Functional and Structural Outcome After Arthroscopic Full-Thickness Rotator Cuff Repair: Single-Row Versus Dual-Row Fixation

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Purpose: The purpose of this study was to compare the functional as well as the structural outcomes of single-row and dual-row fixation after arthroscopic full-thickness rotator cuff repair. Type of Study: Retrospective cohort study. Methods: A consecutive series of 80 shoulders in 78 patients with full-thickness rotator cuff tears was evaluated using the rating scale of the University of California Los Angeles (UCLA) and the shoulder index of the American Shoulder and Elbow Surgeons (ASES) at an average of 35 months (range, 24 to 60 months) after arthroscopic rotator cuff repair. Thirty-nine shoulders were repaired using the single-row technique and 41 shoulders using the dual-row technique. Postoperative cuff integrity was determined through magnetic resonance imaging and was classified into 5 categories: type I, sufficient thickness with homogenously low intensity; type II, sufficient thickness with partial high intensity; type III, insufficient thickness without discontinuity; type IV, presence of a minor discontinuity; type V, presence of a major discontinuity. Results: The average UCLA score improved significantly to 32.4 in the single-row and to 33.1 in the dual-row group. The ASES shoulder index improved significantly to 93.0 in the single-row group and to 94.6 in the dual-row group. However, there was no statistical difference between the groups in the postoperative scores. Postoperative MRI revealed 11 type I, 6 type II, 12 type III, 4 type IV, and 6 type V in the single-row group, and 22 type I, 8 type II, 7 type III, 4 type IV, and no type V in the dual-row group. A statistical difference was observed between the groups ($P < .01$). Conclusions: Arthroscopic rotator cuff repair yielded successful functional outcomes without significant difference between single and dual-row fixation techniques. However, dual-row repairs excelled in structural outcome over the single-row technique. Level of Evidence: Level III. Key Words: Rotator cuff repair—Dual-row fixation—Magnetic resonance imaging—Cuff integrity.

According to recently reported outcome studies, functional outcomes after arthroscopic rotator cuff repair are reasonable and comparable to open or mini-open techniques.1-8 On the other hand, very few studies have reported structural outcomes after arthroscopic rotator cuff repair.9,10 Reported structural outcomes after open or mini-open rotator cuff repair are quite variable, ranging from a 20% to 70% retear rate11-19 because of differences in the imaging method used, such as arthrography,13,16 ultrasonography,10-12 and magnetic resonance imaging (MRI),9,14,15,17-19 and differences in the patient population, such as age or preoperative rotator cuff tear size and tissue quality,10,12,14,18 and the techniques used. Although some investigators have stated that the functional outcome does not correlate well with the structural outcome,10,13,17 a unifying idea common to many is that a better functional outcome may be established in shoulders with better postoperative cuff integrity.11,12,14,18 Because of the lack of structural outcomes reported, some authors believe that arthroscopic rotator cuff repair is inferior in fixation strength.
and postoperative structural outcome to open or mini-open repair. A dual-row fixation for rotator cuff repairs has been developed to strengthen the anchoring of the tendon-to-bone interface with satisfactory functional results. However, there are no published clinical articles supporting the superiority of the dual-row fixation in structural outcome over the conventional single-row fixation methods. The purpose of this study was to retrospectively compare the clinical outcome, including rotator cuff integrity evaluated using MRI, of single-row and dual-row fixation after arthroscopic full-thickness rotator cuff repair using suture anchors.

