Knot Impingement After Rotator Cuff Repair: Is It Real?

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Purpose: The purpose of this study was to compare morphologic features of the acromion after 2 different repair methods (single-row [SR] repair with a minimum of 4 knots and suture-bridge [SB] repair with minimal knots) in medium to large rotator cuff tears. Methods: From May 2005 to July 2012, 1,693 rotator cuff repairs were performed, among them medium to large tears requiring more than 2 anchors for repair; those who had 6-month postoperative magnetic resonance imaging (MRI) scans were included (221 shoulders). They were divided into 2 groups; group A (SR repair) and group B (SB repair). Acromial morphologic characteristics were evaluated using MRI 6 months postoperatively. An acromial defect was defined as an irregular defect or erosion on the flat acromion. Clinical measurements were performed using the American Shoulder and Elbow Surgeons (ASES) score, Constant score, visual analogue scale (VAS) pain score, and range of motion (ROM). Results: Erosion in the acromion was observed in 2 of 118 patients (1.7%) in group A and in 1 of 103 (1%) patients in group B. There was no statistically significant difference between the 2 groups (P = .796). A statistically significant improvement was observed in the clinical scores measured (P = .0043). ROM was not fully recovered to the preoperative level at 6 months postoperatively. Acromioplasty was performed in 2 of 3 patients with acromial erosion. There was acromial erosion in one patient in group A without performing subacromial decompression. Conclusions: Our study showed that there was no difference in acromial erosion in high-profile knots made by an SR compared with double-row (DR) SB low-profile repairs. Level of Evidence: Level III, retrospective comparative study.

Rotator cuff lesions are among the most common shoulder pathologic conditions. The method of rotator cuff repair has evolved substantially in the past few decades. Arthroscopic rotator cuff repair has a good prognosis regarding clinical outcome, with significant improvement in quality of life. Good functional improvement has been noted, even in patients who have massive tears and who received only partial cuff repair and in patients who have had retears of the cuff. Arthroscopic rotator cuff repair is now considered one of the most successful operations, with good clinical and radiologic outcomes. Satisfactory results have been reported in more than 80% of patients. However, the reported failure rates range from 10.3% to 33.3%. Arthroscopic rotator cuff repair techniques require a method of securing the tendon to the bone to obtain a stable construct. One of the keys to successful rotator cuff repair is firm and adequate suturing of the torn tendon that leads to covering the footprint of the humeral head with or without suture anchors in all rotator cuff operations. Recently, the suture-bridge (SB) technique or knotless construct has decreased the use of knots during rotator cuff repair, yet a substantial portion of the repair still needs knot tying to produce a good repair, and a strong and secure knot is required to provide adequate soft tissue apposition for good healing.

Recently, we shifted our practice from SR reconstruction to SB repair, making minimal knots that protrude under the subacromial space for medium to large full-thickness rotator cuff tears. We questioned whether changes in this reconstruction method would have some effect on the acromial undersurface erosion or osteolysis. Therefore, the purpose of this study was to compare acromial morphologic characteristics after 2 different repair methods: single-row (SR) repair with a
minimum of 4 knots and SB repair with minimal knots in medium to large rotator cuff tears. Our hypothesis was that the protruding knots in the SR technique would result in more acromial erosion because of impingement than would SB repair, which uses low-profile suture materials.

**Methods**

**Study Population**

We retrospectively reviewed arthroscopic cuff repairs performed by one senior author from May 2005 to July 2012. Until 2010, we practiced the SR repair and from 2011 we performed the SB technique. We performed 1,693 arthroscopic rotator cuff repairs in that period. Medium to large tears requiring more than 2 anchors for repair as well as tears in patients who had undergone 6-month postoperative magnetic resonance imaging (MRI) were included. We excluded shoulders with tendon loss and those in which complete repair (type I or II repair) could not be performed. Two hundred twenty-one patients satisfied the inclusion criteria. They were divided into 2 groups: group A (SR repair) and group B (SB repair). Acromial morphologic characteristics were evaluated by MRI 6 months postoperatively. An acromial defect was defined as an irregular defect or erosion on the flat acromion. Clinical measurements were performed with American Shoulder and Elbow Surgeons (ASES) score, Constant score, visual analogue (VAS) pain score, and range of motion (ROM).

