Arthroscopic Transosseous and Transosseous-Equivalent Rotator Cuff Repair: An Analysis of Cost, Operative Time, and Clinical Outcomes

Adam J. Seidl, MD, Nicholas J. Lombardi, BS, Mark D. Lazarus, MD, Eric M. Black, MD, Mitchell G. Maltenfort, PhD, Matthew D. Pepe, MD, and Luke S. Austin, MD

Abstract

The incidence of arthroscopic rotator cuff repair (RCR) continues to rise. Given the changing healthcare climate, it is becoming increasingly important to critically evaluate current practice and attempt to make modifications that decrease costs without compromising patient outcomes.

We conducted a study of the costs associated with arthroscopic anchorless (transosseous [TO]) RCR and those associated with the more commonly performed anchor-based TO-equivalent (TOE) method to determine whether there are any cost savings with the TO-RCR method.

Twenty-one consecutive patients who underwent arthroscopic TO-RCR were prospectively enrolled in the study and matched on tear size and concomitant procedures with patients who underwent arthroscopic TOE-RCR. The groups' implant costs and operative times were obtained and compared. Outcome measures, including scores on the VAS (visual analog scale) for pain, the SANE (Single Assessment Numeric Evaluation), and the SST (Simple Shoulder Test), recorded at 3, 6, and >12 months after surgery, were compared between the TO and TOE groups.

Mean implant cost was $946.91 less for the TO group than the TOE group—a significant difference. Mean operative time was not significantly different between the TO and TOE groups. There was significant improvement on all outcomes measures (VAS, SANE, SST) at >12 months, and this improvement was not significantly different between the groups.

Arthroscopic TO-RCR provides significant cost savings over TOE-RCR with no significant difference in operative time or short-term outcomes.

The rate of medical visits for rotator cuff pathology and the US incidence of arthroscopic rotator cuff repair (RCR) have increased over the past 10 years.[1] The increased use of RCR has been justified with improved patient outcomes.[2,3] Advances in surgical techniques and instrumentation have contributed to better outcomes for patients with rotator cuff pathology.[3-5] Several studies have validated RCR with functional outcome measures, cost–benefit analysis, and health-related quality-of-life measurements.[6-9]

Healthcare reimbursement models are being changed to include capitated care, pay for performance, and penalties.[10] Given the changing healthcare climate and the increasing incidence of RCR, it is becoming increasingly important for orthopedic surgeons to critically evaluate and modify their practice and procedures to decrease costs without compromising outcomes.[11] RCR outcome studies have focused on comparing open/mini-open with arthroscopic techniques, and single-row with double-row techniques, among others.[4,12-18] Furthermore, several studies on the cost-effectiveness of these surgical techniques have been conducted.[19-21]

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Arthroscopic anchorless (transosseous [TO]) RCR, which is increasingly popular,[22] combines the minimal invasiveness of arthroscopic procedures with the biomechanical strength of open TO repair. In addition, this technique avoids the potential complications and costs associated with suture anchors, such as anchor pullout and greater tuberosity osteolysis.[22,23] Several studies have documented the effectiveness of this technique.[24-26] Biomechanical and clinical outcome data supporting arthroscopic TO-RCR have been published, but there are no reports of studies that have analyzed the cost savings associated with this technique.

In this study, we compared implant costs associated with arthroscopic TO-RCR and arthroscopic TO-equivalent (TOE) RCR. We also evaluated these techniques' operative time and outcomes. Our hypothesis was that arthroscopic TO-RCR can be performed at lower cost and without increasing operative time or compromising outcomes.

Table 1. **Patient Demographics**

	Repair Group	
Demographic	**TO**	**TOE**
Sex, F/M	13/8	13/8
Age, y		
Mean	56	63
SD	7	10
Range	45-67	41-77
Body mass index, kg/m^2		
Mean	27	29
SD	4	5
Range	19-36	22-40
Smoking status		
Current	1	1
Former	3	3
Tear size		
Small	2	2
Medium	12	12
Large	3	3
Massive	4	4
Concomitant procedure		
Distal clavicle excision	1	3
Labral débridement	13	8
Biceps treatment	13	10
Tenotomy	1	8
Tenodesis	12	2
Subacromial decompression	10	11

Abbreviations: TO, transosseous; TOE, transosseous-equivalent.

