Minimum 10-Year Outcomes After Arthroscopic Repair of Partial-Thickness Supraspinatus Rotator Cuff Tears

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Background: The prevalence of partial-thickness rotator cuff tears (PTRCTs) has been reported to be 13% to 40% within the adult population, accounting for 70% of all rotator cuff tears. Approximately 29% of PTRCTs will progress to full-thickness tears if left untreated. The long-term clinical course after arthroscopic repair of PTRCTs is not well known.

Purpose: To investigate minimum 10-year patient-reported outcomes (PROs) after arthroscopic rotator cuff repair (RCR) of the supraspinatus tendon and to report reoperation and complication rates.

Study Design: Case series; Level of evidence, 4.

Methods: Patients were included who underwent arthroscopic RCR of a PTRCT performed by a single surgeon between October 2005 and October 2011. Arthroscopic RCR was performed with a transtendon repair of partial, articular-sided supraspinatus tendon avulsions, bursal-sided repair, or conversion into a full-thickness tear and repair. PRO data were collected preoperatively and at a minimum 10 years postoperatively. PRO measures included the American Shoulder and Elbow Surgeons score, Single Assessment Numeric Evaluation score, the shortened version of Disabilities of the Arm, Shoulder and Hand score (QuickDASH), the 12-Item Short Form Health Survey Physical Component Summary, and patient satisfaction. Subanalyses were performed to determine if tear location or age was associated with outcomes. Retears, revision surgery, and surgical complications were recorded.

Results: In total, 33 patients (21 men, 12 women) at a mean age of 50 years (range, 23-68) met criteria for inclusion. Follow-up was obtained in 28 (87.5%) of the 32 eligible patients $\geq$10 years out from surgery (mean, 12 years; range, 10-15 years). Of the 33 PTCRTs, 21 were articular sided and 12 were bursal sided. Of the 33 patients, 26 underwent concomitant biceps tenodesis. At follow-up, the mean PROs were significantly improved when compared with preoperative levels: American Shoulder and Elbow Surgeons score from 67.3 to 93.7 ($P < .001$), Single Assessment Numeric Evaluation from 70.9 to 91.2 ($P = .004$), QuickDASH from 22.3 to 6.6 ($P < .004$), and 12-Item Short Form Health Survey Physical Component Summary from 44.8 to 54.2 ($P < .001$). Median postoperative satisfaction was 10 (range, 5-10). No patient underwent revision surgery.

Conclusion: Arthroscopic repair of PTRCTs results in excellent clinical outcomes and high patient satisfaction at minimum 10-year follow-up. Furthermore, the procedure is highly durable, with a clinical survivorship rate of 100% at 10 years.

Keywords: arthroscopic rotator cuff repair; partial rotator cuff repairs; minimum 10-year outcomes; shoulder surgery

Partial-thickness rotator cuff tears (PTRCTs) are detected in 13% to 40% of the adult population and in 70% of arthroscopically treated rotator cuff tears.[3,7,12] First-line treatment focuses on nonoperative therapy, including physical therapy, anti-inflammatory medication such as nonsteroidal anti-inflammatory drugs, and activity modification.[5,7,19,20] Even though nonoperative management is highly successful, approximately 29% to 40% of nonoperatively treated PTRCTs will increase to full-thickness rotator cuff tears.[6,9,10]

Since arthroscopic repair of PTRCTs was first reported 2 decades ago, it has become the preferred surgical treatment of symptomatic PTRCTs in the minority of patients whose nonoperative treatment fails.[7] PTRCTs can be classified by size (<50% or >50% tendon thickness) and location (articular, bursal, intratendinous).[5,7,15] Various surgical techniques have been established to treat differing tear patterns. These include completion of the tear with repair, in situ transtendinous repair (partial articular supraspinatus tendon avulsion [PASTA] bridge repair), single-layer repair (PASTA repair), or simple or bridging repairs of bursal-sided tears. Additionally, various suture configurations can be used (single vs double row, knotless vs knotted).[1,7,18,20] Although it has been speculated that completing the PTRCT could lead to distortions in the length and tension of the supraspinatus tendon, several studies have illustrated good to excellent short- to

