant and Oxford Shoulder scores, as well as in both pain subscores, at a mean follow-up of 27 months. The majority of these patients (16; 67%) had long-standing shoulder problems with chronic degenerate tears.

Few studies have investigated the integrity of the repair after mini-open repair of large and massive tears. Liem et al observed a rate of re-tear of 36.8% in isolated supraspinatus tears diagnosed by MRI; Verma et al observed re-tears in 50% in tears > 3 cm using ultrasound. The rates of re-tear after open repair vary greatly, from 10% to 86%. Higher rates for large and massive tears have been found after arthroscopic repairs, ranging from 31% to 94%, and the 17% in our study compares favourably with these results.

Ultrasound examination was used in this study to assess the integrity of the repair. The literature on post-operative ultrasound is sparse. Only one recent study by Pickett et al compared ultrasound with arthroscopic findings in 44 patients. They demonstrated a sensitivity of 91% and a specificity of 86% for the detection of a tear of the rotator cuff in the previously operated shoulder. These figures are slightly higher than those reported for MRI after surgical repair. Ultrasound examination is dependent on the operator and the equipment. In order to increase the reliability of the examination, all were carried out by an experienced musculoskeletal sonographer whose locally audited results for detecting rotator cuff tears are comparable to those reported in the literature.

The technique of repair plays an important part in tendon to bone healing of these tears. Healing without gap formation is a major factor in restoring post-operative function. Burkhart et al showed in a biomechanical study that fixation by suture anchors is stronger than by transosseous tunnels. Barber, Herbert and Click stated that all available biodegradable suture anchors have adequate pull-out strength to resist physiological loads. A two-row repair has been shown to be superior to one-row, with better recreation of the footprint, higher resistance to cyclic displacement, increased stiffness and ultimate load to failure. The modified Mason-Allen stitch was first described by Gerber et al and was found to have a higher tensile strength than simple mattress sutures.

Previous studies have varied with regard to the influence of the size of tear and the integrity of the repair on functional outcome and patient satisfaction. Cofield et al in a prospective long-term study of open repair of chronic tears found size to be the most important determinant of outcome, and similar results were reported by Kim et al. Others found no difference in outcome between tears of different sizes. Verma et al identified the integrity of repair as an important predictor of outcome, with significant deficits in function in patients with a re-tear. We observed no difference in shoulder scores either pre- or post-operatively between patients with large or massive tears. However, it is possible that the results might have been different if small and medium-sized tears had been included.

The strengths of this study include the prospective collection of data, the availability of pre- and post-operative scores, and the involvement of independent clinicians for patient assessment and ultrasound examination. The limitations are the lack of a control group and the relatively small number of patients studied. The small number of patients with a re-tear in this study did not allow sufficient analysis to show a difference in outcome in relation to the integrity of repair. However, we believe that our results show a trend towards poorer functional outcome in patients with a re-tear.

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


