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Patient-reported outcomes of arthroscopic repair for partial or full-thickness upper third subscapularis tendon tears with open sub-pectoral biceps tenodesis: minimum 10-year outcomes

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Background: Although short-term results are promising, there are limited data for long-term results of arthroscopic subscapularis (SSC) repair. The purpose of this study is to report minimum 10-year outcomes of primary arthroscopic repair of isolated partial or full-thickness tears of the upper third of the SSC tendon.

Methods: Patients who underwent arthroscopic repair of isolated upper third SSC tears, Lafosse type I (>50% of tendon thickness) or type II were included. Surgeries were performed by a single surgeon between November 2005 and August 2011. Patient-reported outcome measures were prospectively collected and retrospectively reviewed at minimum follow-up of 10 years. Patient-reported outcomes utilized included the American Shoulder and Elbow Surgeons score, Single Assessment Numeric Evaluation score (SANE), Quick Disabilities of the Arm, Shoulder and Hand score (QuickDASH), the Short Form 12 physical component summary, return to activity, and patient satisfaction. A subanalysis of patient age and outcomes was performed. Retears, revision surgeries, and surgical complications were recorded.

Results: In total, 29 patients with isolated upper third SSC repairs were identified. After application of exclusion criteria, 14 patients were included in the final analysis. Follow-up could be obtained from 11 patients. The mean age at surgery was 52.7 years (range: 36-72) and the mean follow-up was 12 years (range 10-15 years). The American Shoulder and Elbow Surgeons score improved from 52.9 ± 21.8 preoperatively to 92.2 ± 13.7 postoperatively ($P < .001$). Regarding the SANE and QuickDASH scores, only postoperative data were available. Mean postoperative SANE, QuickDASH, and Short Form 12 physical component summary scores were 90.27 ± 10.5, 14.6 ± 15.5, and 49.2 ± 6.6, respectively. Median patient satisfaction was 10 (range 6-10). Patients reported improvements in sleep, activities of daily living, and sports. There was no correlation between patient age and clinical outcome ($P > .05$). No

The Vail Health Hospital Institutional Review Board approved this study (protocol 2021-103).
Research performed at the Steadman Philippon Research Institute, Vail, CO, USA.

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patients underwent revision surgery for a SSC retear.

Conclusion: Arthroscopic repair of upper third SSC tendon tears leads to improved clinical scores and high patient satisfaction at minimum 10-year follow-up. The procedure is durable, with no failures in the presented cohort.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Subscapularis; rotator cuff tear; rotator cuff repair; clinical outcomes; arthroscopic rotator cuff repair; shoulder arthroscopy

The subscapularis (SSC) is the largest, most powerful, and most anterior of the rotator cuff muscles. The integrity of the SSC muscle and tendon is crucial to balance the forces of the rotator cuff and for dynamic anterior glenohumeral stability.[6,15,16,26,29] Isolated SSC tears are rare and often overlooked injuries, with a prevalence of only 4% of all rotator cuff tears (RCTs).[8] Although isolated tears are uncommon, approximately 50% of RCTs show concomitant SSC lesions based on preoperative magnetic resonance imagings and intraoperative assessments.[18] The etiology of SSC tears can be atraumatic, often accompanied by subcoracoid impingement, or traumatic, involving forced hyperextension or external rotation of the abducted arm.[9,19,23] SSC tears can be classified by location (upper 1/3, upper 2/3, or entire tendon footprint) and extent (partial vs. complete thickness) according to the Lafosse and the Fox and Romeo classification systems.[10,18]

The loss of active internal rotation that occurs with SSC tears results in a deficient transverse force couple, which can ultimately lead to glenohumeral instability. Conservative management is often unsuccessful, and surgical treatment is typically necessary for active patients.[26,28] Early reports of repairs using open surgical approaches showed successful clinical outcomes.[2,12] Further advancements were made with the introduction of arthroscopic refixation, described by Burkhart et al 2 decades ago.[5,11,24] Several study groups have reported preliminary and short-term outcomes after arthroscopic SSC repair with similar clinical outcomes compared to the open approaches.[1,15,18,21,25] Described surgical techniques involve 1 or 2 anchor refixation using a modified Mason-Allen, mattress, or knotless configuration, with most cases addressing the long head biceps (LHB) tendon with tenotomy or tenodesis.[1,3,18,21,25] In a systematic review of 8 short-term follow-up studies, Saltzman et al reported satisfactory clinical results for arthroscopic repair of the SSC with no differences between the surgical technique (single vs. double row).[25]

