Functional and Radiographic Outcomes After Arthroscopic Transosseous Suture Repair of Medium Sized Rotator Cuff Tears

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**Purpose:** To evaluate the functional and anatomical outcomes after arthroscopic transosseous suture (TOS) repair of 2 to 4 cm sized rotator cuff tears and to identify preoperative factors influencing repair failure. **Methods:** From May 2013 to August 2014, patients with symptomatic 2 to 4 cm full-thickness tears underwent arthroscopic TOS repair, and those who could be followed up for a minimum of 2 years were included in this retrospective study. Functional and anatomical outcomes were analyzed up to 2 years postoperatively. Factors affecting cuff repair failure were evaluated, using both univariate and multivariate analyses. **Results:** Twenty-seven patients were included. On preoperative magnetic resonance imaging data, the mean anteroposterior dimension tear size was 27.0 ± 3.3 mm and mean retraction was 30.7 ± 3.1 mm. Anatomic failure (Sugaya III, IV, and V) rate was 33% with arthroscopic TOS repair; however, significant improvements were found regardless of cuff healing. Mean American Shoulder and Elbow Surgeons score (range, 0-100) improved from 48.8 ± 16.6 preoperatively to 80.1 ± 11.1 postoperatively (P < .001), mean Constant score (range, 0-100) improved from 54.5 ± 11.8 to 73.7 ± 8.5 (P < .001), and mean pain visual analog scale score (range, 0-10) improved from 3.9 ± 1.7 to 2.0 ± 1.1 (P < .001). These changes reached each minimal clinically important difference previously reported. Greater tear size in anteroposterior dimension (P = .034), decreased acromiohumeral distance (P = .022), and higher fatty infiltration of supraspinatus (P = .011) were independent preoperative factors associated with repair failure. Twelve patients (44%) experienced intraoperative bone laceration. **Conclusions:** Arthroscopic TOS repair was a reliable technique for patients with 2 to 4 cm size rotator cuff tear. Preoperative factors associated with cuff repair failure were greater tear size in anteroposterior dimension, decreased acromiohumeral distance, and higher fatty infiltration of supraspinatus. **Level of Evidence:** Level III, retrospective comparative study.
In an attempt to overcome these concerns, an arthroscopic transosseous suture (TOS) rotator cuff repair technique was introduced without the use of an anchor. Several instruments are available for performing the TOS technique, including the aiming guide with K-wires and the anterior cruciate ligament guide. Although early published reports have shown promising results, data concerning outcomes after arthroscopic TOS rotator cuff repair are scarce.

The purposes of this study were to evaluate the functional and anatomical outcomes after arthroscopic TOS repair of 2 to 4 cm sized rotator cuff tears and to identify preoperative factors influencing repair failure. The hypothesis of the current study was that arthroscopic TOS repair would lead to significant improvements in 2 to 4 cm sized rotator cuff tears in terms of functional and anatomic outcomes and preoperative factors that correlated with failure after arthroscopic TOS rotator cuff repair could be identified.

Methods

Patient Selection

Between May 1, 2013, and August 31, 2014, patients who underwent arthroscopic TOS rotator cuff repair at our institution were identified. Patients who had (1) a symptomatic 2-4 cm size full-thickness rotator cuff tear confirmed by preoperative magnetic resonance imaging (MRI), (2) an anatomic outcome analysis including MRI at 1 year after surgery, and (3) a functional outcome analysis at 2 years after surgery were included. Patients who had glenohumeral arthritis, an isolated subscapularis tear, a partial or small tear (<2 cm), large or massive tear (>4 cm), or any previous shoulder surgery or who refused to undergo MRI at 1 year after surgery were excluded.

Institutional Review Board approval was obtained for this study protocol, and all patients provided informed consent prior to their participation after receiving an explanation of the contents and purposes of the study.

Patient Variables

Demographic variables included age, sex, symptom duration, hand dominance, presence of diabetes mellitus and hypertension, smoking status, bone mineral density (BMD), acromiohumeral distance (AHD), anteroposterior (AP) dimension cuff tear size, cuff retraction size, fatty infiltration of supraspinatus (FI of SST), and tangent sign. Surgical variables were suture configuration (simple stitch, X-BOX stitch), biceps procedure (tenotomy, tenodesis), and bone laceration during the operation.

