J Shoulder Elbow Surg (2020) 29, S48–S52

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

# Factors influencing operative time in arthroscopic rotator cuff repair: a comparison of knotless single-row vs. transosseous equivalent dual-row techniques

**Jason A. Boyd, MD*, Spero G. Karas, MD, Ryan J. Urchek, MD, Kevin X. Farley, BS, Albert T. Anastasio, MD, Michael B. Gottschalk, MD**

*Emory University, Atlanta, GA, USA*

**Background:** Despite the widespread use of arthroscopic rotator cuff repair (aRCR), there remains considerable debate on the benefits of a dual-row vs. a single-row (SR) repair technique. This study compares operative time of a knotless SR technique with transosseous equivalent (TOE) dual-row technique for aRCR and defines patient-specific factors that affect operative time.

**Methods:** Data from 118 patients who underwent aRCR with a knotless SR technique was compared with data from 95 patients who underwent aRCR with a TOE technique by a single surgeon between 2014 and 2018. Baseline patient demographic information and operative time were recorded and compared between the 2 groups. Subgroup analysis was performed to determine if demographic information or tear size influenced operative time.

**Results:** The average operative time in the SR group was 75.68 minutes and the average operative time in the TOE group was 89.24 minutes ($P < .001$). When controlling for all concomitant procedures, the operative time in the TOE group was 8.1 minutes longer than the SR group ($P = .029$). Average tear size in an anterior-posterior direction was larger in the TOE group vs. the SR group, 26.09 mm vs. 15.18 mm ($P < .001$).

**Conclusion:** When controlling for concomitant procedures, a knotless, TOE dual-row technique for aRCR adds an average of 8 minutes' operative time compared with a knotless SR technique. This was despite a significantly larger tear size in the TOE group.

**Level of evidence:** Level III; Retrospective Cohort Comparison; Treatment Study



**Keywords:** Rotator cuff; arthroscopy; operative time; shoulder; sports medicine; tendon repair

Arthroscopic rotator cuff repair (aRCR) is one of the most commonly used and successful procedures performed by orthopedic surgeons. Despite good clinical results, there is considerable debate on the optimal repair technique. In addition, issues with complete tendon to bone healing still

Data collection and all protocols were approved by the Institutional Review Board of the Emory University in Atlanta, GA (Emory Institutional Review Board no. 00104362).

*Reprint requests: Jason A. Boyd, MD, 333 Timber Run Dr, Canfield, OH 44406, USA.

E-mail address: jasonaboyd07@gmail.com (J.A. Boyd).

1058-2746/$ - see front matter © 2019 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.
https://doi.org/10.1016/j.jse.2019.10.015

exist. A 2010 systematic review of the literature reported that the overall retear rate following aRCR was 20.4%.[11] The knotless dual-row transosseous equivalent (TOE) repair technique has been developed in an attempt to improve biomechanical integrity of the repair construct and to decrease the retear rate.

Several biomechanical studies and 1 multicenter randomized controlled trial confirmed the utility of dual-row techniques in improving initial strength, decreasing gap formation, and decreasing retear rates compared with single-row (SR) constructs.[6,8,9] Furthermore, failure rates in large and massive tears after knotless TOE techniques have been shown to be 21% and 22%, respectively, which is lower than previous retear rates with older techniques.[7]

Several authors have evaluated the clinical outcomes of a knotless and knotted dual-row TOE construct. In a study of 73 patients, Boyer et al[2] found a lower but not statistically significant retear rate in knotless TOE vs. knotted TOE constructs. Hug et al[5] found similar results in their 22-patient cohort. Millett et al found that the repair technique did not affect the final functional outcome, but patients with knotless TOE repair were less likely to have a retear.[10] Dukan et al[4] demonstrated good midterm results of knotless TOE repairs, with 88% tendon healing and dramatic improvements in ASES and Constant scores at 5 years. The above studies support the use of a knotless TOE technique to increase the repair's biomechanical integrity and to decrease the retear rate. To date, the impact of a TOE repair technique on operative time, which typically requires the placement of more anchors and sutures, has yet to be established.