**METHODS**

**Patient Selection**

From February 1999 to April 2002, 132 consecutive shoulders in 130 patients who failed conservative treatment underwent arthroscopic primary rotator cuff repair by a single surgeon (H.S.). Full-thickness or partial-thickness defects were confirmed by preoperative MRI in all patients. The criteria for inclusion in this study were a full-thickness rotator cuff tear confirmed during surgery and no major associated pathology that would need to be addressed at the time of arthroscopic surgery, such as glenoid fractures or Bankart lesions. Twenty-two patients with a partial-thickness rotator cuff tear and 4 patients with associated pathology were excluded from this study. Therefore, 106 shoulders in 104 patients met the inclusion criteria. Among them, 26 patients were unable or unwilling to undergo postoperative MRI and were excluded. Consequently, this study included 80 shoulders in 78 patients followed-up for a mean of 35 months (range, 24 to 60 months) with an overall follow-up rate of 75.5%. There were 54 male and 24 female patients with an average age of 57.9 years (range, 34 to 73 years) at the time of surgery. The surgery was performed in the dominant extremity in 62 patients and in the nondominant extremity in 18. In the early part of the series, the patients mainly underwent arthroscopic rotator cuff repair using a single-row technique whereas in the latter parts of the series, the patients received a dual-row technique (Fig 1). There were 39 shoulders in 39 patients in the single-row group, including 28 male and 11 female patients, with an average age of 57.7 years (range, 34 to 72 years) and 41 shoulders in 41 patients in the dual-row group, including 28 male and 13 female patients, with an average age of 58.1 years (range, 36 to 73 years). The follow-up rate was 70.9% (39 of 55) and 80.4% (41 of 51), respectively. The average follow-up at the time of postoperative functional evaluation was 41.3 months.

**FIGURE 1.** (A) Single-row fixation and (B) dual-row fixation. Arrows indicate suture anchors and the direction inserted.
respectively (range, 24 to 60) and 28.2 months (range, 24 to 53), respectively ($P < .01$). Preoperative tear size was assessed during arthroscopic surgery. Sixteen tears were small (less than 1 cm in length), 34 were medium (1 to 3 cm), 25 were large (3 to 5 cm), and 5 were massive (>5 cm). There were 6 small, 17 medium, 14 large, and 2 massive tears in the single-row group, and 10 small, 17 medium, 11 large, and 3 massive in the dual-row group.

**Patient Assessment**

The patients underwent a standard history and physical examination as well as imaging studies including bilateral radiographs of anteroposterior view in both internal and external rotation and supraspinatus outlet views and preoperative MRI on the affected side, which confirmed a defect at the tendinous portion of the rotator cuff in all patients. However, the tear size and pattern were determined during diagnostic arthroscopy. All patients were evaluated using the rating and pattern were determined during diagnostic arthroscopy. All patients were evaluated using the rating scale of the University of California Los Angeles (UCLA) $^{23}$ and the shoulder index of the American Shoulder and Elbow Surgeons (ASES) $^{24}$ preoperatively and at the final follow-up at an average of 35 months (range, 24 to 60 months) postoperatively. The UCLA rating scale is a 35-point scale with 10 points for pain, 10 points for function, and 5 points each for strength, motion, and patient satisfaction. The shoulder index of the ASES consists of a pain score and a section including 10 self-assessed activities of daily living. Subjective pain was rated from 0 to 10 on a visual analog scale, which was calculated as a maximum total of 50 points. Ten activities of daily living were rated on a numeric scale, according to the patients’ ability to perform them, which was calculated as a maximum total of 50 points. Therefore, total possible score for the entire ASES index was 100 points.

**MRI Study**

MRI was performed with use of a 1.5-Tesla scanner (Gyrosan Powertrak 3000, Philips, The Netherlands). Oblique coronal, oblique sagittal, and axial T2-weighted spin-echo MRIs (repetition time, 3,200 milliseconds; echo time, 85 milliseconds) were obtained in all patients both preoperatively and postoperatively. Structural and qualitative assessment of the rotator cuff and postoperative cuff integrity was determined. The slice thickness was 4 mm, with an interslice gap of 0.5 mm. The field of view was 18 cm; the image matrix was 256 by 512. Postoperative MRI was performed 1 to 2 years postoperatively with an average of 14.4 months in the single-row group and 13.6 months in the dual-row group ($P = .43$). Postoperative cuff integrity was classified into 5 categories using oblique coronal, oblique sagittal, and transverse views of T2-weighted images: type I, repaired cuff appeared to have sufficient thickness compared with normal cuff with homogenously low intensity on each image; type II, sufficient thickness compared with normal cuff associated with partial high intensity area; type III, insufficient thickness with less than half the thickness when compared with normal cuff, but without discontinuity, suggesting a partial-thickness delaminated tear; type IV, presence of a minor discontinuity in only 1 or 2 slices on both oblique coronal and sagittal images, suggesting a small full-thickness tear; type V: presence of a major discontinuity observed in more than 2 slices on both oblique coronal and sagittal images, suggesting a medium or large full-thickness tear $^{9}$ (Fig 2).

