Mid-term clinical and sonographic outcome of arthroscopic repair of the rotator cuff

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We have conducted a prospective study to assess the mid-term clinical results following arthroscopic repair of the rotator cuff. Patients were evaluated using the Constant score, subjective satisfaction levels and post-operative ultrasound scans.

Of 115 consecutive patients who underwent arthroscopic repair of the rotator cuff at our institution, 102 were available for follow-up. The mean period of follow-up was for 35.8 months (24 to 73). The mean age of the patients was 57.3 years (23 to 78). There were 18 small (≤ 1 cm in diameter), 44 medium (1 cm to 3 cm in diameter), 34 large (3 cm to 5 cm in diameter) and six massive (> 5 cm in diameter) tears. There was a statistically significant increase in the size of the tear with increasing age (p = 0.0048).

The mean pre-operative Constant score was 41.4 points (95% confidence interval, 37.9 to 44.9), which improved to 84.5 (95% confidence interval, 82.2 to 86.9). A significant inverse association (p = 0.0074), was observed between the size of the tear and the post-operative Constant score, with patients having smaller tears attaining higher Constant scores after repair. Post-operatively, 80 patients (78.4%) were able to resume their occupations and 84 (82.4%) returned to their pre-injury leisure activities. Only eight (7.8%) of 102 patients were not satisfied with the outcome.

Recurrent tears were detected by ultrasound in 19 (18.6%) patients, and were generally smaller than the original ones. Patients with recurrent tears experienced a mean improvement of 31.6 points (95% confidence interval, 23.6 to 39.6) in their post-operative Constant scores. Those with intact repairs had significantly improved (p < 0.0001) Constant scores (mean improvement 46.3 points, 95% confidence interval, 41.9 to 50.6). Patient satisfaction was high in 94 cases (92%), irrespective of the outcome of the Constant score. Recurrent tears appear to be linked to age-related degeneration.

Arthroscopic repair of the rotator cuff leads to high rates of satisfaction (92%) and good functional results, albeit with a recurrence rate of 18.6% (19 of 102).

Arthroscopic repair of the rotator cuff is gaining in popularity. This can be attributed to the technological advances of arthroscopic equipment and surgical techniques. Recent publications have demonstrated similar results to those of mini-open repair.1,2 The arthroscopic technique provides several potential advantages, such as less trauma to the deltoid, a reduced risk of post-operative stiffness, improved visualisation and mobilisation of large tears, reduced patient discomfort post-operatively and reduced morbidity. A major potential disadvantage is the technical difficulty of the procedure.

We conducted a study to evaluate the medium-term clinical results of arthroscopic repair of the rotator cuff, performed at our institution. Using ultrasound examination,3-5 we evaluated the incidence and size of recurrent tears.

Patients and Methods

We studied 115 consecutive patients who underwent arthroscopic repair of the rotator cuff between October 1998 and May 2003. All operations were performed by the senior authors (OL, SC). The clinical diagnosis of a rotator cuff tear was supported by either ultrasound (77) or MR scans (23). In the remaining two patients the diagnosis was made on clinical grounds with the assistance of plain radiographs.

Patients with stiffness did not undergo rotator cuff repair until their stiffness was resolved. These patients were treated with a two-stage procedure. First, a manipulation of the shoulder under general anaesthesia and interscalene block was followed by intensive physiotherapy aiming at full passive range of movement. Only when this was achieved...
would we then proceed to arthroscopic repair of the rotator cuff, usually three to six weeks later.

The extent of the tear was assessed using the classification of Post, Silver and Singh. We used the shaver blade (< 4 mm wide) as a template to measure the size of rotator cuff tears.

Of the 115 patients, 102 (102 shoulders) were available for follow-up. The mean age of the patients was 57.3 years (23 to 78). In 48 patients (47%), a history of significant trauma was present. There were 18 small (< 1 cm in diameter), 44 medium (1 cm to 3 cm in diameter), 34 large (3 cm to 5 cm in diameter) and six massive (> 5 cm in diameter) tears.