Materials and Methods

Our Institutional Review Board approved this study. Between February 2013 and January 2014, participating surgeons performed 43 arthroscopic TO-RCRs that met the study's inclusion criteria. Twenty-one of the 43 patients enrolled and became the study group. The control group of 21 patients, who underwent arthroscopic TOE-RCR the preceding year (between January 2012 and January 2013), was matched to the study group on tear size and concomitant procedures, including biceps treatment, labral treatment, acromioplasty, and distal clavicle excision (**Table 1**). Males or nonpregnant females, age 18 years or older, with full-thickness rotator cuff tear treated with arthroscopic RCR at one regional healthcare system were eligible for the study. Exclusion criteria were revision repair, irreparable tear, worker compensation claim, and subscapularis repair.

The primary outcome measure was implant cost (amount paid by institution). Cost was determined and reported by an independent third party using Cerner Surginet as the operating room documentation system and McKessen Pathways Materials Management System for item pricing.

All arthroscopic RCRs were performed by 1 of 3 orthopedic surgeons fellowship-trained in either sports medicine or shoulder and elbow surgery. Using the Cofield classification,[27] the treating surgeon recorded the size of the rotator cuff tear: small (<1 cm), medium (1-3 cm), large (3-5 cm), massive (>5 cm). The surgeon also recorded the number of suture anchors used, repair technique, biceps treatment, execution of subacromial decompression, execution of distal clavicle excision, and intraoperative complications. TO repair surgical technique is described in the next section. TOE repair was double-row repair with suture anchors. The number of suture anchors varied by tear size: small (3 anchors), medium (2-5 anchors), large (4-6 anchors), massive (4-5 anchors).

Secondary outcome measures were operative time (time from cut to close) and scores on pain VAS (visual analog scale), SANE (Single Assessment Numeric Evaluation), and SST (Simple Shoulder Test). Demographic information was also obtained: age, sex, body mass index, smoking status (Table 1). All patients were asked to fill out questionnaires before surgery and 3, 6, and >12 months after surgery. Outcome surveys were scored by a single research coordinator, who recorded each patient's outcome scores at the preoperative and postoperative intervals. Follow-up of >12 months was reached by 17 (81%) of the 21 TO patients and 14 (67%) of the 21 TOE patients. For >12 months, the overall rate of follow-up was 74%.

All patients followed the same postoperative rehabilitation protocol: sling immobilization with pendulums for 6 weeks starting at 2 weeks, passive range of motion starting at 6 weeks, and active range of motion starting at 8 weeks. At 3 months, they were allowed progressive resistant exercises with a 10-pound limit, and at 4.5 months they progressed to a 20-pound limit. At 6 months, they were cleared for discharge.

Surgical Technique: Arthroscopic Transosseous Repair

Surgery was performed with the patient in either the beach-chair position or the lateral decubitus position, based on surgeon preference. Our technique is similar to what has been described in the past.[22,28] The glenohumeral joint is accessed through a standard posterior portal, followed by an anterior accessory portal through the rotator interval. Standard diagnostic arthroscopy is performed and intra-articular pathology addressed. Next, the scope is placed in the subacromial space through the posterior portal. A lateral subacromial portal is established and cannulated, and a bursectomy performed. The scope is then placed in a posterolateral portal for better visualization of the rotator cuff tear. The greater tuberosity is débrided with a curette to prepare the bed for repair. An ArthroTunneler (Tornier) is used to pass sutures through the greater tuberosity. For standard 2-tunnel repair, 3 sutures are placed through each tunnel. All 6 sutures are next passed (using a suture passer) through the rotator cuff. The second and fifth suture ends that are passed through the cuff are brought out through the cannula and tied together. They are then brought into the shoulder by pulling on the opposite ends and tied alongside the greater tuberosity to create a box stitch. The box stitch acts as a medial row fixation and as a rip stitch that strengthens the vertical mattress sutures against pullout. The other 4 sutures are tied in vertical mattress configuration.