**Surgical Procedure**

All procedures were performed with the patient under general anesthesia in the beach-chair position. A posterior portal was established for the initial assessment of the glenohumeral joint. An anterior portal through the rotator interval was established as the working portal for the treatment of intra-articular lesions. The tear size and presence of delamination $^{25}$ were carefully inspected.

The arthroscope was then removed from the glenohumeral joint and redirected into the subacromial space. A lateral portal and a posterolateral portal were also established. Any pathologic bursal tissue that impeded clear- ance of the space was removed and arthroscopic subacromial decompression was performed to create a flat acromial undersurface in all patients. The amount of bone removed varied, depending on the amount of proliferation of acromial osteophytes in each patient. Osteophytes in the inferior part of the acromioclavicular joint and the distal end of the clavicle were also removed if necessary. The posterolateral portal was mainly used as the viewing portal in these procedures.

The tear size and pattern were again evaluated and the mobility and reparability of the torn cuff were estimated. If the mobility of the tendon was insufficient in larger tears, a tendon mobilization procedure, such as a partial or entire capsulotomy, coracohumeral ligament release, and a rotator interval slide, $^{26}$ was performed before the repair in the majority of massive and large tears in both series. The footprint of the
FIGURE 2. Postoperative rotator cuff integrity was classified into 5 categories: (A) type I, sufficient thickness with homogenously low intensity; (B) type II, sufficient thickness with partial high intensity; (C) type III, insufficient thickness without discontinuity (thinned cuff); (D) type IV, presence of minor discontinuity; and (E) type V, presence of a major discontinuity.

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greater tuberosity was debrided and a thin layer of cortical bone was removed. A bone trough was not created. A hole was punched at the medial side of the footprint through an accessory superolateral portal. In the single-row fixation method (Fig 1), a metal suture anchor loaded with No. 2 permanent sutures was inserted through the superolateral accessory portal. The No. 2 permanent suture was placed approximately 5 to 10 mm from the margin of the tendon using a suture grasper (Mitek, Norwood, MA) or other tissue penetrating instruments and a Caspari punch (Linvatec, Largo, FL) loaded with looped No. 2-0 nylon suture. A suture relay was performed intra-articularly.27

The number of suture anchors varied with the size of the tear and the type of the repair techniques. We used an average of 2.4 anchors (range, 1 to 3) in the single-row and 3.2 anchors (range, 2 to 5) per tear in the dual-row group. After all simple repair sutures were placed, knot tying was performed using a self-locking sliding knot. To accomplish secure knot tying, the arm was abducted with optimal degree of rotation to reduce tensile force on the suture during the knot tying in all shoulders. This process facilitates secure knot tying even after obtaining adequate tension to the tendon with the arm at the side through the mobilization procedure. Longitudinal tears or U-shaped tears were repaired with No. 2 Ethibond (Ethicon, Somerville, NJ) by side-to-side stitches before cuff-to-bone fixation.

The dual-row technique varied according to the presence of delamination. In a delaminated shoulder, the medial row of anchors was inserted first and located just lateral to the articular surface of the humeral head, and sutures were then placed through the margin of the inferior (and usually more medial) layer of the cuff. After all simple repair sutures were placed, knot tying was performed with the shoulder abducted to reduce the tensile force for the same reason as the single-row (Fig 3). Next, a lateral row of anchors was inserted at the lateral ridge of the greater tuberosity. Sutures were then placed through the superior layer of the cuff. After placing all simple sutures, knot tying was performed in the same fashion (Fig 4).