**Surgical technique.** The technique used depended on the size and configuration of each tear. Subacromial decompression was performed in 99 patients (97.1%), depending on the presence of an impingement lesion. In patients with acute traumatic tears in whom no impingement lesion was found at arthroscopy, subacromial decompression was not performed.

For small to medium-sized C-shaped tears, the repair techniques varied from a simple single-row technique with one or two suture anchors to the ‘parachute technique’. This was developed by one of the senior authors (OL) and consists of a suture and knot configuration that resembles a parachute (Fig. 1), thereby increasing the contact area and pressure between the tendon and its footprint. After debridement of the tear, mobilisation of the cuff and preparation of the footprint, one or two suture-loaded anchors are inserted into the area of the footprint. Using penetrating graspers, the two limbs of each suture are passed through the healthy edge of the tear anteriorly, creating a configuration of a horizontal mattress suture. The same technique is applied to the remaining suture in the anchor, but the sutures are pulled out posteriorly, creating another horizontal mattress suture. By doing this alone, the cuff is approximated to the footprint. In order to increase the contact area between tendon and bone, the trailing ends of each mattress suture are tied to each other and then cut.

For L-shaped or inverted L-shaped tears, a single-row technique with two anchors and side-to-side suture repair was used.

For larger tears, or after a repair with the parachute technique, where there was a flap of cuff tissue laterally, we used a double-row technique in a ‘ratchet-loop configuration’ which was developed by one of the senior authors (OL) (Fig. 2). In this technique, a second double suture-loaded anchor is placed laterally. One pair of sutures is used for the anterior leaf of the tear, and the other pair for the posterior leaf. Using a penetrating grasper, the suture is taken through the cuff, creating a loop of suture which is left out through the cuff. The free end of the same suture limb which has been passed through the cuff is then passed through the loop. It is then tied to the limb of the suture that has not been passed through the cuff using a non-sliding knot, creating a ratchet-loop (pulley) configuration. The procedure is repeated for the posterior leaf of the cuff. This suture configuration multiplies the lateral pull on the cuff by four times. The ratchet-loop technique doubles the load on the cuff tendon for each suture by creating a pulley system, there are two sutures per anchor, hence the load is multiplied by four. This follows the basic principles of force equilibrium and mechanical statics in the use of pulley systems.
A number of different suture anchors were used in our patients, including the Fastin RC with Ethibond sutures (Mitek, Division of Ethicon, Inc., Johnson & Johnson Company, Westwood, Massachusetts), Biofastin RC with Ethibond sutures (Mitek, Division of Ethicon Inc., Johnson & Johnson Company), with Twinfix Ultrabraid sutures (Smith & Nephew, Endoscopy Division, Andover, Massachusetts), and the Spiralock with Orthocord sutures (Mitek, Division of Ethicon Inc., Johnson & Johnson Company).

For massive U-shaped tears, a marginal convergence repair with side-to-side sutures was used. This was augmented by a lateral suture anchor repair if needed. Post-operatively, all patients used a sling for six weeks. During this period, they were allowed only passive movements consisting of pendulum and passive-assisted exercises, depending on the size of the tear and intra-operative findings. At six weeks after operation active movements were gradually incorporated, progressing to resistive and strengthening exercises. Physiotherapy continued for up to six months after operation, based on the progress of each patient.

**Post-operative assessment.** For each patient, the symptoms, the type of imaging and operative details were collected prospectively using the computerised database of our institution. All available patients were called back to attend a review clinic. The patients were then assessed clinically using the Constant score\textsuperscript{10} and a subjective satisfaction score or the subjective shoulder value (SSV)\textsuperscript{11} which is defined as a patient’s subjective shoulder assessment expressed as a percentage of an entirely normal shoulder, which would score 100%, and sonographically with an ultrasound scan (Sonosite 180, Sonosite Inc., Bothell, Washington), which was performed by an experienced operator (BV).

Failures were defined as all dissatisfaction patients and patients who had revision arthroscopy for any reason. Not all patients whose tear recurred were dissatisfied with the result and therefore were not always classified as failures.

