Published in final edited form as:

Orthopedics. 2015 May ; 38(5): e352–e358. doi:10.3928/01477447-20150504-50.

Arthroscopic Transosseous Rotator Cuff Repair: Technical Note, Outcomes, and Complications

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Abstract

The goal of this study was to review the authors' initial experience with arthroscopic transosseous rotator cuff repair. Thirty-one patients with full-thickness rotator cuff tears underwent arthroscopic transosseous rotator cuff repair over a 15-month period. Preoperatively, demographics and subjective scores were recorded. Postoperatively, pain levels, subjective shoulder values, satisfaction scores, American Shoulder and Elbow Surgeons (ASES) scores, complications, and reoperations were noted with a minimum 2-year follow-up. The relationships between pre- and intraoperative variables and outcome scores were determined with univariate analysis. Average patient age was 56 years, and 23 patients (74%) were men. Twenty patients (65%) underwent primary rotator cuff repair, and 11 patients (35%) underwent revision repair. Average time to follow-up was 26 months. Average preoperative pain level and subjective shoulder value were 5.1 of 10 and 35%, respectively. Average postoperative scores included pain level of 0.9 of 10, subjective shoulder value of 84%, satisfaction score of 90.6 of 100, and ASES score of 86.3 of 100. There were 3 (9.7%) major and 2 (6%) minor complications. Patients undergoing revision rotator cuff repair had significantly worse outcomes (pain level, subjective shoulder value, ASES score; $P < .05$) compared with those undergoing primary repair, and cortical augmentation did not significantly affect outcome. Overall, outcomes after arthroscopic transosseous rotator cuff repair are good, although patients undergoing revision repair do not have the same outcomes as those undergoing primary cuff repair. The procedure is not without complications (9.7% major, 6% minor complications). Cortical augmentation may be used to supplement fixation, although it does not necessarily affect outcomes. Patients without such augmentation may be at increased risk for suture cutout through the bone.

Rotator cuff repair surgery has evolved substantially over the past few decades. Until recently, the gold standard for comparison in rotator cuff repair surgery was open repair with

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The authors have no relevant financial relationships to disclose.

transosseous fixation, and many argue that this is still the case.¹ This technique has shown good to excellent long-term clinical outcomes²⁻⁴ and is well supported in a variety of biomechanical studies.⁵⁻¹⁴ The advent of modern arthroscopic techniques has allowed surgeons to obtain excellent fixation strength and outcomes arthroscopically.¹⁵⁻¹⁸ In the hands of an experienced arthroscopic surgeon, arthroscopic rotator cuff repair has multiple advantages over open repair. These include the ability to inspect the entire glenohumeral joint for associated pathology, the ability to fully characterize tear patterns, preservation of the deltoid origin, and decreased postoperative pain and stiffness.^{15,17}

A variety of fixation techniques and configurations are used in arthroscopic rotator cuff repair. Most use suture anchors as the primary method of fixation. Recent reports have described a double-row transosseous equivalent fixation technique as a superior method of rotator cuff repair fixation, with improved biomechanical characteristics (ie, strength, stiffness, load to failure, and gapping), increased compression across the rotator cuff footprint for maximal healing, and high radiographic healing rates.¹⁹⁻²²

The added utility of placing multiple anchors in 2 rows, a practice that may substantially increase surgical time and implant cost, has been questioned.²³ Additionally, suture anchors may have marginal efficacy in cases of revision where multiple anchors have previously been dispersed throughout the tuberosity footprint and/or there is poor bone stock to support anchor fixation.

The search for improved methods of rotator cuff repair recently led to the development of an all-arthroscopic transosseous rotator cuff repair technique. The goal of this technique is to replicate the open transosseous repair fixation method while conferring all of the advantages of arthroscopic techniques.²⁴⁻²⁶ To the authors' knowledge, no studies have described the outcomes and complications of this novel surgical method. This study reports the authors' initial experience, surgical technique, outcomes, and complications with arthroscopic transosseous rotator cuff repair. They hypothesized that outcomes would be good to excellent with this technique.