Statistical Analysis

After obtaining the TO and TOE implant costs, we compared them using a generalized linear model with negative binomial distribution and an identity link function so returned parameters were in additive dollars. This comparison included evaluation of tear size and concomitant procedures. Operative times for TO and TOE were obtained and evaluated, and then compared using time-to-event analysis and the log-rank test. Outcome scores were obtained from patients at baseline and 3, 6, and >12 months after surgery and were compared using a linear mixed model that identified change in outcome scores over time, and difference in outcome scores between the TO and TOE groups.

Results

Table 1 lists patient demographics, including age, sex, body mass index, smoking status, and concomitant procedures. The TO and TOE groups had identical tear-size distributions. In addition, they had similar numbers of concomitant procedures,

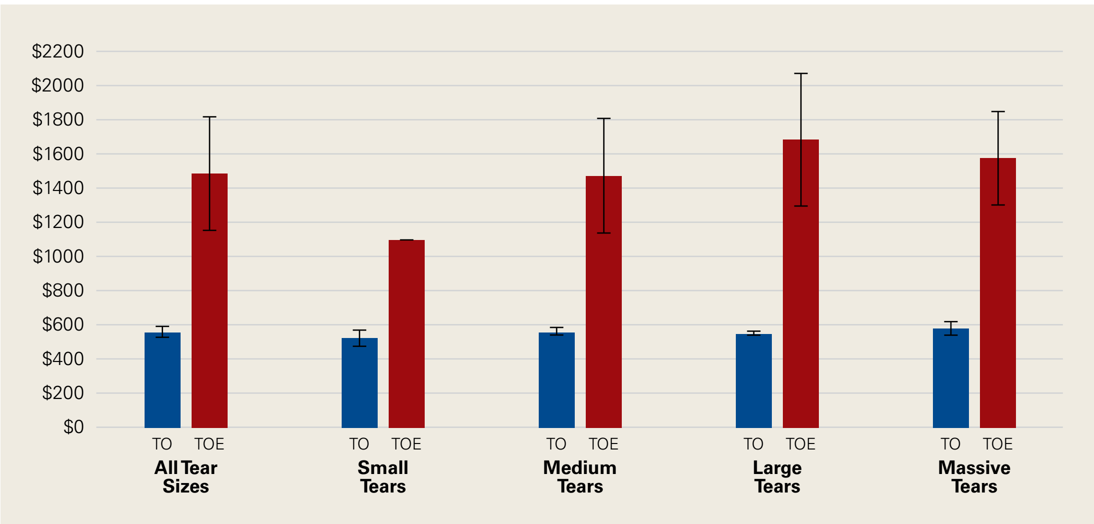

Figure 1. Mean implant costs for transosseous (TO) and transosseous-equivalent (TOE) groups by tear size. Error bars represent standard deviations.

Table 2. **Outcome Scores at Baseline and 3, 6, and >12 Months After Surgery for TO and TOE Groups**

	Baseline		3 Months		6 Months		>12 Months	
Score	**TO**	**TOE**	**TO**	**TOE**	**TO**	**TOE**	**TO**	**TOE**
SST	4.76	3.88	5.79	5.27	8.53	8.46	10.82	9.71
VAS	5.74	5.75	3.23	3.77	2.60	2.03	0.88	1.64
SANE	51.43%	44.69%	56.93%	64.80%	78.77%	78.93%	88.12%	82.86%

Abbreviations: SANE, Single Assessment Numeric Evaluation; SST, Simple Shoulder Test; TO, transosseous; TOE, transosseous-equivalent; VAS, visual analog scale.

though our study was underpowered to confirm equivalence. Treatment techniques differed: more biceps tenodesis cases in the TO group (n = 12) than in the TOE group (n = 2) and more biceps tenotomy cases in the TOE group (n = 8) than in the TO group (n = 1).

TO implant cost was significantly lower than TOE implant cost for all tear sizes and independent of concomitant procedures (**Figure 1**). Mean (SD) implant cost was $563.10 ($29.65) for the TO group and $1489.00 ($331.05) for the TOE group. With all other factors controlled, mean (SD) implant cost was $946.91 ($100.70) more expensive for the TOE group ($P < .0001$).