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midterm clinical results for the arthroscopic repair of PTRCTs independent of surgical technique.[1,7,8,14,20] Arthroscopic repair of PTRCTs has been shown to be superior to debridement, with 6% to 34% of debrided PTRCTs converting to full-thickness tears.[1,20]

Reports of long-term clinical outcomes of partial rotator cuff repairs (RCRs) are scarce.[11] To our knowledge, there are currently no minimum 10-year outcome studies for arthroscopic repair of partial RCRs. The purpose of this study was to investigate prospective minimum 10-year outcomes, long-term survivorship, and failure rates after arthroscopic partial RCR of the supraspinatus tendon. Additionally, the study aimed to determine if tear pattern or patient age at surgery was associated with long-term clinical outcomes. It was hypothesized that patients undergoing arthroscopic repair of their PTRCTs would have persistent excellent clinical results with low failure rates at minimum 10-year follow-up and that these results would be independent of rupture morphology or age.

METHODS

This institutional review board–approved study (Vail Health Hospital 2021-109) was a retrospective review of prospectively collected data. PTRCT repair surgery was performed by a single surgeon (P.J.M.) between October 2005 and October 2011. Patients were eligible for inclusion if they had a partial-thickness tear (articular or bursal sided) of the supraspinatus tendon that was repaired arthroscopically and they were aged 18 to 70 years at the time of surgical intervention. Patients who previously refused to participate in research or died before final follow-up were excluded from analysis. Additional exclusion criteria were previous RCR of the supraspinatus tendon; glenohumeral osteoarthritis (Hamada grade >2); fatty infiltration (Goutallier >3); concomitant fractures of the shoulder girdle; or concomitant ipsilateral upper limb/shoulder pathology that led to additional procedures being performed other than subacromial decompression, biceps tenodesis, or limited debridement of the glenohumeral joint. Patient demographic, imaging, and surgical information was collected.

Surgical Technique

Partial rotator cuff tear surgical techniques have been described previously and are briefly detailed here.[20]

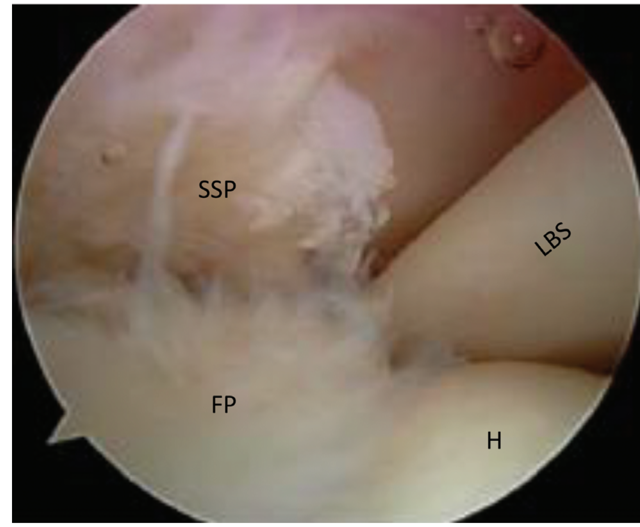

Figure 1. Articular-sided partial tear of the musculus supraspinatus (SSP) with the humeral head (H), long head biceps tendon (LBS), and footprint (FP) visible.

Surgical procedures were performed with the patient under general anesthesia with use of an adjuvant interscalene nerve blockade. The patient was placed in the beach-chair position with the operative extremity placed in a pneumatic arm holder (Tenet T-Max Beach Chair and Spider Arm Positioner; Smith & Nephew). Diagnostic arthroscopy was performed through a standard posterior viewing portal and anterior working portal (Figure 1).