Materials and Methods

The authors performed a retrospective review of their surgical procedural database from January 1, 2010, to May 1, 2011, to identify patients with full-thickness rotator cuff tears who underwent arthroscopic repair with transosseous bone tunnel fixation (ArthroTunnel; Tornier Inc, Edina, Minnesota). Included were patients who underwent arthroscopic transosseous rotator cuff repair for full-thickness rotator cuff tear within the specified period, were older than 18 years, had a minimum follow-up of more than 2 years, and had primary or revision repair. Patients were also included if initial attempts at arthroscopic transosseous fixation were unsuccessful or if they required intraoperative conversion to a supplemented fixation method. Patients with less than 2 years of follow-up were excluded. No patients were excluded based on age, race, sex, or workers' compensation status.

Recorded preoperative data included subjective shoulder value,^{27,28} visual analog scale score for pain, and range of motion in forward elevation. Additionally, note was made of

previous attempts at rotator cuff repair as well as intraoperative use of cortical augmentation.

Two years after the index surgery, patients were contacted. At this time, subjective shoulder value, visual analog scale score, subjective satisfaction score (level of satisfaction with the procedure rated from 0-100), and American Shoulder and Elbow Surgeons (ASES) score were recorded. Active range of motion in forward elevation was measured at the most recent clinical follow-up. Routine magnetic resonance imaging scan to visualize tendon healing was not performed unless re-tear was suspected. Intraoperative and postoperative complications and subsequent surgical procedures were noted. Major complications were defined as infection, nerve injury, rotator cuff re-tear, or need for reoperation. Minor complications included any intraoperative event that was unexpected and necessitated additional or alternative means of fixation.

The relationships between 2 preoperative or intraoperative variables (primary or revision repair and the use of cortical augmentation) and each of the 4 postoperative outcome scores were analyzed (visual analog scale score, subjective shoulder value, satisfaction score, ASES score) with a paired Wilcoxon rank sum test. Because data were non-normal in distribution as determined by a test for normality, *t* test was not used. $P < .05$ was considered significant.

Surgical Technique

All rotator cuff repairs were performed by Jon JP Warner, MD, Chief, Shoulder Service, Massachusetts General Hospital. Procedures were performed with the patient in the beach chair position after interscalene block. Routine inspection of the glenohumeral joint, subacromial bursectomy, rotator cuff debridement and mobilization, and footprint preparation were performed in the standard fashion through standard arthroscopic portals. For each hole drilled, a superior portal was used just off the lateral margin of the acromion to facilitate vertical drilling at the articular margin. A lower portal (approximately 2-4 cm off the lateral acromion in line with the superior portal) was used for lateral drilling through the tuberosity and for suture passage (Figure 1).

Drilling of bone tunnels began with the medial tunnels, using a 2.9-mm drill oriented vertically at the articular margin through the superior portal. The hooked device (ArthroTunnel) was introduced into the vertical drill tunnel, facilitating a 2.5-mm horizontal drill hole to be placed laterally (approximately 1.5 cm distal to the lateral edge of the greater tuberosity) and intersecting the vertical drill hole. The lateral drill hole was placed as lateral and distal on the tuberosity as possible for maximal bone strength against suture cutout.⁶ A shuttle suture was introduced through the device via loop retrieval, and this was used to pass 3 braided nonabsorbable sutures into each drill hole. These were then passed through the rotator cuff using a hooked suture passer. Suture configurations varied depending on the size and configuration of the tear. Standard arthroscopic knot tying was used, with the knot placed overlying the medial drill hole to maximize tension of the tendon on the medial bone margin. The rehabilitation protocol consisted of a sling and minimal shoulder motion for 2 weeks, pendulum exercises at postoperative weeks 2 to 4, gentle

passive range of motion exercises at postoperative weeks 4 to 6, active range of motion at 6 weeks, and strengthening at 3 months postoperatively.

In patients who underwent revision with multiple anchors embedded in the rotator cuff footprint, anchors that were loose or prominent were removed. Well-fixed anchors were typically left alone, and loose suture material was removed. The locations of transosseous tunnels were chosen to avoid anchors that were still in place. When large anchors were removed from ideal locations of fixation in the footprint, the bone voids that were left behind could be adequately used as starting points for the medial vertical drill holes (Figure 2). When the footprint was believed to consist of poor bone stock, a cortical augmentation device (Cuff Link; DePuy-Mitek, Raynham, Massachusetts) was used to increase suture stability and minimize the risk of cutout. Once the drill holes were placed and the shuttle suture was passed, the device was slid down the shuttle suture using an arthroscopic knot pusher and impacted into the bone. After the device was fixed to the lateral tuberosity, the fixation sutures were passed through the device and the remaining tunnel using the shuttle suture (Figure 3).