**Statistical analysis.** Differences in means were tested using Student’s $t$-test and analysis of variance (ANOVA). Associations between categorical variables were investigated using the chi-squared test. Pre- and post-operative values of the overall Constant scores, as well as of the individual items’ scores, are presented as mean values with 95% confidence intervals (CI), differences between pre- and post-operative values were tested using the paired $t$-test. The association between tear size (small, medium, large, massive) and Constant score deciles (30 to 100 points in ten-point increments) was investigated using the chi-squared test.

Statistical analysis was carried out using SAS/STAT, Release 8.2 (SAS Institute Inc., Cary, North Carolina). A value of $p < 0.05$ was considered significant.

**Results**

There were 73 men and 42 women. Of these, 13 were lost to follow-up, leaving 102 patients for the study. There were 38 women and 64 men. The right shoulder was involved in 66 patients and the left in 36. The mean follow-up time was for 35.8 months (24 to 73).

Pre-operative symptoms were pain in all 102 patients and weakness in 53 (52%).

Tears in 85 patients (83.3%) involved mainly the supraspinatus tendon. In ten patients (9.8%) the infraspinatus tendon was primarily involved (posterior tear) and seven (6.9%) had isolated tears of the subscapularis. With increasing age there was a statistically significant increase in the size of the tears ($p = 0.0048$, ANOVA) (Fig. 3).

Fraying, degeneration or instability of the long head of the biceps tendon were addressed by tenotomy or arthroscopic tenodesis. Of the 15 patients with fraying and degeneration, three were treated by tenotomy and arthroscopic tenodesis. Of the 15 patients with fraying and degeneration, three were treated by tenotomy and arthroscopic tenodesis.
There were eight more patients with only mild fraying of the biceps tendon, which was left in situ. Of the five patients with instability of the biceps tendon, two were treated by tenotomy and three with arthroscopic tenodesis. In 14 patients the biceps tendon was absent or found to be torn at arthroscopy (Table I).

The mean pre-operative Constant score was 41.4 (95% CI 37.9 to 44.9). Following surgery, the mean Constant score was 84.5 (95% CI 82.2 to 86.9; p < 0.0001). Significant improvement was observed in all parameters comprising the Constant score (p < 0.0001, Fig. 4), including a substantial improvement in strength.

A significant association (p = 0.0074, chi-squared test) was observed between the size of the tear and the postoperative Constant score, with patients who had smaller tears scoring higher post-operatively (Fig. 5).

Irrespective of the size of tear, patients in all size groups demonstrated improved mean Constant scores post-operatively (Table II). Following surgery, 80 patients (78.4%) returned to their work and 84 (82.4%) to their pre-injury leisure activities. Only eight patients (7.8%) were not satisfied with their outcome, and five of these underwent revision surgery.

Ultrasound scans performed post-operatively revealed recurrent rotator cuff tears in 19 patients (18.6%). Only six of these (5.9%) were dissatisfied with the outcome. The mean age of patients with recurrent tears was significantly higher than in those with an intact repair (62.4 vs 56.7 years, p = 0.02, one-sided t-test). We investigated the relationship of the failed repairs to the size of the tears (Table III). Of the patients with recurrent tears, only three experienced a second tear of equal or greater magnitude than their original lesion.

Despite the sonographic finding of a recurrent rotator cuff tear in some patients there was still a significant improvement of 31.6 points (95% CI 23.6 to 39.6) in the mean Constant score (p < 0.0001, Student’s t-test). There was statistically significant higher improvement of 46.3 points (95% CI 41.9 to 50.6) (p < 0.0001, Student’s t-test) in the group with an intact repair (Table IV). Most patients (n = 94, 92.2%) were subjectively satisfied, irrespective of the objective outcome as measured with the Constant score.

Although a higher percentage of recurrences was observed in the patients with massive tears, no statistically significant association was found between the pre-operative size of tears and the rate of recurrence (Table V). There was a high (92%) overall rate of satisfaction and 96 (83.4%) were sound at a mean follow-up of 35.8 months. A recurrent tear was not classified as a failure unless the patient was dissatisfied, and this was the case in only a small portion (6 of 19, 5.9%) of patients with recurrent tears. This observation is consistent with that of Jost et al, who reported that a rotator cuff repair may yield a good to excellent clinical result, even in patients with recurrent tears after surgery.