After confirmation of the PTRCT, glenohumeral debridement and subacromial bursectomy were completed. Before RCR, a lateral acromioplasty was performed to create a Bigliani type 1 acromion if indicated. In case of a biceps reflection pulley lesion, biceps tendon degeneration, tenosynovitis, fraying, or a superior labrum anterior-to-posterior lesion, a tenotomy followed by subpectoral tenodesis of the biceps tendon was later performed as described by Pogorzelski et al.[13]

The size of the tear was measured during surgery by the senior surgeon (P.J.M.) with the help of a calibrated probe. The calibration was additionally used to measure the medial-to-lateral length of the supraspinatus footprint, from either the intra-articular side (for articular-sided tears) or the subacromial side (for bursal-sided tears).

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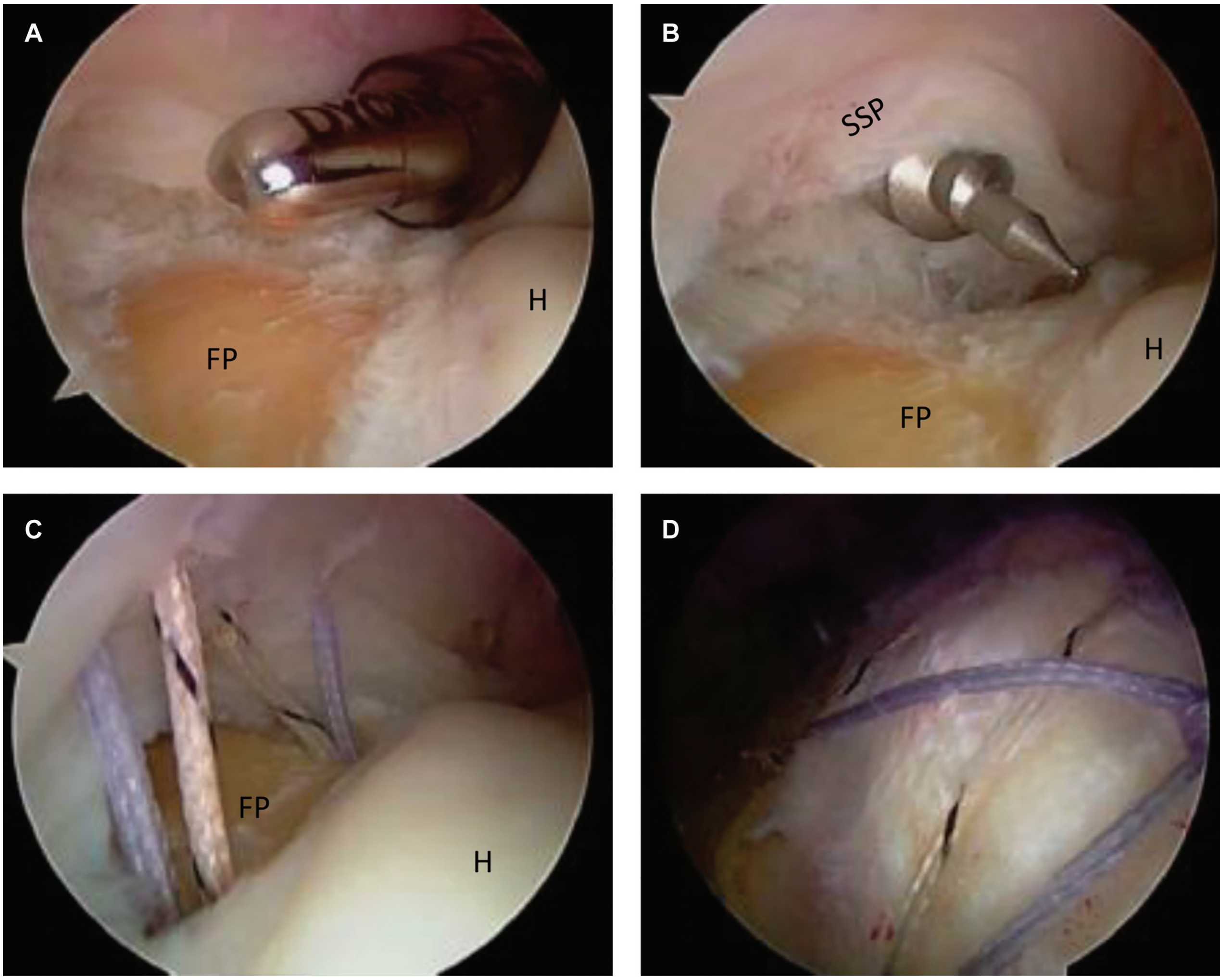