Although short-term results are promising, there is limited data for long-term results of arthroscopic SSC repair. The purpose of this study is to report minimum 10-year outcomes of primary arthroscopic repair of partial or full-thickness tears of the upper third of the SSC tendon. It was hypothesized that the 1 anchor SSC repair would result in satisfactory clinical outcomes, high patient satisfaction, and low revision rates at long-term follow-up.

Methods

This institutional review board approved study (V.H.H. #2021-103) was a retrospective review of prospectively collected data. SSC surgeries were performed by a single surgeon (P.J.M.) between November 2005 and August 2011. Patients were eligible for inclusion if they had an isolated partial (Lafosse type I) or full-thickness tear of the upper third (Lafosse type II) SSC which was repaired arthroscopically with a single anchor and were a minimum of 10 years out from surgery. As previously described with regards to the anatomic extensions of the SSC footprint,[7] the upper third was defined as the superior 1 cm of the tendon. Partial-thickness tears were repaired if they involved more than 50% of the tendon thickness and additionally 5 mm or more of the tendon's upper third. The term "isolated" was defined as repair of the SSC tendon only, with no additional repair or reconstructive procedures, other than LHB tenodesis. Thus, patients with concomitant repair of the supraspinatus/infraspinatus tendon were excluded from the study population. Additional exclusion criteria were grade 4 cartilage lesions, previous refusal to participate in research or death before the time of final follow-up. Patient demographic, imaging, and surgical information was collected.

Surgical technique

The surgical technique has been described previously by Katthagen et al.[15] Operations were performed with the patients positioned in the beach chair position. Diagnostic arthroscopy was performed using standard posterior viewing and anterior working portals in the rotator interval. Once SSC pathology was identified (Fig. 1), a 70° arthroscope was used to visualize the SSC tendon and the lesser tuberosity from over the top of the humeral head. At this point, subcoracoid soft tissue decompression was performed. An additional osseous coracoplasty was performed as previously described[4] if the coracohumeral distance was narrowed (<10 mm in men; <8 mm in women). For SSC repairs, a knotted technique was used early in the study period and a knotless technique was used for more recent repairs.

For the knotted repair technique, a double-loaded bioabsorbable anchor (5.5 Bio Corkscrew anchor; Arthrex, Naples, FL, USA) was placed in the exposed footprint area (Fig. 2, *A*). Next, the upper third of the SSC was perforated with a spinal needle and No. 1 polydioxanone suture (PDS; Ethicon US, Somerville, NJ, USA) (Fig. 2, *B*), and a passing technique was used to shuttle the 2 high-strength No. 2 sutures through the tendon (Fig. 2, *C*). The SSC was secured down to its anatomic footprint using sliding locking Weston knots (Fig. 2, *D*). The arm was then taken through range of motion to confirm a stable repair.

For the knotless repair technique, a percutaneous spinal needle was inserted through the upper third of the SSC and a PDS was shuttled out through the anterior-superior portal. Suture tape (FiberTape; Arthrex) was then passed through the torn SSC. Next, a 4.75-mm tap was used to make a hole in the exposed anatomic SSC footprint. The suture tape was passed through a bioabsorbable anchor (4.75 Bio SwiveLock; Arthrex). This was placed into the bone socket and the SSC was repaired.

Concomitant pathologies were addressed with débridement and/or decompression. In all cases in which the LHB was present, it was released prior to repairing the SSC, and an open subpectoral biceps tenodesis was performed after the repair of the SSC with a subpectoral approach. Per exclusion criteria, no additional repair or reconstructive procedures were performed in the study cohort.