Most patients took the BMD test 1 day before the surgery, but if patients had taken it within 1 year prior to surgery, those results were used because we deduced that BMD results did not show significant changes in 1 year. To reduce costs, the time frame of the BMD test was set to 1 year before surgery. BMD was measured using dual-energy x-ray absorptiometry (Hologic QDR 4500 ATM, Hologic, Bedford, MA). The lowest T score of the proximal femur or lumbar spine was used for analysis.

AHD measurement was determined electronically with a picture archiving and communication system (PACS) workstation (PiViewSTAR, INFINITT, Gurogu, South Korea) on conventional true AP views obtained with the patient maintaining a neutral rotation of the shoulder. On images, AHD is defined as the shortest distance from the inferior acromion to the superior humeral head. AHD assessment using true AP radiographs is known to be a reliable and reproducible method of measurement.

Cuff tear size and retraction size were measured on preoperative MRI (Magnetom Skyra 3.0T, Siemens, Erlangen, Germany). All measurements were performed with a PACS workstation; using the most representative T2 sagittal image, the AP dimension tear size was measured from the posterior tendon border to the anterior tendon border at the rotator interval edge (the biceps border acting as a marker to locate the rotator interval). On the coronal image, the tear retraction size was measured along with the medial-lateral orientation, in a straight line from the most medial tendon edge to the lateral footprint or the lateral cuff tissue stump.

FI of SST was measured using preoperative MRI (Magnetom Skyra 3.0T, Siemens) according to the method established by Goutallier et al. Scans were evaluated at the level where the scapular spine and body form a Y-shape in the oblique sagittal view.

The tangent sign was used to identify the presence of supraspinatus atrophy. A negative tangent sign was defined as the finding that the supraspinatus muscle does not cross a line drawn through the superior border of the scapular spine and the superior margin of the coracoid process on the most lateral image where the scapular spine continues with the scapular body.

Surgical Technique

All surgeries were performed under general anesthesia, without an interscalene block in the lateral position, and by a single senior surgeon (K-C.N.). Four portal (anterior, posterior, anterolateral, and posterolateral) techniques were routinely used in all cases. In patients who underwent biceps bony tenodesis, a fifth portal was added approximately 2 cm away from to the anterolateral acromion corner in line with the biceps tendon/transverse humeral ligament.

Routine diagnostic arthroscopy was followed by subacromial decompression and bursectomy with limited acromioplasty of the anterolateral corner of the acromion in all patients. All patients underwent...
arthroscopic TOS rotator cuff repair for superior and/or posterosuperior lesions, as previously described by Garofalo et al.\textsuperscript{11} After subacromial decompression, footprint preparation, and appropriate releases of the rotator cuff, intersecting TOS bone tunnels were created using the ArthroTunneler (Tornier, Edina, MN; \textit{Fig 1A}). In these cases (with 2 to 4 cm rotator cuff tear), the 2-tunnel technique was employed. Three-strand no. 2 FiberWire (Arthrex, Naples, FL) sutures were used for rotator cuff repair. Suture passage was conducted using a combined antegrade/retrograde delivery technique, with retrieval and tying by either a simple stitch or an X-BOX stitch configuration (\textit{Fig 1 B and C}). These were randomly allocated prior to surgery by assignment of the randomization number to the subjects. We generated a random digit for each patient and allocated patients according to odd and even. Of note, advanced repair techniques, such as side-to-side sutures for L-shaped/reverse L-shaped tears and margin convergence techniques for larger U-shaped tears, were used. However, with careful attention to the use of appropriate arthroscopic releases and advanced repair techniques when needed, all tears could be mobilized and repaired to their native footprint. No bone augmentation device was used in any patient in this series.

If proximal disinsertion, fraying/tearing, instability, or tenosynovitis of the biceps tendon was visualized, tenotomy at the supraglenoid tubercle was performed during diagnostic arthroscopy. Biceps tenodesis was performed in younger, active patients or in those patients who expressed concern about cosmetic deformity (i.e., “Popeye” sign) or cramping associated with tenotomy alone. If tenodesis was performed, it involved supraperiostal tenodesis 1 cm below the top of the bicipital groove either with an interference screw or with suture anchors.

Rehabilitation Protocol
The same rehabilitation protocol was followed for all patients. Pendulum exercises were started 1 week postoperatively, the abduction sling was removed 6 weeks postoperatively, and active assisted range of motion exercises were initiated 6 weeks postoperatively.