**Surgical Technique**

All operations were performed by a single surgeon with the patient positioned in the lateral decubitus position, with the operative arm placed in a position of 20° to 30° of abduction and 20° of forward flexion (Star Sleeve Traction System; Arthrex, Naples, FL). After initial diagnostic glenohumeral and subacromial examination, the pathologic tissue of the rotator cuff was lightly debrided, and the tear size was measured with a calibrated probe from the lateral portal for medial-lateral size and through an anterior portal for anterior-posterior size. Eighty-five patients received subacromial decompression: 31 patients in group A and 54 patients in group B. The anterior osteophyte was removed and type II and type III acromia were converted to a type I acromion.

After determining the proper location for suture anchor placement with a spinal needle in the shoulders in group A, the Bio-Corkscrew Suture Anchor (Arthrex, Naples, FL) with double-loaded sutures was inserted into the lateral aspect of the footprint. Sutures were passed through the tendon edge by shuttling with No. 0 PDS (Ethicon, Somerville, NJ). Rotator cuff tears were repaired with simple stitches for the SR repairs using nonsliding Revo knots tied in mattress fashion. Depending on tear size, 2 to 3 double-loaded suture anchors were inserted into the medial portion of the footprint just adjacent to cartilage in group B. Sutures were shuttled through tendon as previously described. Not all the sutures were tied in the medial row. Usually, only 2 knots (out of 4 medial-row suture passages) were tied in the medial row. One limb from each suture-loop pair was collected and fixed in the lateral row with polyetheretherketone knotless suture anchors (PopLok; ConMed Linvatec, Largo, FL). The other limbs were similarly fixed in another suture anchor.

In patients with L- or U-shaped tears with a noticeable mobile segment, side-to-end repair was primarily performed in both groups to restore the rotator cuff configuration and to prevent propagation of the tears. A routine rehabilitation protocol was followed in all patients, with immobilization for 4 to 6 weeks followed by active-assisted exercises and then stretching and strengthening exercises.

**MRI Acquisition and Evaluation**

Postoperative MR images were acquired in all patients at an average of 5.7 months (range, 4 to 10 months). MRI was performed with a 3.0 TMR imager (Gyroscan Intera Achieva; Philips Medical Systems, Best, The Netherlands) with a dedicated receive-only shoulder coil. Standard image acquisition protocol was used. Oblique coronal T2-weighted and oblique sagittal T2-weighted images were evaluated to determine the loss of normal contour of the inferior surface of the acromion and the presence of hyperintense lesions. The presence of such lesions was defined as an acromial defect or osteolysis. The measurements were analyzed by 2 orthopaedic surgeons who were unaware of surgical details.

**Clinical Evaluation**

Preoperative shoulder scores were collected from patient records and included ASES score, Constant score, the VAS for pain, and the passive ROM measurement. The assessment was repeated at the 6-month follow-up visit.

**Sample Size Calculation**

With a .05 2-sided significance level and a power of 80%, it was postulated that the expected difference in the mean values for follow-up ASES scores between the 2 groups would be 7 points, the common standard deviation would be 10 points, the expected difference in the mean values for follow-up forward elevation between the 2 groups would be 15°, and the standard deviation would be 21°. Assuming that the t test was used, the sample size of each group was determined to be 34 patients (nQuery Advisor 3.0; Statistical Solutions, Cork, Ireland).
Statistical Analysis

Interobserver variability was also tested with intra-class correlation analysis. All statistical analyses were performed using SPSS, version 12.0 (SPSS, Chicago, IL). A Student’s $t$ test was used to compare the VAS pain score, ROM, and functional scores between the 2 groups. $P < .05$ was considered significant.

Results

The average age at surgery was 60.1 years (range, 36 to 76 years). There were 92 men and 129 women. Surgery was on the dominant side in 159 shoulders and on the nondominant side in 62 shoulders. The mean time from symptom onset to surgery was 16.8 months (range, 8 to 50 months). Data on acromial erosion in each group were obtained by separate observers. The mean interobserver correlation coefficient (0.92) was found to be highly significant.