In the shoulders without delamination, the medial portion of the rotator cuff was penetrated using the tissue penetrating instruments and the sutures were grasped and passed in a mattress fashion. Before proceeding to the knot tying for the medial row, a lateral row of anchors was inserted at the lateral margin of the greater tuberosity. Then the sutures for the lateral row were placed through the lateral margin of the cuff. Knot tying for the lateral row simple sutures was performed first, and then the repair was completed with the knot tying for the medial row in a mattress fashion (Fig 5). We follow this pattern of knot tying because it provides a secure tendon-bone interface.

**Postoperative Protocol**

The shoulders were immobilized for 3 weeks using a sling immobilizer with an abduction pillow (DeRoyal, Powell, TN). Isometric cuff exercise and
relaxation of muscles around the shoulder girdle were initiated on the day after surgery. After the immobilization period, passive and assisted-active exercises were initiated for forward flexion and external rotation avoiding provocation of pain. After 6 weeks, patients began strengthening exercises of the rotator cuff and scapular stabilizers. Rehabilitation was consistently performed with the assistance of physical therapists.

Three months after the operation, patients were permitted to practice light sports activities. Full return to sports and heavy labor were allowed after 6 months according to individual functional recovery.

Statistical Analysis

The Student $t$ test was used to compare the difference between the preoperative and postoperative

![Figure 4](image1.png)  
**Figure 4.** Arthroscopic images of a right shoulder with delamination (same shoulder as Fig 3) viewed from the posterolateral portal show the lateral row fixation (A) before and (B) after knot tying. *Lateral ridge of the greater tuberosity. **Superficial layer of the repaired shoulder with delamination.

![Figure 5](image2.png)  
**Figure 5.** Arthroscopic pictures of a right shoulder without delamination viewed from the posterolateral portal show (A) a completed mattress suture of medial row and (B) simple sutures of lateral row fixation.
scores of the UCLA rating scale and the shoulder index of the ASES. The Mann-Whitney U test was used to compare the postoperative cuff integrity of the single-row and the dual-row group. The significance level was set at \( P = .05 \).

## RESULTS

### Functional Outcome

Both rating systems reflected a significant improvement in the status of the shoulders when the preoperative scores were compared with those at the time of the final follow-up (\( P < .01 \)). The average total score increased from preoperative 14.8 (range, 3-22) to 32.4 (range, 16-35) in the single-row group and from 14.4 (range, 5-21) to 33.1 (range, 19-35) in the dual-row group with use of the UCLA rating scale. The average total score improved from 45.8 (range, 5-70) to 93.0 (range, 45-100) in the single-row group and from 40.4 (range, 10-65) to 94.6 (range, 60-100) in the dual-row group with use of the ASES shoulder index. However, there was no statistical difference between the groups in the average postoperative total scores with use of the UCLA rating scale (\( P = .44 \)) or the ASES shoulder index (\( P = .49 \)) (Table 1).

### Structural Outcome

Postoperative MRI examination of cuff integrity revealed 11 type I (28.2%), 6 type II (15.4%), 12 type III (30.1%), 4 type IV (10.3), and 6 type V (15.4) in the single-row group, and 22 type I (53.7%), 8 type II (19.5%), 7 type III (17.1%), and 4 type IV (9.8%) in the dual-row group. To put it differently, there were 18 (46.2%) versus 30 (73.2%) cuffs with sufficient thickness, 12 (30.1%) versus 7 (17.1%) cuffs with insufficient thickness, and 10 (25.6%) versus 4 (9.8%) return cuffs in the order named. A statistical difference was observed between the 2 groups (\( P < .01 \)). For the small to medium tears, 3 patients (13%) had a defect in the single-row group, whereas no patient developed a defect in the dual-row group. In the large and massive tears, 7 patients (44%) developed a defect on MRI in the single-row group versus 4 patients (29%) in the dual-row group.

### Complications

There were no intraoperative or perioperative complications. No patients had neural injury, wound infection, or suture anchor problems.