Outcome Measurements
Functional outcomes of the involved shoulder were evaluated using the American Shoulder and Elbow Surgeons (ASES) score, Constant score, and pain intensity by visual analog scale (VAS) score. Functional outcomes were assessed at preoperative admission and at 2 years postoperatively.

Anatomic outcomes were evaluated by MRI at 1 year after surgery. All patients who underwent a TOS rotator cuff repair at the authors’ institution were advised to undergo MRI for the evaluation of repair failure at 1 year postoperatively. A musculoskeletal radiologist with more than 10 years of experience interpreted the MRI findings and determined repair failure. Rotator cuff retear as repair failure was graded according to the system classification of Sugaya et al.\textsuperscript{19} Sugaya type III is defined as insufficient thickness without discontinuity and suggests a partial tear. Type IV is a minor discontinuity and suggests a small tear. Type V is defined as a major discontinuity and represents an obvious tear. In the present study, for practical purposes, patients with postoperative MRI findings of Sugaya classification type III, suggesting a partial-thickness tear, were assigned to the failed healing group. Numerous studies had reported that postoperative Sugaya type III lesions could progress to full-thickness tears.\textsuperscript{20,21} Kartus et al.\textsuperscript{22} considered a partial-thickness tear as an intermediate stage that will eventually become a full-thickness tear. We believe that not only the structural integrity but also the thickness of the cuff is critically important to guarantee good healing.

Other complications such as intraoperative bone laceration, infection, wound problems, nerve injury, and deltoid muscle problems were also identified. We compared the outcomes between patients with and without a bone laceration.

Statistical Analysis
Wilcoxon’s signed rank test for multiple comparisons was used to compare the preoperative and postoperative scores for the functional and anatomical outcomes.

Univariate analyses were performed using logistic regression analysis for the categorical variables to determine the differences according to anatomical cuff repair failure. For testing the independence of each explanatory variable, a multicollinearity test was applied.\textsuperscript{23} There was functional dependence between the cuff retraction size variable and AP dimension cuff tear and there were multicollinearity problems. Therefore, the cuff retraction size variable was eliminated from the analysis. Multivariate logistic regression analysis was applied to determine independent factors affecting anatomic cuff repair failure by inputting the significant variables derived from the univariate analysis after the multicollinearity test.

Statistical analyses were conducted using SPSS software 20.0 (IBM, Armonk, NY). All statistical tests were 2-tailed. Statistical significance of Wilcoxon’s signed rank test was defined as a \(P\) value < .001, and that of other tests was defined as a \(P\) value < .05.

Results

Patient Data
Among 56 patients who underwent arthroscopic TOS rotator cuff repair at our institution, 27 patients who
satisfied the inclusion and exclusion criteria were included in this retrospective study. Mean patient age was 58.3 ± 8.5 years (range, 33-76 years), and the mean follow-up period after surgery was 31.8 ± 3.8 months (range, 25-40 months). Mean preoperative AHD was 9.6 ± 2.3 mm (range, 5.8-15.3 mm). Mean AP dimension cuff tear size was 27.0 ± 3.3 mm, and the mean amount of retraction was...

**Fig 1.** Schematic diagrams of the TOS repair. (A) The suture is passed through the bone tunnel, using ArthroTunneler. (B, C) Arthroscopic pictures of the simple stitch and X-BOX stitch with corresponding arthroscopic images from the posterolateral portal. (TOS, transosseous suture.)
30.7 ± 3.1 mm. Mean FI of SST was 14.5% ± 14.0%.

Ten patients underwent cuff repair with a simple stitch and 17 patients with an X-BOX stitch (Table 1).

### Outcomes After Arthroscopic TOS Rotator Cuff Repair

All patients achieved significant improvements in every functional outcome measurement evaluated at the 2-year postoperative follow-up visit. Mean ASES score (range, 0-100) improved from 48.8 ± 16.6 preoperatively to 80.1 ± 11.1 postoperatively (P < .001), mean Constant score (range, 0-100) improved from 54.5 ± 11.8 to 73.7 ± 8.5 (P < .001), and mean pain VAS score (range, 0-10) improved from 3.9 ± 1.7 to 2.0 ± 1.1 (P < .001). All functional score changes reached the minimal clinically important difference (MCID) previously reported.24,25

Repaired rotator cuffs did not heal in 9 of 27 patients (33%) based on MRI findings (Sugaya III, IV, and V). The mean retear size of failed repairs was 4.2 ± 5.4 mm in the AP dimension and showed 4.5 ± 3.9 mm retraction.