Results

Demographics

During the study period, 31 patients with full-thickness rotator cuff tears underwent arthroscopic rotator cuff repair with transosseous fixation. Demographic features of the study sample are summarized in Table 1. Revision rotator cuff surgery was defined as repair of a previous unsuccessful rotator cuff repair, diagnosed by persistent pain and weakness after rotator cuff repair, with confirmation of tear recurrence on imaging studies. Most revision repairs had 1 previous failed repair ($n=7$), and 4 patients had 2 previous failed repairs. Three patients (10%) had workers' compensation claims.

Average time to follow-up was 28 months (minimum, 24 months; range, 24-41 months).

Intraoperative Findings

In most patients ($n=20$, 65%), 2 bone tunnels (1 anterior, 1 posterior), each with 3 corresponding sutures, were used for transosseous fixation. Cortical augmentation was used in only 7 cases (23%; 3 revision, 4 primary). Older patient age was not significantly associated with either the number of bone tunnels used or the need for a cortical augmentation device ($P=.48$ and $P=.09$, respectively). Men were significantly more likely than women to undergo 2-tunnel fixation ($P=.01$), and there was no association between sex and the use of cortical augmentation ($P=.42$).

Outcomes

Preoperative and postoperative outcome scores are summarized in Table 2. Average preoperative active forward elevation was 130° and improved to 155° postoperatively at the most recent clinical follow-up.

Average postoperative subjective shoulder value and visual analog scale score improved significantly to 84% and 0.9 of 10, respectively ($P<.001$) at follow-up. Average

postoperative satisfaction score was high, at 90.6 of 100, and average ASES score was 86.3 of 100.

Primary repair was significantly associated with an improvement in outcome measures compared with revision rotator cuff repair. Cortical augmentation was not significantly associated with improved outcome scores (Table 2).

Complications

Of the 31 patients in the original cohort, 3 had major complications (9.7%). All 3 had recurrence of rotator cuff tears. One of these patients had a fall 2 months postoperatively and presented with pain and weakness of the operative shoulder. On revision arthroscopy, it was evident that the transosseous sutures had pulled through the rotator cuff tendon and the bone tunnels were intact. Cortical augmentation was used and was also intact. The patient underwent revision repair with multiple large suture anchors and had excellent outcome scores at the most recent follow-up (subjective shoulder value, 90%; visual analog scale score, 0 of 10; satisfaction score, 95%; ASES score, 91.7). Two patients had clinical and radiographic evidence of recurrence of atraumatic rotator cuff tears. One patient who had undergone at least 3 previous unsuccessful rotator cuff repairs declined further surgery. The mechanism of failure in this case was unclear, and outcome scores were poor (subjective shoulder value, 0%; visual analog scale score, 9 of 10; satisfaction score, 35%; ASES score, 10). The other patient presented to an outside institution, where an attempted revision was performed and was unsuccessful. Outcome scores were similarly suboptimal (subjective shoulder value, 55%; visual analog scale score, 2 of 10; satisfaction score, 50%; ASES score, 71.7).

Two patients (6%) had minor complications. Both included intraoperative suture cutout from bone during arthroscopic knot tying and tensioning of the rotator cuff to the footprint. A 44-year-old patient undergoing primary repair for a large tear had 2 transosseous tunnels used when the anterior sutures pulled through the bone via a suture cutout mechanism (Figure 4). The posterior tunnel remained intact, and the repair was supplemented with a large metal anchor anteriorly in the region of poor bone stock. In the other case, a 62-year-old patient was undergoing a similar repair when both tunnels failed via the mechanism discussed earlier. A formal open approach was subsequently undertaken, and the rotator cuff was repaired in a double-row fashion, medially with large, 6.5-mm metal anchors and laterally with knotless suture anchors. Both patients had good to excellent final outcome scores (visual analog scale score, 0 of 10; satisfaction score, 100%; ASES score, >80).

Discussion

The authors reported short-term outcomes, complications, and technical pearls encountered in a series of 31 patients with more than 2 years of follow-up after arthroscopic transosseous rotator cuff repair. The study sample included all patients who underwent arthroscopic transosseous rotator cuff repair performed by the same surgeon at a single institution. During the study period, the authors' practice had no strict guidelines for performing arthroscopic anchorless vs anchored repair, although patients undergoing revision with prior anchors littering the tuberosity were more likely to undergo anchorless cuff repair. In this

series, 35% (11 shoulders) of the repairs were revision procedures for a previous failed repair, accounting for a relatively higher proportion than in other series, given the referral nature of the authors' practice.