### DISCUSSION

Although patient population and surgical technique were different, Galatz et al. recently reported a surprisingly poor structural outcome after arthroscopic large and massive rotator cuff tears. In their series, 17 of 18 patients (94%) had a recurrent defect as evaluated through ultrasonography performed 2 years postoperatively. They mentioned that arthroscopic repair of the rotator cuff might not yield as strong a repair as traditional open or mini-open repair. They also suggested that an arthroscopic repair may not be the most appropriate procedure for a younger person with a massive tear in whom long-term strength is more important, although this population may have potentially good tissue quality amenable to repair compared with those in older age groups. Until enough structural outcome data are available on the arthroscopic technique, many surgeons will continue to view the open technique as the gold standard in terms of security of fixation and postoperative cuff integrity. According to Gerber et al., the ideal repair should have high initial fixation, minimal gap formation, and mechanical stability that is sufficient until the tendon-to-bone healing is completed. Dual-row repair provides a more anatomic repair by creating a large area

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**TABLE 1. Results of the Total Scores in Each Group**

<table>
<thead>
<tr>
<th>Shoulder Score (points)</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCLA single-row</td>
<td>14.8 (5.8)</td>
<td>32.4 (4.7)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>UCLA dual-row</td>
<td>14.4 (4.5)</td>
<td>33.1 (3.4)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>ASES single-row</td>
<td>45.8 (19.4)</td>
<td>92.9 (12.1)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>ASES dual-row</td>
<td>40.4 (12.3)</td>
<td>94.6 (9.3)</td>
<td>&lt;.01</td>
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</table>

NOTE. The values are given as the mean and (standard deviation). UCLA, the rating scale of the University of California at Los Angeles. ASES, the shoulder index of the American Shoulder and Elbow Surgeons.

**TABLE 2. Postoperative Shoulder Scores in Each Group**

<table>
<thead>
<tr>
<th>Shoulder Score (points)</th>
<th>Single-Row</th>
<th>Dual-Row</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCLA (total)</td>
<td>32.4 (4.7)</td>
<td>33.1 (3.4)</td>
<td>.44</td>
</tr>
<tr>
<td>Pain</td>
<td>9.0 (1.5)</td>
<td>9.1 (1.4)</td>
<td>.71</td>
</tr>
<tr>
<td>Function</td>
<td>9.2 (1.5)</td>
<td>9.5 (1.1)</td>
<td>.43</td>
</tr>
<tr>
<td>Range of motion</td>
<td>4.9 (0.22)</td>
<td>5.0 (0)</td>
<td>NA</td>
</tr>
<tr>
<td>Strength</td>
<td>4.7 (0.52)</td>
<td>4.9 (0.33)</td>
<td>.06</td>
</tr>
<tr>
<td>ASES (total)</td>
<td>92.9 (12.1)</td>
<td>94.6 (9.3)</td>
<td>.49</td>
</tr>
<tr>
<td>Pain</td>
<td>46.3 (6.6)</td>
<td>46.6 (6.2)</td>
<td>.83</td>
</tr>
<tr>
<td>Function</td>
<td>46.8 (6.3)</td>
<td>48.0 (3.9)</td>
<td>.29</td>
</tr>
</tbody>
</table>
of contact of the repaired tendon with the footprint of
the greater tuberosity.²⁰,²² Waltrip et al.²¹ compared
initial fixation strength in a cadaveric study of a novel
double-row repair, using suture anchor for the medial
row and transosseous fixation for the lateral row, with
the isolated single-row suture anchor and traditional
isolated transosseous technique. Initial fixation
strength of their double-row technique exceeded that
of isolated single-row repairs using either suture an-
chors or transosseous tunnels. Further, Meier et al.²⁹
showed in a cadaveric study that double-row suture
anchor fixation provided superior repair contact area,
reproducing 100% of the original supraspinatus foot-
print, when compared with single-row repairs of su-
ture anchors or transosseous sutures. Although the
fixation methods used in these studies differ slightly,
these results provide rationale and validity to the con-
cept of dual-row fixation for rotator cuff repair.