### Factors Affecting Rotator Cuff Repair Failure

As compared with the patients without failure, those with repair failure showed significant differences in terms of larger tear size in the AP dimension (P = .019), more retraction (P = .011), decreased AHD (P = .017), and higher FI of SST (P = .027; Table 2) in the univariate analysis.

In the multivariate logistic regression analysis, after testing multicollinearity, more retraction (P = .034), decreased AHD (P = .022), and higher FI of SST (P = .011) were significantly associated with cuff repair failure as independent preoperative factors. Decreased AHD was associated with 2.22 odds of repair failure (95% confidence interval [CI], 1.12-4.40; Table 3).

### Table 1. Demographic Data

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>58.3 ± 8.5 (33-76)</th>
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<tbody>
<tr>
<td>Sex (male:female), n</td>
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<tr>
<td>Symptom duration, mo</td>
<td>26.7 ± 38.0 (1-130)</td>
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<tr>
<td>Hand dominance (+:−), n</td>
<td>16:11</td>
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<tr>
<td>Diabetes mellitus (+:−), n</td>
<td>5:22</td>
</tr>
<tr>
<td>Hypertension (+:−), n</td>
<td>6:21</td>
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<tr>
<td>Smoking (+:−), n</td>
<td>4:23</td>
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<tr>
<td>Bone mineral density (T-score)</td>
<td>−2.1 ± 0.7 (−0.8 to −3.5)</td>
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<tr>
<td>Acromiohumeral distance, mm</td>
<td>9.6 ± 2.3 (5.8-15.3)</td>
</tr>
<tr>
<td>Anteroposterior dimension</td>
<td>27.0 ± 3.3 (20-40)</td>
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<tr>
<td>Amount of retraction, mm</td>
<td>30.7 ± 3.1 (20-40)</td>
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<tr>
<td>Fatty infiltration of supraspinatus, %</td>
<td>14.5 ± 14.0 (0.7-65.3)</td>
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<tr>
<td>Tangent sign (positive:negative), n</td>
<td>5:22</td>
</tr>
<tr>
<td>Repair technique (simple:X-BOX), n</td>
<td>10:17</td>
</tr>
<tr>
<td>Biceps procedure</td>
<td>20:7</td>
</tr>
<tr>
<td>(tenotomy:tenodesis), n</td>
<td>12:15</td>
</tr>
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</table>

### Table 2. Clinical Factors Associated With Rotator Cuff Healing on Univariate Analysis Using Logistic Regression*  

<table>
<thead>
<tr>
<th>Repair</th>
<th>Success</th>
<th>Failure</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>58.2 ± 9.7</td>
<td>58.7 ± 5.7</td>
<td>1.000</td>
</tr>
<tr>
<td>Sex (male:female), n</td>
<td>7:11</td>
<td>3:6</td>
<td>.778</td>
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<tr>
<td>Symptom duration, mo</td>
<td>24.1 ± 29.5</td>
<td>32.0 ± 52.9</td>
<td>.311</td>
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<tr>
<td>Hand dominance (+:−), n</td>
<td>9:9</td>
<td>7:2</td>
<td>.178</td>
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<tr>
<td>Diabetes mellitus (+:−), n</td>
<td>3:15</td>
<td>2:7</td>
<td>.727</td>
</tr>
<tr>
<td>Hypertension (+:−), n</td>
<td>4:14</td>
<td>2:7</td>
<td>1.000</td>
</tr>
<tr>
<td>Smoking (+:−), n</td>
<td>3:15</td>
<td>1:8</td>
<td>.704</td>
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<tr>
<td>Bone mineral density (T-score)</td>
<td>−2.2 ± 0.7</td>
<td>−1.9 ± 0.6</td>
<td>.348</td>
</tr>
<tr>
<td>Acromiohumeral distance, mm</td>
<td>10.5 ± 2.1</td>
<td>7.8 ± 1.6</td>
<td>.017</td>
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<tr>
<td>Anteroposterior dimension</td>
<td>24.3 ± 2.7</td>
<td>32.4 ± 3.6</td>
<td>.019</td>
</tr>
<tr>
<td>Amount of retraction, mm</td>
<td>28.0 ± 2.7</td>
<td>36.1 ± 3.3</td>
<td>.011</td>
</tr>
<tr>
<td>Fatty infiltration of supraspinatus, %</td>
<td>9.4 ± 7.9</td>
<td>24.7 ± 18.2</td>
<td>.027</td>
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<tr>
<td>Tangent sign (positive:negative), n</td>
<td>2:16</td>
<td>3:6</td>
<td>.179</td>
</tr>
<tr>
<td>Repair technique (simple:X-BOX), n</td>
<td>6:12</td>
<td>4:5</td>
<td>.574</td>
</tr>
<tr>
<td>Biceps procedure (tenotomy:tenodesis), n</td>
<td>12:6</td>
<td>8:1</td>
<td>.237</td>
</tr>
<tr>
<td>Bone laceration (+:−), n</td>
<td>9:9</td>
<td>3:6</td>
<td>.415</td>
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</table>