The current study aimed to (1) compare the operative time of a knotless SR technique with that of a transosseous equivalent dual-row technique for aRCR and (2) to define patient-specific factors that may affect operative time.

## Methods

The prospectively collected data of 213 patients who underwent primary aRCR by a single surgeon between 2014 and 2018 was retrospectively reviewed. Data collection and all protocols were approved by the appropriate institutional review board. Of these 213 patients, 118 (55.4%) underwent an SR repair whereas 95 (44.6%) underwent a TOE dual-row repair. We included patients older than 18 years who had received a primary rotator cuff repair either with an SR or dual-row TOE construct. We excluded patients who had had a prior rotator cuff repair on the same shoulder or who were younger than 18 years.

Preoperative and demographic information was collected through retrospective chart review. The baseline characteristics noted preoperatively were age, sex, presence of medical comorbidity, body mass index (BMI), race, and history of trauma. Operative characteristics were recorded, including whether or not an additional procedure was undertaken in addition to the primary rotator cuff repair. Additional procedures documented included subacromial decompression, labral débridement, biceps tenotomy, biceps tenodesis, and distal clavicle excision. Tear size including

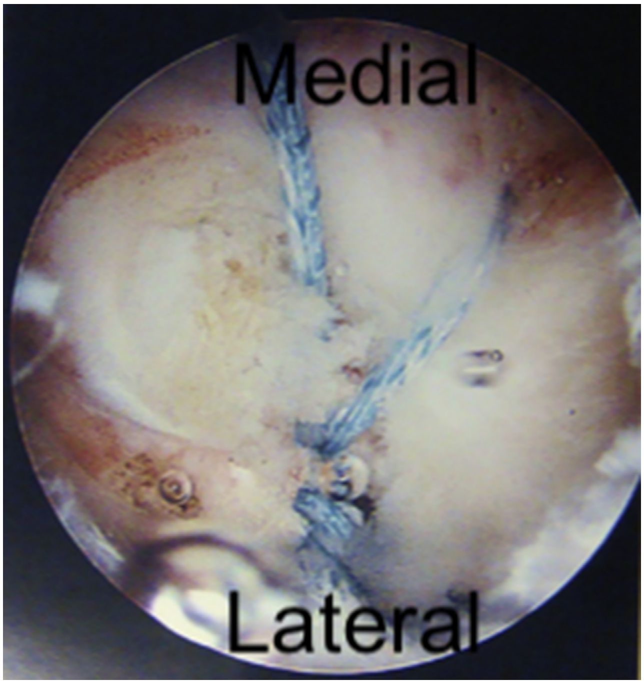


**Figure 1** Arthroscopic view of a completed single-row repair viewing from the lateral portal. The repair is being performed on a right shoulder, with the patient in the beach chair position.

involvement of the infraspinatus and/or the subscapularis in the tear was documented as well. Surgical time was recorded through retrospective chart review of anesthesia documentation for both the SR and TOE groups. All concomitant procedures were included in total operative time as this was recorded from skin incision to skin closure via anesthesia documentation.

All procedures were performed arthroscopically by the senior surgeon in a university-based, ambulatory surgery center. All surgeries were performed in the beach chair position with the aid of general anesthesia and a regional nerve block. After an examination under anesthesia, a diagnostic arthroscopy of the glenohumeral joint was performed from the posterior portal. Labral pathology was addressed, and biceps tenotomy was performed before entering the subacromial space if necessary. The subacromial space was then entered from the posterior portal. Bursectomy was performed to allow visualization of the rotator cuff tear. Subacromial decompression and acromioplasty were performed if there was evidence of impingement.