Operative time was not significantly different between the TO and TOE groups. Mean (SD) operative time was 82.38 (24.09) minutes for the TO group and 81.71 (17.27) minutes for the TOE group. With all other factors controlled, mean operative time was 5.96 minutes shorter for the TOE group, but the difference was not significant ($P = .549$).

There was no significant difference in preoperative pain VAS ($P = .93$), SANE ($P = .35$), or SST ($P = .36$) scores between the TO and TOE groups. At all postoperative follow-ups (3, 6, and >12 months), there was significant ($P < .0001$) improvement in outcome scores (VAS, SANE, SST) for both groups (**Table 2**). There was no significant difference in pain VAS ($P = .688$), SANE ($P = .882$), or SST ($P = .272$) scores (**Figure 2**) between the groups across all time points.

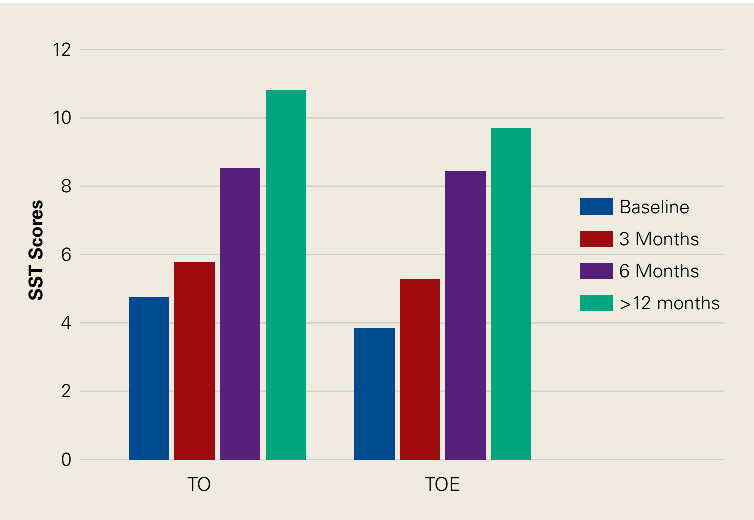

Figure 2. Simple Shoulder Test (SST) scores at baseline and 3, 6, and >12 months after surgery for transosseous (TO) and transosseous-equivalent (TOE) groups.

Discussion

RCR is one of the most common orthopedic surgical procedures, and its use has increased over the past decade.[9,21] This increase coincides with the emergence of new repair techniques and implants. These advancements come at a cost. Given the increasingly cost-conscious healthcare environment and its changing reimbursement models, now surgeons must evaluate the economics of their surgical procedures in an attempt to decrease costs without compromising outcomes. We hypothesized that arthroscopic TO-RCR can be performed at lower cost relative to arthroscopic TOE-RCR and without increasing operative time or compromising short-term outcomes.

Studies on the cost-effectiveness of different RCR techniques have been conducted.[19-21] Adla and colleagues[19] found that open RCR was more cost-effective than arthroscopic RCR, with most of the difference attributable to disposables and suture anchors. Genuario and colleagues[21] found that double-row RCR was not as cost-effective as single-row RCR in treating tears of any size. They attributed the difference to 2 more anchors and about 15 more minutes in the operating room.

The increased interest in healthcare costs and the understanding that a substantial part of the cost of arthroscopic RCR is attributable to implants (suture anchors, specifically) led to recent efforts to eliminate the need for anchors. Newly available instrumentation was designed to assist in arthroscopic anchorless repair constructs using the concepts of traditional TO repair.[22] Although still considered to be the RCR gold standard, TO fixation has been used less often in recent years, owing to the shift from open to arthroscopic surgery.[24] Arthroscopic TO-RCR allows for all the benefits of arthroscopic surgery, plus the biological and mechanical benefits of traditional open or mini-open TO repair. In addition, this technique eliminates the cost of anchors. Kummer and colleagues[25] confirmed with biomechanical testing that arthroscopic TO repair and double-row TOE repair are similar in strength, with a trend of less tendon displacement in the TO group.