In treating our series of rotator cuff tears, we found
great advantages to the arthroscopic procedure over
the traditional open or mini-open procedures thanks to
the excellent visualization, especially in the manage-
ment of large retracted or delaminated rotator cuffs.
Precise evaluation of the delamination and cuff mo-
bilization including capsulotomy are more straightfor-
ward under arthroscopic control.⁹,³⁰,³¹ Structural outcome
of the large and massive tears presented in this
study was far better than the result reported by Galatz
et al.¹⁰ in both the single-row and dual-row technique.
The outcome of the dual-row technique for the large
and massive tears in the present study was even better
than the reported structural outcome in open proce-
dures.¹¹,¹²,¹⁶,¹⁸,¹⁹ We believe that our special attention
to the delamination and careful management of this
pathology, which seems to be facilitated under arthro-
scopic control, may have helped us in achieving better
structural outcomes.

The functional outcome of the present study did not
reveal significant difference between the single-row
and dual-row group. However, clinically, we feel that
the patients with poor cuff integrity have a tendency to
complain of weakness or inferior durability of
strength.⁹,¹¹,¹⁴,¹⁸ In fact, the difference in the postop-
erative strength scores of the UCLA rating scale be-
tween the 2 groups almost reached the significant level
(Table 2). We believe that the outcome measures used
and the relatively small number of patients enrolled in
this study could have masked the functional differ-
ences. The structural outcome of the dual-row tech-
nique proved quite favorable even in the large and
massive rotator cuff tears. Although the tendon quality
is not influenced by the type of repair, dual-row rota-
tor cuff repair provides a tendon-bone interface better
suited for biologic healing and restoring normal anat-
omy.

Higher cost and prolonged surgery time are among
possible concerns regarding arthroscopic dual-row ro-
tator cuff repair. However, we believe that the benefit
of arthroscopic repair for patients more than over-
comes the cost issue if we can provide better structural
and functional outcomes with higher patient satisfac-
tion. As we have shown in the present study, the
difference in average number of anchors used between
single-and dual-row was less than 1 anchor. If we can
achieve better structural outcome by using the dual-
row technique, it is worth trying because the effect on
the cost is minimal in comparison with the benefit of
the dual-row repair. Further, we believe that the sur-
geon can reduce surgical time by improving his or her
technical skills, which is primarily a learning curve
issue.

The strengths of this study included the use of a
single surgeon’s technique and MRI evaluation of cuff
integrity, which is a validated technique in assessing
both the preoperative and postoperative rotator cuff
abnormalities.¹⁹,³²-³⁶ Although quality of images is a

<table>
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<th>Table 3. Postoperative Cuff Integrity</th>
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<tbody>
<tr>
<td>Repair Method and Tear Size</td>
</tr>
<tr>
<td>Single-row (total)*</td>
</tr>
<tr>
<td>Small to medium*</td>
</tr>
<tr>
<td>Large to massive†</td>
</tr>
<tr>
<td>Dual-row (total)*</td>
</tr>
<tr>
<td>Small to medium*</td>
</tr>
<tr>
<td>Large to massive†</td>
</tr>
</tbody>
</table>

NOTE. The values are given as the number of patients and (percentage).
* A statistical difference was observed in overall (P < .01) and small to medium tears (P < .05) between the single-row and dual-row group.
† A statistical difference was not observed in large and massive tears between the single-row and dual-row group (P > .12).
key to promote accuracy of diagnosis. MRI is accurate, commonly available, minimally invasive, and less operator dependent compared with ultrasound or arthrography. The limitations of this study included the study design, which was a retrospective comparison of 2 case series. Also the single-row technique was performed in the surgeon’s early experience with arthroscopic rotator cuff repair. Although the follow-up period differed between the series, this had no influence on functional outcomes. We believe that the information provided by this study supports the use of dual-row rotator cuff with its superior structural repair integrity when compared with single-row fixation techniques.

REFERENCES

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