The erosion in the acromion was observed in 2 of 118 (1.7%) patients in group A (Fig 1) and in one of 103 (1.0%) patients in group B (Fig 2). A statistically significant improvement was observed in the clinical scores measured in both groups ($P = .0043$). General clinical scores all improved, including the 3 patients described (Fig 3). In group A, the ASES score increased significantly from 45.4 (range, 11 to 81) preoperatively to 63.9 (range, 29 to 96) 6 months postoperatively. In group B, the ASES score also increased from 46.2

Fig 1. Coronal and sagittal oblique view of T2-weighted MRI scans: (A and C) before surgery and (B and D) 6 months postoperatively. The single-row (SR) repair was performed without acromioplasty. Compared with before surgery, an acromial erosion with an irregular defect on the flat acromion was detected.

Fig 2. Coronal and sagittal oblique view of T2-weighted magnetic resonance (MR) images: (A and C) before surgery and (B and D) 6 months postoperatively. The suture-bridge (SB) repair was performed with acromioplasty. Compared with before surgery, acromial erosion with an irregular defect on the flat acromion was detected.
(range, 8 to 85) preoperatively to 58.3 (range, 23 to 95) 6 months postoperatively. ROM was not fully recovered to preoperative levels at 6 months postoperatively (Fig 4). In group A, the forward elevation decreased from 143.6° (range, 30° to 170°) to 121.5° (range, 60° to 160°) (Table 1). In group B, the forward elevation decreased from 146.3° (range, 50° to 170°) to 119.8° (range, 80° to 160°) (Table 2).

The erosion in the acromion was observed in 2 of 118 (1.7%) patients in group A and in 1 of 103 (1.0%) patients in group B. Acromioplasty was performed in 31 patients in group A and in 54 patients in group B. Acromioplasty was performed in 2 of the 3 patients showing acromial erosion, one after another in each group. Of 2 patients showing acromial erosion in group A, one patient was a 61-year-old woman. Her ASES score improved from 41 to 60, and her Constant score improved from 31 to 61. The other patient was a 68-year-old woman. Her ASES score improved from 31 to 65, and her Constant score improved from 20 to 64. The However, the postoperative ROM was decreased from the preoperative ROM in both patients. The patient showing acromial erosion in group B was a 50-year-old woman. Her ASES score improved from 25 to 62, and her Constant score improved from 20 to 61. Her ROM was mildly increased from before operation.

Retears were determined based on rotator cuff integrity on radiologic studies. MRI 6 months after surgery showed high signal intensity in 3 of 118 (11.0%) patients in group A and in 7 of 103 (6.8%) patients in group B. However, despite numerical differences, there were no statistically significant differences between the 2 groups (P = .264).

Discussion

Recently, impingement of the knots in the subacromial space has been suggested as a cause for subacromial osteolysis and the consequent discomfort of weakness and poor function.10

Although there is some reporting10 of knot impingements, especially for those SR configurations, it seems the incidence is rare. Our study showed that there was no difference in acromial erosion between 2 different repair methods.

Lately, stronger braided nonabsorbable suture materials have replaced all the anchor suture limbs. These suture materials have enabled us to make firmer knots without concern for suture breakage during knot tying and management, which frequently occurred in previous Ethibond-loaded anchors (Ethicon, Somerville, NJ). This has caused a tremendous change in our practice because we do not need to reinsert the anchor because of suture breakage during knot tying. However, these strong suture material characteristics raise some concerns of knot impingement both intra-articularly and under the acromion. Furthermore,

### Table 1. Comparison Between Preoperative and Postoperative 6-Month Clinical Scores in Single-Row Repair Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative</th>
<th>6 Months Postoperatively</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS pain score</td>
<td>5.1 ± 1.9</td>
<td>2.7 ± 1.2</td>
<td>&lt;.001</td>
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<tr>
<td>ASES score</td>
<td>45.4 ± 13.4</td>
<td>63.9 ± 23.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Constant score</td>
<td>49.9 ± 16.2</td>
<td>63.0 ± 20.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Range of motion (°)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward elevation</td>
<td>143.6 ± 13.4</td>
<td>121.5 ± 15.4</td>
<td>.082</td>
</tr>
<tr>
<td>External rotation</td>
<td>39.8 ± 13.5</td>
<td>17.0 ± 9.3</td>
<td>&lt;.05</td>
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</tbody>
</table>

ASES, American Shoulder and Elbow Surgeons; VAS, visual analogue scale.