For all patients, the next step in the operation was débridement of the rotator cuff back to viable tissue. A shaver/burr was used to produce a decorticated surface for cuff fixation. When needed, releases were performed of the coracohumeral ligaments and superior labral attachments, humeral ligaments, and superior labral attachments. The anterior-posterior dimensions of the rotator cuff tear were measured. According to the senior author's preference, SR constructs were used for tears <2 cm and TOE constructs were used for tears >2 cm.

For the patients who underwent SR rotator cuff repairs, sutures were passed 15-17 mm medial to the tear's free edge via a lateral cannula in an inverted horizontal mattress fashion using an antegrade suture passing device (Expressew; Mitek, Raynham, MA, USA). These sutures were then secured to the greater tuberosity using a knotless suture anchor (SwiveLock; Arthrex, Naples, FL,

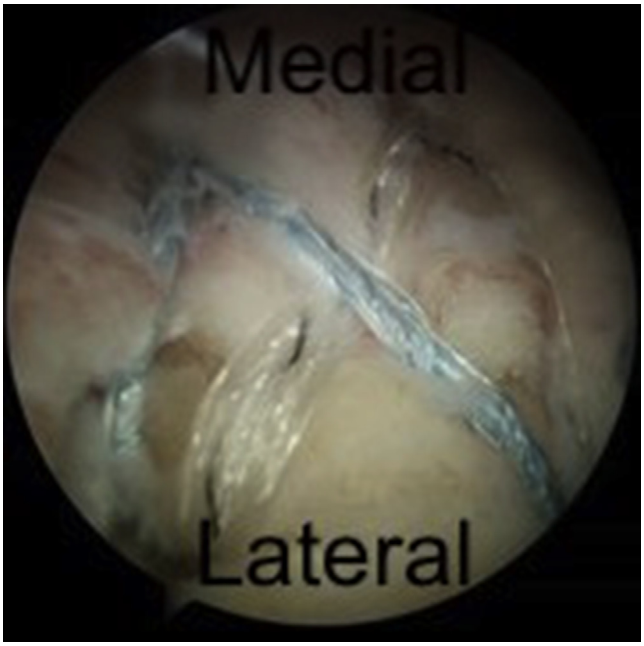


**Figure 2** Arthroscopic view of a completed TOE repair viewing from the lateral portal. The repair is being performed on a right shoulder, with the patient in the beach chair position.

USA) to create a knotless repair. A secure repair was visualized subacromially (Fig. 1).

For the patients who underwent TOE repair, the cuff was débrided back to viable tissue as described above. Medial-row anchors loaded with tape suture (SwiveLock; Arthrex) were placed in the medial aspect of the anatomic footprint through a percutaneous portal off the edge of the acromion. An antegrade suture-passer was then used to individually shuttle the medial-row sutures through the tendon 15-17 mm medial to the tear margin. These sutures were then secured laterally on the greater tuberosity using a second row of knotless suture anchors to create a knotless construct (Fig. 2).

In cases where subscapularis involvement was noted, this tendon was fixed before the posterior superior rotator cuff tendons. Repair of the subscapularis was performed arthroscopically in a manner similar to the technique described above for the posterior superior tendons.

After the conclusion of the rotator cuff repair, distal clavicle excision was performed using a motorized burr if indicated. Finally, a mini-open subpectoral biceps tenodesis was performed in those patients who demonstrated biceps tendon pathology.

Postoperatively, shoulders were immobilized in a sling for 4-8 weeks, depending on tear size. Physiotherapy was performed according to a standardized protocol with active motion beginning at 4-8 weeks and strengthening beginning at 10-12 weeks. Generally, full unrestricted activities were allowed 6 months postoperatively.

## Statistical analysis

A normal distribution to the data was confirmed and means of surgical times were compared using a *t* test. Differences in categorical variables were assessed with $\chi^2$ or Fisher exact tests. Following the univariate analyses, multivariate linear regression analysis was performed to control for the effect of multiple operative characteristics and patient demographics, while assessing the contribution of a dual-row repair to operative times. This model included BMI and age as continuous variables and multiple operative characteristics as categorical variables. Statistical analyses were performed using SPSS software (version 25.0; IBM, Armonk, NY, USA). For all tests, a $P$ value $<.05$ was considered significant.