After arthroscopic transosseous rotator cuff repair, patients had statistically significant improvements in visual analog scale score and subjective shoulder value and high overall satisfaction and ASES scores. In patients undergoing primary rotator cuff repair, improvement and outcome scores were even higher than the authors' reported averages (subjective shoulder value, 92%; visual analog scale score, 0.4; satisfaction score, 94.9; ASES score, 92.6). These outcome scores are on par with other studies in the literature reporting a variety of arthroscopic primary repair methods.²⁹⁻³³ The authors included minor complications in the outcome analysis, even though the rotator cuff was not completely repaired in a transosseous manner, to provide an intention-to-treat analysis. The authors believed that it was important to include these 2 patients because of the initial plan to treat them with the transosseous procedure and did not wish to skew the data positively via omission of these complications.

This study found that outcomes in primary and revision surgery are significantly different with arthroscopic transosseous rotator cuff repair. Patients undergoing revision repair had worse outcomes and greater pain at 2 years compared with those undergoing primary repair, despite similar baseline characteristics. On average, ASES scores were 18 points lower, representing a clinically noticeable difference in function between the 2 patient groups.³⁴ Additionally, subjective shoulder value was 22% lower, visual analog scale score was 1.3 points higher, and satisfaction score was 12.2 points lower in the revision group ($P<.05$, except for satisfaction score, which showed a trend toward significance at $P<.15$). This finding is not surprising because the outcomes after revision arthroscopic rotator cuff repair reported in the literature are not the same as in primary surgery.³⁵⁻³⁸

Despite outcomes that were significantly worse after revision repair in the current cohort, the results after revision surgery using the arthroscopic transosseous technique were similar to those of other studies in the literature. Average published ASES scores after revision arthroscopic repair range from 68 of 100 to 75 of 100, which are similar to the value of 75 of 100 observed in the current study.^{35,36,38} Additionally, pain levels reported in the literature range from 2 of 10 to 2.8 of 10, again similar to the authors' cohort average of 1.7 of 10 for revision rotator cuff repair.^{35,36,38} These similarities indicate that arthroscopic transosseous revision repair has similar outcomes to other methods of arthroscopic repair previously detailed. Larger studies with longer follow-up are needed to compare techniques in this challenging patient setting.

Cortical augmentation was used when bone stock was believed to be insufficient to support suture fixation and supplemental fixation to the tuberosity was necessary. It is not used in all cases because patients with adequate bone stock typically have excellent fixation with sutures alone, as has been done with open transosseous repair in the past. However, this intraoperative decision is subjective, and improper judgment regarding tuberosity bone stock can lead to suture pullout.

Caldwell et al⁶ showed that such augmentation may increase the pullout strength of sutures from the bone by approximately 2-fold. Other biomechanical studies supported the use of lateral augmentation to prevent suture pullout.³⁹⁻⁴¹ In the current series, cortical augmentation did not significantly affect outcomes. It is plausible that the use of cortical augmentation as an additional means of fixation prevented suture pullout in patients with poor bone stock, thereby equalizing outcomes to the level of other patients with improved bone stock. Additionally, this study showed no significant association between patient age or sex and the use of cortical augmentation, indicating that other factors can affect a surgeon's perceived adequacy of bone stock in the tuberosity.

It is difficult to predict which patients may be at risk for intraoperative suture pullout. In 2 patients undergoing primary repair, transosseous sutures failed intraoperatively as a result of suture cutout through the tuberosity. On tensioning and knot tying, the sutures pulled through the bone spanning between the tunnels and thus did not secure the tendon to the underlying footprint. Similar to suture anchors, bone stock and suture location correlate with pullout strength of the transosseous sutures.^{6,40,42} If there is doubt about the quality of bone stock in the greater tuberosity, cortical augmentation is recommended to improve the stability of the construct. Additionally, it is important to place the lateral drill holes as far lateral and distal off the tip of the greater tuberosity as possible (bone bridge >10 mm) to maximize pullout strength.

Arthroscopic transosseous rotator cuff repair can provide significant cost savings for a procedure that has become quite expensive, especially with the use of multiple suture anchors in various configurations. Arthroscopic transosseous repair uses medial and lateral fixation and allows compression of the rotator cuff over its natural footprint, all without the need for suture anchors. This could be particularly helpful in massive rotator cuff repair and revision.