Discussion

It has been shown that an ultrasound scan of the rotator cuff using hand-held devices has a sensitivity of 94.1% for partial- and 99.6% for full-thickness tears. Specificity has been reported at 96.1% for partial- and 85.7% for full-thickness tears, respectively. Other studies have shown that there are significant differences between ultrasonography and MRI, in their accuracy in identifying and measuring the size of full- and partial-thickness tears of the rotator cuff. The accuracy of post-operative shoulder imaging with ultrasound has been validated by Prickett et al, who
reviewed the sonographic findings in 44 patients undergoing revision shoulder surgery. Using the intra-operative findings as the gold standard, the authors reported that the ultrasound correctly identified 20 of 22 recurrent tears of the rotator cuff, yielding a sensitivity and specificity of 91% and 86%, respectively, with an accuracy of 89%.

In 97.1% of our patients, an arthroscopic subacromial decompression was performed in conjunction with the repair of the rotator cuff. Of the patients who experienced a recurrent tear of the rotator cuff, only one did not have a decompression at the time of the initial surgery. The success of the repair of the rotator cuff has been commonly attributed to a concomitant subacro-

### Table II. Comparison of pre- and post-operative Constant scores of patients grouped according to the size of their rotator cuff tear (reported as mean values with 95% confidence intervals (CI) in parentheses; p-values calculated using Student’s t-test)

<table>
<thead>
<tr>
<th>Size of tear</th>
<th>Number of patients</th>
<th>Pre-operative Mean (95% CI)</th>
<th>Post-operative Mean (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>18</td>
<td>39.7 (32.8 to 46.6)</td>
<td>87.4 (81.6 to 93.3)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Medium</td>
<td>44</td>
<td>46.2 (41.0 to 51.3)</td>
<td>86.8 (83.9 to 89.7)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Large</td>
<td>34</td>
<td>36.8 (29.7 to 44.0)</td>
<td>82.3 (79.1 to 87.3)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Massive</td>
<td>6</td>
<td>31.0 (0.0 to 65.2)</td>
<td>66.3 (48.4 to 84.3)</td>
<td>0.0177</td>
</tr>
<tr>
<td>Overall</td>
<td>102</td>
<td>41.4 (37.9 to 44.9)</td>
<td>84.5 (82.2 to 86.9)</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

### Table III. Re-tear of the rotator cuff in relation to the original tears

<table>
<thead>
<tr>
<th>Size of tear (pre-operatively)</th>
<th>Thinning/partial-thickness tear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive</td>
<td>Mass</td>
</tr>
<tr>
<td>Massive</td>
<td>1</td>
</tr>
<tr>
<td>Large</td>
<td>-</td>
</tr>
<tr>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>Small</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table IV. Comparison of the Constant score and its parameters between patients with and without recurrent tears of the rotator cuff (reported as mean values with 95% confidence intervals (CI))

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intact repairs (n = 96)</td>
<td>Recurrent tears (n = 19)</td>
<td>Intact repairs (n = 83)</td>
</tr>
<tr>
<td></td>
<td>Lower limit</td>
<td>Upper limit</td>
<td>Lower limit</td>
</tr>
<tr>
<td>Pain</td>
<td>3.1</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Activities of daily living (points)</td>
<td>9.8</td>
<td>8.9</td>
<td>9</td>
</tr>
<tr>
<td>Range of movement</td>
<td>27.4</td>
<td>25.4</td>
<td>27.5</td>
</tr>
<tr>
<td>Abduction strength</td>
<td>7.3</td>
<td>6.4</td>
<td>8.2</td>
</tr>
<tr>
<td>Constant score</td>
<td>41.3</td>
<td>37.2</td>
<td>45.4</td>
</tr>
</tbody>
</table>

* Student’s t-test

### Table V. Association between re-tear rate and original rotator cuff tear size (numbers of patients presented with percentages in parentheses). No significant association was found between re-tear and size (p = 0.2348, chi-squared test)