Figure 2. Arthroscopic repair of partial-thickness rotator cuff tear: (A) Preparation of supraspinatus (SSP) footprint (FP) after debridement. (B) Penetration of the SSP with an anchor. (C) Positioning the anchor in the anatomic FP. (D) Visualization of the completed arthroscopic transtendon suture bridge with an additional lateral row. H, humeral head.

The ratio of the tear size to the total length of the supraspinatus footprint was defined as tear expansion. The result, expressed as a percentage, was used for determining the optimal repair technique.

The partial-thickness tears of the supraspinatus tendon were localized with a spinal needle, and a No. 2 polydioxanone suture (Ethicon) was used to mark the location of the tear. The arthroscope was then repositioned in the subacromial space, and an anterolateral portal was established under direct visualization. The decision whether to complete the tear was made intraoperatively on the basis of structural findings: if the supraspinatus tendon integrity was mainly preserved and the tissue quality was sufficient without delamination, in situ repair (ie, transtendinous) was performed. However, if the tissue appeared insufficient and the collagen fiber structure appeared degenerated, torn, or disorganized, the tear was completed to remove all damaged tissue and then repaired. For tears involving <75% tendon thickness and a width <1 cm in the anteroposterior direction, repairs were performed with a single anchor (Arthrex). For tears >75% thickness and >1 cm in width or those that were completed and repaired, a double-row repair construct was used.

For bursal-sided tears, a bridge-type repair was performed with sutures or suture tape and threaded suture anchors. For articular-sided tears, the sutures were shuttled through the rotator cuff from the subacromial to intra-articular side in a similar fashion to the bursal-sided tears; however, the suture anchor was placed intra-articularly at the cartilage-bone interface through a mini-split of the supraspinatus tendon. The partial repair technique is illustrated in Figure 2.

Postoperative Rehabilitation

Postoperatively, patients were immobilized in a sling with an abduction pillow for 4 to 6 weeks. Full passive range of motion and pendulum exercises were allowed immediately after surgery. Active and active-assisted range of motion was allowed starting at 4 to 6 weeks, whereas strengthening exercises were restricted until ≥6 weeks. Full unrestricted activities were typically permitted between 12 and 16 weeks postoperatively. Clearance for progression through rehabilitation phases was based on progress with physical therapy, patient factors, and intraoperative assessment of tissue quality and repair strength.

Patient-Reported Outcomes

Minimum 10-year follow-up was obtained via electronic questionnaire and compared with preoperatively collected patient-reported outcome (PRO) scores. Shoulder-specific PROs included the American Shoulder and Elbow Surgeons (ASES) score, Single Assessment Numeric Evaluation (SANE) score, and the shortened version of Disabilities of the Arm, Shoulder and Hand (QuickDASH) score. General patient health was assessed with the Physical Component Summary of the 12-Item Short Form Health Survey questionnaire. Patient satisfaction with surgical outcomes was also assessed (1-10; 10 = highly satisfied). Complications and further surgical interventions were recorded. PROs available in the institutional database at 2 and 5 years postoperatively were included to illustrate progression. If patients had not returned their prospectively administered annual questionnaires after 10 years, they were contacted regarding elective participation in the study. PRO collection was performed only via electronic questionnaire to limit respondent bias. Further questions were asked regarding additional surgery, return to activity, and reasons for activity modification. Failure was defined as revision RCR surgery or conversion to shoulder arthroplasty.