## Results

A total of 213 patients were included in the final analysis for this study. There were 118 patients in the SR group and 95 patients in the TOE group. There was no difference in demographic data between the 2 groups (Table I), although the TOE group was more likely to be undergoing surgery for a traumatic injury (61.4%), as opposed to 37.3% in the SR group ($P < .001$). The average total operative time including concomitant procedures in the SR group was 75.68 minutes, and the average total operative time including concomitant procedures in the TOE group was 89.24 minutes ($P < .001$).

The average numbers of concomitant procedures performed in the SR and TOE groups were 3.3 and 3.27, respectively ($P = .435$). The types and frequency of concomitant procedures performed within each group is listed in Table II. There were significantly more subacromial decompressions and distal clavicle excisions performed in the SR group ($P = .031$). There were more mini-open biceps tenodeses performed in the TOE group vs. the SR group (63.2% vs. 52.1%) although this did not reach statistical significance ($P = .107$).

When controlling for all concomitant procedures via linear regression, the operative time in the TOE group was 8.1 minutes longer than the SR group ($P = .029$). Tears involving the subscapularis increased operative time by an average of 25.33 minutes ($P = .012$). Infraspinatus involvement did not increase operative time ($P = .216$). Similarly, increasing age and increasing BMI did not alter operative time ($P = .174$ and $P = .419$ respectively). None of the other operative factors were significantly associated with an increase in operative time as listed in Table III.

The average tear size in the anterior posterior direction in the TOE group was 11 mm larger than the SR group (26.30 mm vs. 15.04 mm, $P < .001$). Within the TOE group, operative time for repairing large (3-5 cm) and massive tears (>5 cm) was slightly longer ($P = .038$) than that for medium tears (1-3 cm), as listed in Table IV.

## Discussion

The present study helps to answer the question of whether using a knotless, TOE rotator cuff repair technique increases operative time compared with a knotless SR technique. It also helps define some of the patient- and tear-

**Table I** Patient demographics

| | SR | TOE | *P* value |
|---|---|---|---|
| Body mass index, mean ± SD | 29.11 ± 12.20 | 30.20 ± 6.41 | .49 |
| Age, yr, mean ± SD | 57.51 ± 8.50 | 56.36 ± 9.06 | .395 |
| Female sex, n (%) | 47 (39.8) | 29 (33.0) | .312 |
| Traumatic injury, n (%) | 44 (37.3) | 51 (61.4) | <.001 |

*SD*, standard deviation; *SR*, single-row; *TOE*, transosseous equivalent.

**Table II** Concomitant procedures associated with rotator cuff repair

| | SR | TOE | *P* value |
|---|---|---|---|
| Operative time, minutes, mean ± SD | 89.24 ± 20.51 | 75.68 ± 22.85 | <.001 |
| Distal clavicle excision | 39 (33.1) | 14 (14.7) | .002 |
| Biceps tenodesis | 61 (52.1) | 60 (63.2) | .107 |
| Biceps tenotomy | 81 (68.6) | 69 (72.6) | .526 |
| Subacromial decompression | 109 (92.4) | 76 (80) | .008 |
| Labral débridement | 96 (81.4) | 78 (82.1) | .888 |
| Infraspinatus involvement | 7 (5.9) | 26 (27.4) | <.001 |
| Subscapularis involvement | 2 (1.7) | 6 (6.3) | .143 |
| Size of tear, mm, mean ± SD | 15.04 ± 6.30 | 26.30 ± 7.76 | <.001 |

*SD*, standard deviation; *SR*, single-row; *TOE*, transosseous equivalent. Unless otherwise noted, values are n (%).