### Table 2. Comparison Between Preoperative and Postoperative 6-Month Clinical Scores in Suture-Bridge Repair Group

<table>
<thead>
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<th>Variable</th>
<th>Preoperative</th>
<th>6 Months Postoperatively</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS pain score</td>
<td>5.2 ± 2.3</td>
<td>3.1 ± 2.0</td>
<td>&lt;.05</td>
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<tr>
<td>ASES score</td>
<td>46.2 ± 18.1</td>
<td>58.3 ± 17.6</td>
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<tr>
<td>Constant score</td>
<td>50.5 ± 14.0</td>
<td>55.3 ± 11.4</td>
<td>&lt;.001</td>
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<tr>
<td>Range of motion (°)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Forward elevation</td>
<td>146.3 ± 28.5</td>
<td>119.8 ± 24.6</td>
<td>.091</td>
</tr>
<tr>
<td>External rotation</td>
<td>45.9 ± 14.2</td>
<td>21.5 ± 19.7</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

ASES, American Shoulder and Elbow Surgeons; VAS, visual analogue scale.
there is some reporting of acromial osteolysis caused by the knots.\textsuperscript{10} This might be true especially for those who perform acromioplasty and expose weak cancellous bone under the knots. Low-profile knots or thinner suture materials can be helpful, making these knots not protrude as much as possible, especially knots in the subacromial space where the space is quite limited. Nonetheless, it is inevitable to leave the knot under the acromion.

Currently, there are 2 popular arthroscopic techniques using suture anchors for repairing rotator cuff tears; SR fixation and the double-row (DR) repair technique. Earlier arthroscopic SR repair techniques achieved partial restoration of the footprint of the rotator cuff, whereas the DR repair technique presented many biomechanical advantages and higher rates of tendon-to-bone healing. There are some studies in the literature comparing the clinical results of SR and DR techniques, and none of them have found any statistically significant difference between the 2 methods.\textsuperscript{11,12} In our study, even though we performed the SB technique instead of the DR repair, our clinical results are similar to those previously reported in the literature in that the SR and SB groups showed similar results on the functional scores without any statistically significant difference ($P = .704$).

The theoretical risk of an adverse reaction to knots has been recognized in nonorthopaedic circumstances. Rijssel et al.\textsuperscript{13} histologically assessed the tissue reaction surrounding surgical knots in rats. They suggested that the use of thick-gauge suture materials adds much more to the total amount of foreign body and tissue reaction in the wound than does the addition of extra throws in the knot. Trimbos et al.\textsuperscript{14} also reported that the thickness of the suture contributes much more to the volume of the knot than does the number of throws.

Although extensive increases in arthroscopic cuff surgery have occurred, impingement of the knot under the acromion has not been recognized. Theoretically, in arthroscopic repair, the knots are made with more throws of half-hitches, causing thicker knots. Furthermore, recent improvement in suture materials that makes them much stronger has raised concerns of impingement of the cartilage or acromion. Our study shows that at least on the acromial undersurface, knot impingement might be a very rare phenomenon, and we can be relatively relieved to do SR repair with prominent knots.

The potential for bulky knots to cause impingement has always been suspected but had never been studied until recently. Newer suture materials are tougher and long lasting. Arthroscopic knots are inherently weaker, and consequently many more throws are needed for optimal knot stability. This makes arthroscopic knots bulkier than in those used in open surgery.

**Limitations**

The limitation of our study was that the MRI was only 6 months after surgery. Even so, Hotta et al.\textsuperscript{10} also reviewed 6-month postoperative MRIs, and the difference may exist in postoperative 3-year MRIs, so we have reading bias. Further studies with larger numbers of patients with subacromial osteolysis are required to clarify the influence of knot impingement on the outcome.

**Conclusions**

Our study showed that there was no difference in acromial erosion in high-profile knots made by an SR technique compared with DR SB low-profile repairs.

**References**

11. Koh KH, Kang KC, Lim TK, Shon MS, Yoo JC. Prospective randomized clinical trial of single- versus double-row...
suture anchor repair in 2- to 4-cm rotator cuff tears: Clinical and magnetic resonance imaging results. *Arthroscopy* 2011;27:453-462.