Statistical Analysis

For normally distributed variables, an independent or paired *t* test was used. For nonparametric data, the Mann-Whitney or Kruskal-Wallis test was performed. The pre- and postoperative scores of each patient were compared with a Wilcoxon signed-rank test. The Spearman rank correlation test was used for nonparametric continuous data. Categorical data are presented as numbers with percentages, and normally distributed continuous data as mean and standard deviation. Continuous data that were not normally distributed are presented as mean with range. Failure was defined as progression to revision surgery for a repeat rotator cuff tear or conversion to shoulder arthroplasty. The level of significance was set at $P < .05$. Statistical analysis was performed with SPSS Version 11.0 (IBM). Spearman rho correlation was used to determine the correlation of age and outcomes, and the Mann-Whitney *U* test was used to determine the association of tear location (bursal or articular sided) and outcomes.

Statistical power was considered given the fixed available sample size. Based on an alpha level of .05 and nonparametric 2-tailed hypothesis testing, a sample of 28 patients with 10-year follow-up was sufficient to detect an effect size of 0.48 (rho) for correlations between continuous variables and an effect size of 1.18 (Cohen *d*) for between-group mean differences ($n_1 = 10$ and $n_2 = 18$) with 80% statistical power. Associations more subtle than these effect sizes cannot be ruled out by the current study.

RESULTS

A search of the institutional database revealed 121 patients with an arthroscopic repair of a PTRCT performed by a single surgeon between October 2005 and October 2011. Of these, 62 patients were excluded for a nonisolated tear with additional concomitant procedures. Application of further exclusion criteria left a final study population of 33 patients (21 men, 12 women) with a mean age of 50 years (range, 23-68 years) at the time of surgery. No patients underwent revision RCR or conversion to shoulder arthroplasty. One patient unfortunately died during the study time frame and was unavailable for follow-up. Minimum 10-year follow-up was obtained in 28 of 32 shoulders (87.5%). Patient selection is illustrated in Figure 3.

The patient cohort consisted of 9 (27.3%) with an identified traumatic incident and 2 (6.1%) being treated under workers' compensation. Symptoms reported on preoperative shoulder questionnaires included pain in 28 (84.4%), weakness in 15 (45.4%), and loss of function in 13 (39.4%).

Of the 33 PTRCTs in the final cohort, 21 (63.6%) were articular sided and 12 (36.4%) bursal sided. The majority of PTRCT repairs were performed in situ (28 patients, 84.8%), whereas 5 (15.2%) involved completion of the tear before the repair. Of the 33 patients, 26 (78.8%) underwent biceps tenodesis. All repairs were 1-tendon repairs involving the supraspinatus tendon. Surgical and patient demographic information is summarized in Table 1.

Clinical Outcomes

At minimum 10-year follow-up (mean, 12 years; range, 10-15 years), all PRO scores demonstrated significant improvements from baseline preoperative scores ($P < .005$). Table 2 illustrates pre- and postoperative PRO scores. When evaluated at postoperative 2 and 5 years, shoulder-specific PROs showed significant improvement at 2-year follow-up, which was maintained through final follow-up at a minimum 10 years (Figure 4). No shoulder-specific PROs changed significantly between the 2- and 5-year or 5- and 10-year time points. Median satisfaction was 10 (range 5-10), indicating "very satisfied" with the postoperative outcome. Spearman rank correlation demonstrated no correlation of patient age at surgery and postoperative PROs (Table 3). Mann-Whitney *U* testing revealed no association of tear location (bursal vs articular side) and postoperative PROs (Table 4).