**Table III** Linear regression of factors associated with operative time

| Operative detail | Beta, min* | 95% CI | *P* value |
|---|---|---|---|
| Infraspinatus involvement | 6.17 | −3.642, 15.978 | .216 |
| Subscapularis involvement | 25.33 | 5.664, 44.992 | .012 |
| Dual-row repair | 8.05 | 0.851, 15.246 | .029 |
| Subacromial decompression | −5.41 | −15.991, 5.173 | .314 |
| Labral débridement | 6.21 | −4.112, 16.536 | .236 |
| Biceps tenotomy | 7.24 | −5.415, 19.891 | .260 |
| Biceps tenodesis | 3.86 | −6.204, 13.932 | .450 |
| Distal clavicle excision | 4.33 | −3.596, 12.262 | .282 |
| Age | −0.29 | −0.712, 0.13 | .174 |
| Body mass index | −0.13 | −0.457, 0.191 | .419 |

*CI*, confidence interval.
* Beta coefficient with 95% CI obtained through linear regression while controlling for patient and operative characteristics; beta represents the change in operating room time (in minutes) associated with the patient or operative detail displayed.

**Table IV** Comparison of operative time within TOE group based on tear size

| | n | Time, mean ± SD | *P* value |
|---|---|---|---|
| Large or massive tears (>5 mm, 3-5 mm) | 80 | 95.42 ± 26.81 | .038 |
| Medium tears (1-3 mm) | 15 | 86.17 ± 15.615 | |

*SD*, standard deviation; *TOE*, transosseous equivalent.

specific factors that may increase operative time, which may assist surgeons in increasing efficiency in the operating room and surgical scheduling. We found that the TOE technique, compared with the SR technique, significantly increased operative time by an average of 8 minutes when controlling for concomitant procedures via linear regression. However, this was in the presence of significantly larger rotator cuff tears (26.1 mm vs. 15.2 mm).

We were not surprised to discover that tears involving the subscapularis increased the operative time significantly. This correlates with the senior surgeon's clinical experience that large tears involving the subscapularis are often retracted and require increased time to safely dissect and mobilize to create a tension-free repair. Interestingly, several factors did not increase operative time. Within the TOE group, tears involving the infraspinatus did not increase operative time. Similarly, older patient age and increasing BMI did not increase operative time. This may suggest that once a surgeon is comfortable with the TOE technique, he or she can easily tackle larger tears without significantly increasing the operative time of the procedure.

The results of this study add to the current available literature on the topic. Black et al[1] found the average operative time of a knotless TOE repair to be 99 minutes when employing a similar technique. Our operative time was slightly faster than the referenced study and may represent the continued evolution of the TOE technique. Curry et al[3] recently studied the factors influencing the operative time of aRCR at an ambulatory care center. They found that beach chair position increased operative time compared with lateral decubitus (115.8 vs. 89.6 minutes). Although we did not perform any of the surgeries in the lateral decubitus position, our operative times are similar at 89 minutes in the TOE cohort in the beach chair position. This demonstrates that beach chair positioning can be comparable to lateral decubitus positioning with regard to operative time. The above study also found an increase in operative time as an increasing number of tendons was involved in the repair.

The present study has several limitations. First, the study is retrospective in nature. Second, the study was done at a teaching institution where the senior surgeon is assisted by residents and fellows at different stages in training. This may introduce some bias into the operative time depending on the level of training of the assistant. Finally, we are only able to comment on the 2 repair techniques performed by the senior surgeon and we are unable to compare matched cohorts receiving these 2 repairs to cohorts receiving other rotator cuff repair procedures.

However, this study has certain strengths as well. Primarily, all procedures were done by a single surgeon at the same institution, which limits technical biases as much as possible. Second, the study includes a large cohort of patients with a wide variety of pathology in terms of tear size and chronicity. Lastly, the study directly compared 2 knotless techniques for aRCR, which eliminates the variability of knot tying.