Limitations

The study had several limitations. Patients were identified retrospectively, and there were no uniform selection criteria for a patient to undergo arthroscopic transosseous repair vs other modalities, such as single-row or transosseous equivalent repair, during the study period. The authors did not use another subset of patients undergoing rotator cuff repair to compare outcomes of transosseous repair, although they did use historical data. Additionally, routine follow-up imaging was not readily available unless patient symptoms warranted. Finally, a sample size of 31 patients is relatively small.

Conclusion

Overall, outcomes after arthroscopic transosseous rotator cuff repair are good. However, outcomes are not as good in patients undergoing revision repair as in those undergoing primary cuff repair. The procedure is not without complications (9.7% major, 6% minor). Cortical augmentation may be used to supplement fixation, although this does not necessarily affect outcomes. Patients without such augmentation may be at increased risk for suture cutout through the bone.

Acknowledgments

The authors thank Dr Jon JP Warner for his contributions to the manuscript.

Dr Jain is supported by funding from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), project number 1K23AR059199.

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Figure 1.

Lateral view of a right shoulder with portal markings in anticipation of a 2-tunnel repair. A metal instrument points to the anterior far lateral portal where the transosseous device will be inserted to drill the lateral (horizontal) drill tunnel.

Figure 2.

Lateral view of a right shoulder undergoing revision rotator cuff repair. On the left, a retained anchor can be visualized in the tuberosity, and on the right a void is present where 1 anchor has been removed (A). The bone void is used as a vertical transosseous tunnel, and the transosseous device is inserted to drill a perpendicular horizontal hole (B). A green shuttle suture is visualized traversing the transosseous tunnel and will be used to shuttle 3 braided sutures (C). Three braided sutures are placed in each of 2 transosseous tunnels and will be used for rotator cuff fixation (D).

Figure 3.
Lateral view of a right shoulder where a cortical augmentation device has been used to support sutures in the tuberosity footprint.

Figure 4. Lateral view of a right shoulder where anterior fixation sutures have pulled through the lateral bone tunnel in a “cheese-grating” fashion on tensioning the rotator cuff and arthroscopic knot tying. In this case, a large metal anchor was used to supplement fixation on the anterior repair margin.

Table 1

Study Population Demographics

Demographic	Value
Patients, No.	31
Age, average (range), y	56 (38-86)
Sex, No.	
Male	23 (74%)
Female	8 (26%)
Surgical side, No.	
Right	22 (71%)
Left	9 (29%)
Mode of repair, No.	
Primary	20 (65%)
Revision	11 (35%)
Cortical augmentation, No.	
No	24 (77%)
Yes	7 (23%)

Table 2Pre- and Postoperative Outcome Scores in Each Subgroup^a

Category	Preoperative			Postoperative		
	Visual Analog Scale Score	Subjective Shoulder Value	Visual Analog Scale Score	Subjective Shoulder Value	Satisfaction Score	American Shoulder and Elbow Surgeons Score
Primary vs revision (SD; range)						
Primary	5.4 (1.9; 1.5-9)	35% (25%; 0%-90%)	0.4 (1.2; 0-5) ^b	92% (11%; 55%-100%) ^b	94.9 (11.8; 50-100) ^c	92.6 (10.0; 66.7-100) ^b
Revision	4.6 (2.2; 0-7.5)	37% (24%; 2%-70%)	1.7 (2.8; 0-9) ^b	70% (30%; 0%-95%) ^b	82.7 (24.4; 35-100) ^c	75.0 (26.7; 10-100) ^b
Cortical augmentation (SD; range)						
No	4.8 (1.8; 0-8)	35% (25%; 0%-90%)	0.9 (2.1; 0-9)	84% (22%; 0%-100%)	91.0 (17.1; 35-100)	86.2 (20.0; 10-100)
Yes	6.0 (2.6; 2-9)	36% (25%; 0%-65%)	0.6 (1.5; 0-4)	83% (24%; 30%-100%)	89.0 (21.9; 40-100)	86.9 (18.5; 46.7-100)
Overall (SD; range)	5.1 (2.0; 0-9)	35% (24%; 0%-90%)	0.9 (2.0; 0-9)	84% (22.3%; 0%-100%)	90.6 (17.9; 35-100)	86.3 (19.4; 10-100)

^a Differences between each score within the individual subgroups were independently calculated by the Wilcoxon test.^b P<.05 between each subgroup.^c P<.15 between each subgroup.