Return to Activity

Of the total, 27 patients responded to the additional questions regarding return to activity, with 2 indicating "not applicable." Of the remaining patients, the majority (18/25;

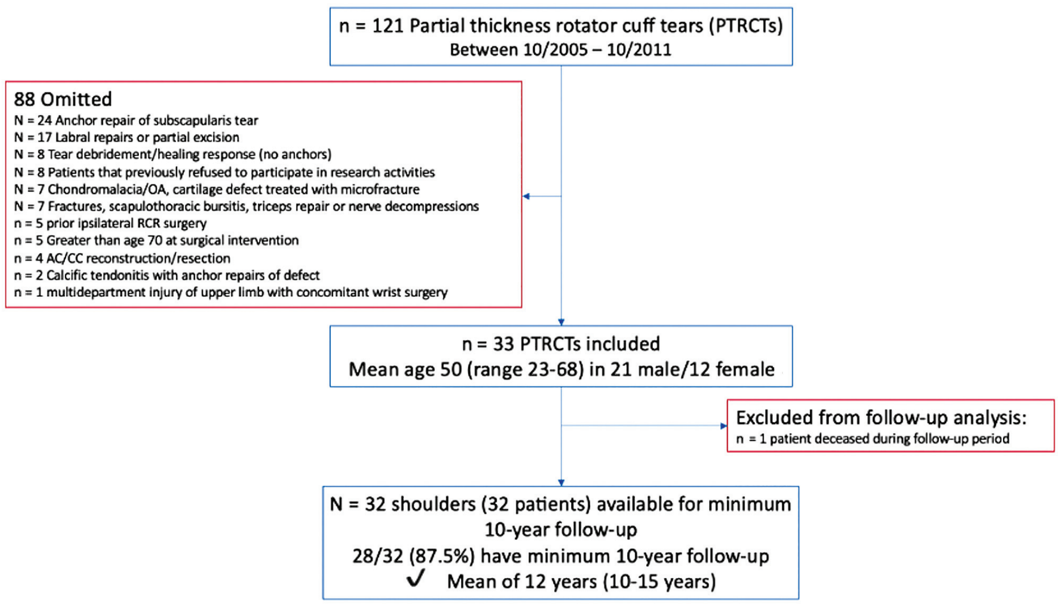

Figure 3. Patient selection and demographics of the study population. AC, acromioclavicular; CC, coracoclavicular; OA, osteoarthritis; RCR, rotator cuff repair.

TABLE 1
Patient Demographic and Surgical Information (33 Patients)[a]

Characteristic	No.
Age at surgery, y	50 ± 11.3 (23-68)[b]
Sex: male	21
Tear side	
Articular	21
Bursal	12
Repair	
In situ	28
Completed tear	5
Subacromial decompression	33
Biceps tenodesis	26

[a]Concomitant procedures not listed in exclusion criteria were subacromial decompression and biceps tenodesis.
[b]Mean ± SD (range).

TABLE 2
Patient-Reported Outcome Scores[a]

Outcome	Preoperative	Postoperative 10 y	*P* Value
ASES	67.3 ± 18.1	93.7 ± 10.5	<.001
SANE	70.9 ± 19.0	91.2 ± 10.9	<.004
QuickDASH	22.3 ± 17.5	6.6 ± 7.6	<.004
SF-12 PCS	44.8 ± 8.0	54.2 ± 9.7	<.001

[a]Data are presented as mean ± SD. ASES, American Shoulder and Elbow Surgeons; PCS, Physical Component Summary; QuickDASH, shortened version of the Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12, 12-Item Short Form Health Survey.

TABLE 3
Spearman Rho Correlation and *P* Values Between Patient Age and Outcome[a]

Outcome	Spearman Rho	*P* Value
ASES	0.043	.8
SANE	0.082	.6
QuickDASH	0.015	.9
SF-12 PCS	0.227	.2

[a]Significance was set at $P < .05$. ASES, American Shoulder and Elbow Surgeons; PCS, Physical Component Summary; QuickDASH, shortened version of the Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12, 12-Item Short Form Health Survey.