*Results are expressed as mean ± standard deviation unless otherwise indicated.

1We defined Sugaya III, IV, and V as repair failure.

2Statistically significant difference between groups (P < .05).

### Complications

Of the 27 patients in the current study, major complications defined as retear (Sugaya III, IV, and V) occurred in 9 patients (33%). Overall, 12 patients (44%) had minor surgical complications, including intraoperative bone laceration when tensioning the knot to the footprint (Fig 2). There was no significant difference in the clinical outcomes between patients who had a bone laceration and those of patients who did not (Table 3; P = .415). No infection, wound problem, axillary nerve injury, or deltoid muscle problem occurred.

### Discussion

The present study demonstrates that arthroscopic TOS technique repairs of medium sized rotator cuff tears were associated with good clinical outcomes and good

### Table 3. Clinical Factors Affecting Rotator Cuff Healing on Multivariate Analysis Using Logistic Regression

| Amount of retraction, mm | .054 | .083 | 0.69 | 0.98 |
| Acromiohumeral distance, mm | .022 | 2.22 | 1.12 | 4.40 |
| Fatty infiltration of supraspinatus, % | .011 | 0.89 | 0.82 | 0.97 |

*Statistically significant difference (P < .05).
structural integrity. Functional outcomes 2 year after surgery showed significant improvement in mean ASES score, Constant score, and pain VAS score compared with preoperative status, regardless of cuff healing. Tashjian et al. reported that the MCID of ASES score and pain VAS score were 20.9 and 1.4, respectively. Kukkonen et al. reported that MCID of Constant score was 10.4. All functional score changes met the threshold of each MCID. This is comparable to findings of other series reporting outcomes 2 years after arthroscopic suture-anchor-based repairs. In the multivariate logistic regression analysis, preoperative factors associated with cuff repair failure were greater tear size in the AP dimension, decreased AHD, and higher FI of SST.

The recent reported failure rates after arthroscopic double-row repair or suture bridge repair vary from 9% to 29%, and the retear rates of this study were 33%. The anatomical outcome 1 year after our procedure was comparable to reported outcomes with suture-anchor-based methods. In the study by Urita et al., those authors sequentially evaluated vascular patterns of TOS and suture bridge techniques at 3 months postoperatively and suggested that the bone tunnels on the footprint used in the TOS method resulted in more blood flow inside the repaired rotator cuff compared with the suture bridge technique. It can be speculated that bone tunnels through the footprint may contribute to biologic healing by increasing blood flow to the repaired rotator cuff.

The TOS technique has been used with good success for decades, and arthroscopic TOS approaches for cuff repair are described in the literature. More recently, arthroscopic tunneling has been performed with results comparable to those of standard anchor approaches. The torn rotator cuff can be compressed to its footprint at the great tuberosity with the arthroscopic TOS repair technique; this may be particularly helpful in the treatment of medium sized rotator cuff tears. In vitro biomechanical studies demonstrated that the TOS technique provides more contact and greater pressure over a defined footprint relative to suture anchors alone. Some studies suggested that the arthroscopic TOS technique provides similar initial fixation strength as does the widely used suture bridge technique.