Our study results support the hypothesis that arthroscopic TO repair provides significant cost savings over tear size–matched arthroscopic TOE repair. Implant cost was substantially higher for TOE repair than for TO repair. Mean (SD) total savings of \$946.91 (\$100.70) ($P < .0001$) can be realized performing TO rather than TOE repair. In the United States, where about 250,000 RCRs are performed each year, the use of TO repair would result in an annual savings of almost \$250 million.[6]

Operative time was analyzed as well. Running an operating room in the United States costs an estimated \$62 per minute (range, \$22-\$133 per minute).[29] Much of this cost is indirect, unrelated to the surgery (eg, capital investment, personnel, insurance), and is being paid even when the operating room is not in use. Therefore, for the hospital's bottom line, operative time savings are less important than direct cost savings (supplies, implants). However, operative time has more of an effect on the surgeon's bottom line, and longer procedures reduce the number of surgeries that can be performed and billed. We found no significant difference in operative time between TO and TOE repairs. Critical evaluation revealed that operative time was 5.96 minutes shorter for TOE repairs, but this difference was not significant ($P = .677$).

Our study results showed no significant difference in clinical outcomes between TO and TOE repair patients. Both groups' outcome scores improved. At all follow-ups, both groups' VAS, SANE, and SST scores were significantly improved. Overall, this is the first study to validate the proposed cost benefit of arthroscopic TO repair and confirm no compromise in patient outcomes.

This study had limitations. First, it enrolled relatively few patients, particularly those with small tears. In addition, despite the fact that patients were matched on tear size and concomitant procedures, the groups differed in their biceps pathology treatments. Of the 13 TO patients who had biceps treatment, 12 underwent tenodesis (1 had tenotomy); in contrast, of the 10 TOE patients who had biceps treatment, only 2 underwent tenodesis (8 had tenotomy). The difference is explained by the consecutive course of this study and the increasing popularity of tenodesis over tenotomy. The TOE group underwent surgery before the TO group did, at a time when the involved surgeons were routinely performing tenotomy more than tenodesis. We did not include the costs of implants related to biceps treatment in our analysis, as our focus was on the implant cost of RCR. As for operative time, biceps tenodesis would be expected to extend surgery and potentially affect the comparison of operative times between the TO and TOE groups. However, despite the fact that 12 of the 13 TO patients underwent biceps tenodesis, there was no significant difference in overall operative time. Last, regarding the effect of biceps treatment on clinical outcomes, there are no data showing improved outcomes with tenodesis over tenotomy in the setting of RCR.

A final limitation is lack of data from longer term (>12 months) follow-up for all patients. Our analysis included cost and operative time data for all 42 enrolled patients, but our clinical outcome data represent only 74% of the patients enrolled. Eleven of the 42 patients were lost to follow-up at >12 months, and outcome scores could not be obtained, despite multiple attempts at contact (phone, mail, email). The study design and primary outcome variable focused on cost analysis rather than clinical outcomes. Nevertheless, our data support our hypothesis that there is no difference in clinical outcomes between TO and TOE repairs.

Conclusion

Arthroscopic TO-RCR provides significant cost savings over arthroscopic TOE-RCR without increasing operative time or compromising outcomes. Arthroscopic TO-RCR may have an important role in the evolving healthcare environment and its changing reimbursement models.

Dr. Seidl is Assistant Professor, Department of Orthopedics, Anschutz Medical Campus, University of Colorado, Aurora, Colorado. Mr. Lombardi is a Research Assistant, Dr. Maltenfort is a Statistician, Dr. Pepe is Assistant Professor, and Dr. Lazarus and Dr. Austin are Associate Professors, Department of Orthopedics, Rothman Institute, Thomas Jefferson University, Philadelphia, Pennsylvania. Dr. Black is an Orthopedic Surgeon, Summit Medical Group, Florham Park, New Jersey.

Address correspondence to: Adam J. Seidl, MD, Department of Orthopedics, Anschutz Medical Campus, University of Colorado, 12631 E 17th Ave, Mail Stop B202, Aurora, CO 80045 (tel, 253-227-8278; fax, 303-724-2978; email, adam.seidl@ucdenver.edu).

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