<table>
<thead>
<tr>
<th>Size of tear</th>
<th>Intact repair (%)</th>
<th>Recurrent tear (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>14 (77.8)</td>
<td>4 (22.2)</td>
<td>18</td>
</tr>
<tr>
<td>Medium</td>
<td>39 (88.6)</td>
<td>5 (11.4)</td>
<td>44</td>
</tr>
<tr>
<td>Large</td>
<td>27 (79.4)</td>
<td>7 (20.6)</td>
<td>34</td>
</tr>
<tr>
<td>Massive</td>
<td>3 (50.0)</td>
<td>3 (50.0)</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>83 (81.4)</td>
<td>19 (18.6)</td>
<td>102</td>
</tr>
</tbody>
</table>
mial decompression. However, Gartsmann and O’Connor specifically looked at this point in their prospective, randomised study of 90 patients. At one year post-operatively, no significant difference between patients with and without subacromial decompression was found, using the American Society of Shoulder Surgeons score.

Ratti et al reported that 36 of 42 rotator cuff repairs appeared intact on ultrasonography. Their failure rate was 14.3%, which is less than in our patients, albeit at a shorter follow-up of 12 months. However, when tears of the subscapularis were included, the failure rate rose to 23%. Tauro demonstrated clinical deterioration of repairs of large and massive tears after one year. Boileau et al described 65 patients who underwent arthroscopic repair of the rotator cuff. Using MRI and CT, they found that 71% of the repairs were sound. They also noted that in 16 patients (24.6%), in whom the insertion of the supraspinatus tendon had not healed, the residual defect was smaller than the initial tear. We also observed that the size of recurrent tears was on the whole smaller than the original tears. The improvement in Constant scores correlated inversely to the size of tears, with smaller improvements observed in patients with larger tears.

Our findings also suggest that the size of the original tear affects the outcome of the repair. The lowest post-operative Constant scores were observed in the patients with massive tears in whom there was a higher rate of failure (16.6%), compared with the patients with small (5.5%) and medium-sized tears (4.5%). The latter may represent tendon degeneration and muscle atrophy. Fuchs et al and Gerber, Fuchs and Hodler demonstrated no significant change in muscle atrophy after successful healing of rotator cuff repairs. Whereas the presence of muscle atrophy pre-operatively was not predictive of a recurrent tear, post-operative atrophy was significantly more common in our patients who experienced recurrent tears of the rotator cuff.

The age of the patient at the time of primary repair is an important factor for the outcome. A recurrent tear after primary repair occurred in two patients (8%) aged less than 50 years and in 22 (18.9%) aged over 50. This may represent failure due to age-related degeneration of the tendon rather than to the technique of the repair. In another study, the failure rate in patients aged over 65 years was 57%. In our study group this was 44%.

In studies on the results of open repair of the rotator cuff, the rate of recurrent tears has been reported to range between 10% and 36% for smaller tears, but was much higher for massive lesions. Bishop et al in a follow-up study of rotator cuff repairs using MRI, found a rate of re-rupture of 31% for open repairs compared with 47% after arthroscopic repair. For smaller tears (< 3 cm), the rate of re-rupture was substantially better after arthroscopic repair (16% vs 26%), whereas for larger tears (> 3 cm) it was higher after arthroscopic repair (16% vs 38%). We found higher rates of re-rupture with increasing size of the original tear. Our finding is in keeping with previous studies on open or arthroscopic repair of the rotator cuff, and probably reflects the reduced mechanical strength associated with degenerate tendons. Higher rates described by some investigators may reflect the steep part of the surgeon’s learning curve in arthroscopic techniques.

Arthroscopic repair of the rotator cuff achieves similar results to open techniques with the added advantages of minimal surgical trauma to the tissues, less post-operative pain, reduced risk of infection and improved cosmesis. It can usually be performed as a day-case and is therefore an attractive option to most patients.

The rate of re-rupture does not appear to be related to the surgical technique but is probably a reflection of mechanical compromise of the tissues due to age-related degeneration. A recurrent tear of the rotator cuff does not necessarily imply a clinical failure. Most of our patients with recurrent tears were satisfied with their result and had significantly improved Constant scores. However, we do not know whether the clinical results of these patients will deteriorate in the future.

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