## Conclusion

When controlling for concomitant procedures, a knotless, TOE dual-row technique for aRCR adds an average of 8 minutes' operative time compared with a knotless SR technique. This was due to a significantly larger tear size in the TOE group. Age, sex, BMI, and involvement of the infraspinatus did not affect surgical time. This information may be helpful to the surgeon who wishes to determine the benefits of TOE repair techniques compared with SR techniques.

## Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

## References

1. Black EM, Austin LS, Narzikul A, Seidi AJ, Martens K, Lazarus MD. Comparison of implant cost and surgical time in arthroscopic transosseous and transosseous equivalent rotator cuff repair. J Shoulder Elbow Surg 2016;25:1449-56. https://doi.org/10.1016/j.jse.2016.01.003
2. Boyer P, Bouthors C, Delcourt T, Stewart O, Hamida F, Mylle G, et al. Arthroscopic double-row cuff repair with suture-bridging: a structural and functional comparison of two techniques. Knee Surg Sports Traumatol Arthrosc 2015;23:478-86. https://doi.org/10.1007/s00167-013-2401-7
3. Curry EJ, Logan C, Suslavich K, Whitlock K, Berkson E, Matzkin E. Factors impacting arthroscopic rotator cuff repair operational throughput time at an ambulatory care center. Orthop Rev (Pavia) 2018;10:75-7. https://doi.org/10.4081/or.2018.7577
4. Dukan R, Ledinot P, Donadio J, Boyer P. Arthroscopic rotator cuff repair with a knotless suture bridge technique: functional and radiological outcomes after a minimum follow-up of 5 years. Arthroscopy 2019;35:2003-11. https://doi.org/10.1016/j.arthro.2019.02.028
5. Hug K, Gerhardt C, Haneveld H, Scheibel M. Arthroscopic knotless-anchor rotator cuff repair: a clinical and radiological evaluation. Knee Surg Sports Traumatol Arthrosc 2015;23:2628-34. https://doi.org/10.1007/s00167-014-3026-1
6. Kim DH, Elattrache NS, Tibone JE, Jun BJ, DeLaMora SN, Kvitne RS, et al. Biomechanical comparison of a single-row versus double-row suture anchor technique for rotator cuff repair. Am J Sports Med 2006;34:407-14. https://doi.org/10.1177/0363546505281238
7. Kim KC, Shin HD, Lee WY. Repair integrity and functional outcomes after arthroscopic suture-bridge rotator cuff repair. J Bone Joint Surg Am 2012;94:e48. https://doi.org/10.2106/JBJS.K.00158
8. Lapner PL, Sabri E, Rakhra K, McRae S, Leiter J, Bell K, et al. A multicenter randomized controlled trial comparing single-row with double-row fixation in arthroscopic rotator cuff repair. J Bone Joint Surg Am 2012;94:1249-57. https://doi.org/10.2106/JBJS.K.00999
9. Ma CB, Comerford L, Wilson J, Puttlitz CM. Biomechanical evaluation of arthroscopic rotator cuff repairs: double-row compared with single-row fixation. J Bone Joint Surg Am 2006;88:403-10. https://doi.org/10.2106/JBJS.D.02887
10. Millett PJ, Espinoza C, Horan MP, Ho CP, Warth RJ, Dorman GJ, et al. Predictors of outcomes after arthroscopic transosseous equivalent rotator cuff repair in 155 cases: a propensity score weighted analysis of knotted and knotless self-reinforcing repair techniques at a minimum of 2 years. Arch Orthop Trauma Surg 2017;137:1399-408. https://doi.org/10.1007/s00402-017-2750-7
11. Slabaugh MA, Nho SJ, Grumet RC, Wilson JB, Seroyer ST, Frank RM, et al. Does the literature confirm superior clinical results in radiographically healed rotator cuffs after rotator cuff repair? Arthroscopy 2010;26:393-403. https://doi.org/10.1016/j.arthro.2009.07.023