TABLE 4
Mann-Whitney *U* Test *P* Values for Association Between Tear Locations (Articular vs Bursal Side)[a]

Outcome	*P* Value
ASES	.057
SANE	.386
QuickDASH	.369
SF-12 PCS	.919

[a]Significance was set at $P < .05$. ASES, American Shoulder and Elbow Surgeons; PCS, Physical Component Summary; QuickDASH, shortened version of the Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12, 12-Item Short Form Health Survey.

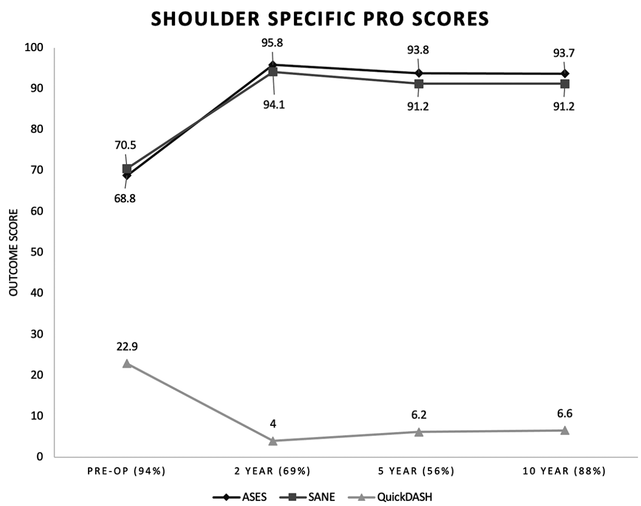

Figure 4. Shoulder-specific patient-reported outcome (PRO) progression over time, preoperatively to 2, 5, and ≥10 years postoperatively. ASES, American Shoulder and Elbow Surgeons; Pre-op, preoperatively; QuickDASH, shortened version of the Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation.

72%) were able to return fully to their original fitness programs. Six patients (24%) reported returning "somewhat" to their programs, and 1 (4%) did not return. The most common reasons for modifying activity after surgery included pain (n = 4), fear of reinjury (n = 4), feelings of instability (n = 4), weakness (n = 3), and lifestyle changes (n = 3).

Failures and Complications

One patient underwent revision surgery for adhesive capsulitis at 3 months postoperatively. The rotator cuff was intact at the time of revision surgery, and no revision repair was needed. None of the patients underwent revision RCR surgery or conversion to shoulder arthroplasty.

DISCUSSION

The most important finding of this study is excellent long-term clinical results after arthroscopic partial-thickness RCR surgery with a mean follow-up of 12 years. Moreover, the durability of the procedure is illustrated with a survival rate of 100% at 10 years and only 1 complication, involving adhesive capsulitis that necessitated subsequent surgery. In this series, the PROs were significantly improved at the time of final follow-up, and retroactive review of 2- and 5-year follow-up data revealed no statistically significant deterioration of PROs at the time of final follow-up. Furthermore, there were no symptomatic retears in the cohort. Notably, there was a high rate of concomitant biceps tendon pathology, which was treated with an open subpectoral biceps tenodesis in nearly 80% of patients and therefore may have contributed to the demonstrated clinical improvement.

Although short- and midterm outcomes of arthroscopic repair of PTRCTs are sufficiently described in the current literature, long-term results are scarce.[1,2,14,20] Short- and midterm studies have demonstrated excellent clinical outcomes of the procedure. At a minimum follow-up of 24 months, Chung et al[2] reported an improved University of California, Los Angeles, score (18.00 ± 2.82 to 27.12 ± 2.54) and ASES score (44.45 ± 14.73 to 90.58 ± 11.09) for high-grade PTRCTs, and Deutsch[4] showed an increased ASES score from 42 preoperatively to 93 postoperatively ($P < .001$).