Postoperative rehabilitation

Postoperatively, surgically treated shoulders were immobilized in a sling with an abduction pillow for 4 to 6 weeks to protect the repair. Full passive range of motion and pendulum exercises were permitted immediately following surgery, whereas active and active-assisted motion was initiated between 4 and 6 weeks after surgery. Shoulder strengthening was delayed until at least 6 weeks after surgery depending on factors such as tissue quality and physiologic patient age. Forced external and internal rotation was avoided for 8 to 12 weeks. Full unrestricted return to activity was typically permitted between 12 and 16 weeks, postoperatively.

Patient-reported outcomes

Minimum 10-year follow-up was obtained via electronic questionnaire and compared to preoperatively collected patient-reported outcome (PRO) scores. Shoulder-specific PROs collected included the American Shoulder and Elbow Surgeons (ASES) score, Single Assessment Numerical Evaluation (SANE) score, and Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score. General patient health was assessed with the physical (PCS) component score of the 12-item Short Form (SF-12) questionnaire. Patient satisfaction with surgical outcomes was also assessed (scale 1-10, 10 = highly satisfied). Additional questions were asked regarding the level of pain associated with recreational activities, activities of daily living (ADLs), and work. Responses to pain-related questions were quantified as none (0), mild (1), moderate (2), or severe (3) and are illustrated as median (50th percentile) and ranges (25th percentile and 75th percentile). Patients were also asked questions regarding reasons for activity modification and the need for additional surgeries. Responses to activity-related questions were quantified as unable (0), very difficult (1), somewhat difficult (2), or normal (3) and are illustrated as median (50th percentile) and ranges (25th percentile and 75th percentile).

Complications and further surgical interventions were recorded. Failure was defined as revision SSC repair or conversion to reverse total shoulder arthroplasty (RTSA) for a symptomatic SSC retear.

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 via electronic questionnaire only to limit response bias.

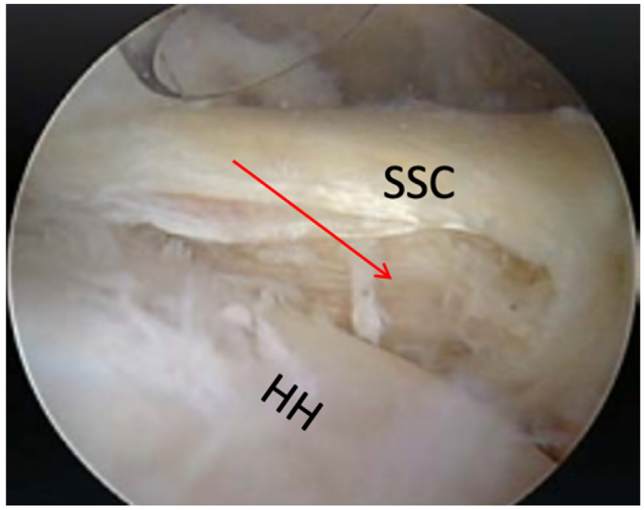

Figure 1 Intraoperative posterior view of a Lafosse I subscapularis (SSC) tendon tear (➔) in relation to the humeral head (HH).

Given the small sample size, the number of possible analyses on factors at baseline that were potentially associated with the postoperative outcome were limited. As such, workers compensation status and tear type (partial, full-thickness) were taken forward towards bivariate analysis.

Statistical analysis

Statistical analysis was performed with SPSS version 11.0 (IBM, Armonk, NY, USA). Categorical data are presented as number and percentages and continuous data as mean ± standard deviation. An independent or paired *t*-test was used for univariate analysis for normally distributed variables. For nonparametric data, the Mann-Whitney or Kruskal-Wallis tests were performed. Spearman rank correlation was used to determine the relationship between age and clinical outcome.

Results

An institutional database review of patients treated by a single senior surgeon between November 2005 and August 2011 identified 29 patients with an isolated full or partial-thickness tear of the upper third of the SSC repaired arthroscopically. Eleven patient shoulders were excluded because their SSC repair involved more than the upper third, were treated with 2 or more anchors or were treated solely with débridement, healing response, and a biceps tenodesis alone. After application of further exclusion criteria, this left a final study population of 14 patients (12 males, 2 females) with a mean age at time of surgery of 52.7 years (range, 36-72). One patient underwent revision surgery (see below). Follow-up was obtained for 11 of the 13 remaining patient shoulders (84.6%) at a mean of 12 years (range: 10-15). Patient selection and demographics are illustrated in Figure 3 and Table I.