In our study, greater tear size in the AP dimension, decreased AHD, and higher FI of SST were significant factors associated with rotator cuff repair failure. Recently, several prospective and retrospective studies have explored preoperative factors associated with rotator cuff repair, with reports in the literature evaluating various factors, including demographic data, clinical variables, rotator cuff integrity, and surgical procedure. According to Boileau et al., patients in the healed cuff tendon group were on average 10 years younger than those in the repair failure group. Chung et al. reported that low BMD negatively affects cuff tendon healing. In that study, patients with osteoporosis and osteopenia had a higher retear rate than normal BMD patients. However, in our study, there was no significant difference in BMD between the healing group and repair failure group, which is consistent with another study also conducted by Chung et al. Poor bone quality may negatively affect fixation strength, which leads to easy pullout of the suture anchor. In terms of simple or X-BOX stitch configuration, no effect of the stitch type was found on cuff tendon healing. An early cadaver study reported that the X-BOX stitch configuration showed higher failure load than the simple suture configuration, although it did not show a statistically significant difference; the same study also showed that the transosseous techniques are far inferior to the suture anchors method of fixation. Decreased AHD was found to negatively affect cuff healing; this result was consistent with that of a previous analysis. Other studies reported that a larger tear size influenced tendon healing and functional outcome; this is consistent with our results. In addition, some studies stated that a higher grade of fatty infiltration correlated with inferior functional outcomes and repair failure. High-grade fatty infiltration of the rotator cuff, especially grade 3 or 4, would be the best indicator of poor muscle and tendon quality. Cho and Rhee indicated that the amount of fatty infiltration graded using the Goutallier classification affected the tendon healing rate. This result is in agreement with our current findings; we showed that higher grade of fatty infiltration in the supraspinatus was an independent preoperative factor negatively influencing
structural integrity after the TOS technique for medium to large rotator cuff tears.

Concerning complications, bone tunnel breakage is the primary concern with this technique, which can occur during the knot-tying and tensioning process, as sutures can cut through the bone tunnels, negatively influencing the security of the repair. A previous cadaver study by Burkhart et al.33 showed that TOS rotator cuff suturing had high repair failure compared with suture-anchor repairs in case of cyclic loading. However, the study conducted by Burkhart et al.33 used a different technique than that used in the current analysis. They use a simple stitch, with the short bone tunnel created in a weak bone area at the footprint margin; in our study, a long bone tunnel was created with the guide that could reach the medial border of the footprint and the distal margin of the great tuberosity. Caldwell et al.34 reported that cortical augmentation could increase the suture pullout strength by approximately 2-fold. The use of bone augmentation to avoid suture pullout is well supported by several biomechanical studies.31,35 We respectively considered the correlation between bone stock and bone laceration to have no statistical meaning. If there is a concern about bone tunnel quality at the great tuberosity, to minimize the risk of suture cut-through, a cortical augmentation is recommended to improve stability. Additionally, placing the lateral holes distal to the footprint aids in increasing pullout strength. In this study, a total of 12 patients experienced bone laceration. This was an intrinsic flaw (inherent complication) of the transosseous repair technique. Bone laceration occurred at cortical bone when the suture strands passing through the bone tunnel were knotted. Although there was no significant difference, the mean BMD score was higher in patients without bone laceration than in those with bone laceration. Poor bone quality may negatively affect the fixation strength, which leads to the suture anchor being easily pulled out or to bone laceration. However, because there is no consensus to measure the bone quality of the greater tuberosity, BMD achieved by the DEXA method may not be an accurate method for local osteoporosis occurring at the greater tuberosity. We believed that this flaw would not affect the cuff repair integrity meaningfully because the lacerations were mostly superficial in this study. There was no significant difference in the clinical outcomes between patients with and without a bone laceration.

A difference from previous studies is that patients with postoperative MRI showing Sugaya type III were assigned to the healing failure group; most studies assigned these patients to the healing group, even though the repaired cuff with Sugaya type III shows tissue continuity. However, less than half the thickness of the cuff tendon is insufficient to guarantee good anatomical and functional outcomes.

**Limitations**

This study has several limitations. First, this retrospective study contains a relatively small number of patients and may be underpowered to detect differences in certain factors (e.g., tear type), but it represents a relatively large group analyzed for clinical outcome following the TOS technique. Second, although there was no significant difference in clinical outcomes between patients with and without bone laceration, a type II error may exist due to the relatively small number of patients. Third, we did not include a comparative group of patients treated with a different method, such as the suture bridge technique.

**Conclusions**

Arthroscopic TOS repair was a reliable technique for patients with 2 to 4 cm size rotator cuff tear. Preoperative factors associated with cuff repair failure were greater tear size in the AP dimension, decreased AHD, and higher FI of SST.

**Acknowledgment**

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