Midterm studies have shown similar results, with a minimum 5-year study by Vap et al[20] reporting an increased ASES score of 60 to 97 ($P = .016$), a decreased QuickDASH score from 27 to 7 ($P = .035$), and a median postoperative satisfaction of 10. To our knowledge, the longest follow-up reported for arthroscopic RCR of PTRCTs is a minimum 8-year follow-up study by Rossi et al.[14] This study found statistically significant improvements in long-term PROs as compared with preoperative scores; however, the postoperative mean ASES score of 85.1 ± 5 is slightly inferior to the results for shorter-term studies.[14,20] As in the Rossi et al cohort, no patients in our study had symptomatic retears after PTRCT repair, yet neither study included imaging at the time of final follow-up.[14] This may be attributed to the durability of their repair, or in the event that a retear occurs, it is asymptomatic.

Regarding return to sport/activity, the majority of patients in the current cohort were able to return at some level to their previous fitness programs, with 72% returning to their original levels of activity. Only 1 patient (4%) was unable participate in the previous fitness program at long-term follow-up. This is in line with the minimum 5-year results of Vap et al[20] (94% return to activity, 76% at previous level) and minimum 8-year results of Rossi et al[14] (87% returned to sport, 80% at previous level).

The excellent clinical outcomes and high survivorship of the current cohort question the need for patch augmentation in PTRCTs. Various resorbable and nonresorbable patches have recently gained interest for use in the operative treatment of PTRCTs. Schlegel et al[16,17] reported promising 2-year results of a resorbable bovine collagen implant in high- and intermediate-grade PTRCTs. The study group reported successful outcomes, with an increased mean ASES score from 60.9 to 92.8 for high-grade PTRCTs and 52.5 to 95.3 for intermediate-grade tears.[16] However, considering the additional anchors and longer operative time needed to affix patches, it may be favorable to forgo augmentation if similar short- to long-term clinical outcomes can be obtained with current repair techniques. Further randomized prospective level 1 studies comparing patch augmentation with control are needed.

As in the studies of Rossi et al[14] and Vap et al,[20] the present study did not reveal an association between tear location (bursal vs articular sided) and clinical outcome. This is in line with a systematic review of outcome studies for high-grade partial tears (>50%), which found bursal-sided tears to have inferior outcomes only if isolated debridement was performed.[7] However, given the lower incidence of bursal-sided tears, higher patient numbers in multicentric settings are needed to verify these monocentric studies. Regarding age, the present study did not show a correlation between patient age and clinical outcomes. This finding is supported by the midterm outcome study by Vap et al. Although physiologic age and tendon quality should be considered in preoperative decision-making, the present results suggest that increased age should not be a contraindication for arthroscopic PTRCT repair.

Limitations

This study has several limitations to consider when interpreting the data. Because of the strict inclusion criteria, the final patient population included 33 patients (28 with follow-up), which limits the ability to perform a robust statistical comparison of factors such as age and tear location in relation to clinical outcomes. An additional 8 potentially eligible patients refused to participate in research, and their outcome is unknown. However, the current cohort is sizable enough to glean valuable data, especially considering the minimum 10-year follow-up. Additionally, no structural imaging findings at final follow-up were included in this study, which prevented the identification of asymptomatic retears. Therefore, it is possible that a retear did occur despite high PROs and patient satisfaction. Another limitation is that QuickDASH and SANE scores were not included in early shoulder questionnaires, so not all patients had preoperative scores. Next, 26 of 33 patients received biceps tenodesis, a procedure that could confound the results. Yet, biceps pathology has often been seen in association with PTRCTs, and it may be a contributing factor to rotator cuff pathology. Finally, all surgical procedures were performed by a single surgeon with extensive experience with arthroscopic RCR surgery, so caution should be taken with generalizing the results.

CONCLUSION

Arthroscopic repair of PTRCTs results in excellent clinical outcomes and high patient satisfaction at minimum 10-year follow-up. Furthermore, the procedure is highly durable, with a clinical survivorship rate of 100% at 10 years.

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