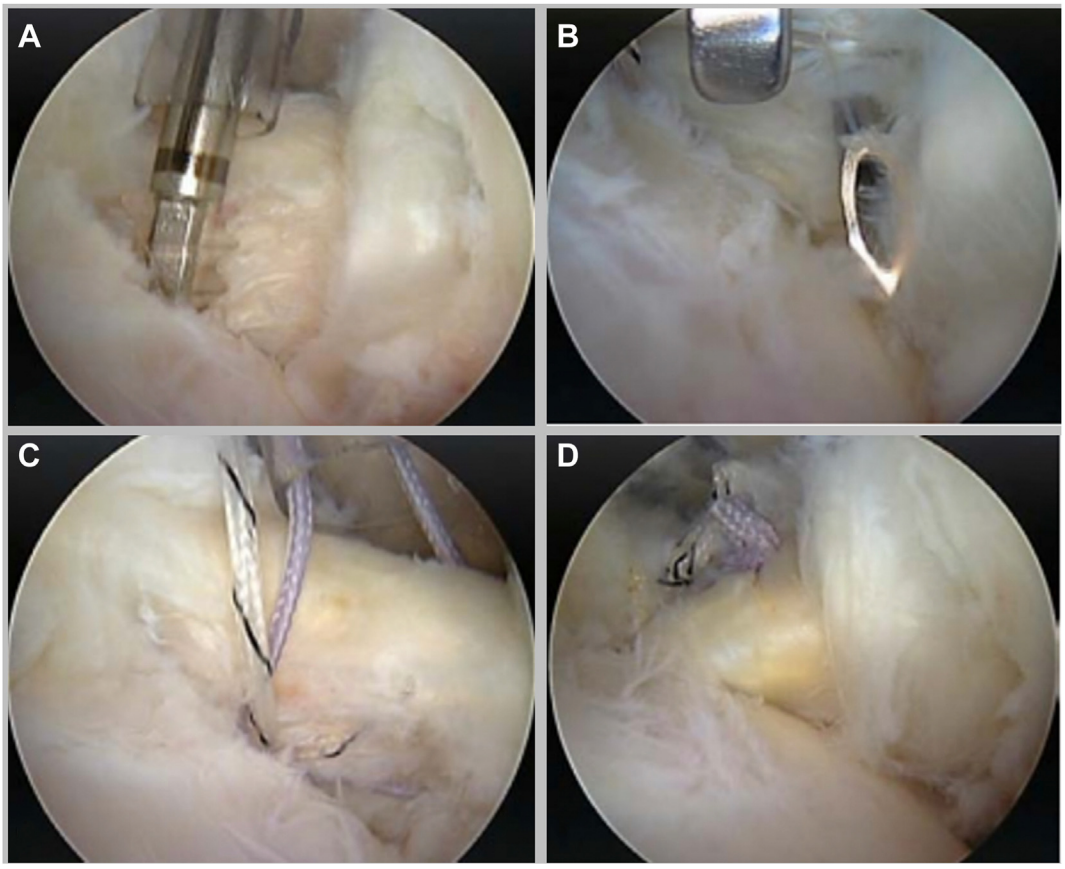

Figure 2 Intraoperative view via a posterior portal of the repair of a Lafosse I subscapularis (SSC) tendon tear. For the earlier knotted repair technique, a double-loaded bioabsorbable anchor (5.5 Bio Corkscrew anchor; Arthrex, Naples, FL, USA) was placed in the exposed footprint area (**A**). Next, the upper-third of the SSC was perforated with a spinal needle (**B**) and No. 1 polydioxanone suture (PDS; Ethicon US, Somerville, NJ, USA) and a passing technique was used to shuttle the 2 high-strength No. 2 sutures through the tendon (**C**). The SSC was secured down to its anatomic footprint using sliding locking Weston knots (**D**).

In 2 cases (14.2%) a traumatic incident was reported as the initial cause of the SSC tear, with the remaining cases reporting an insidious onset. Five patients (35.7%) were treated under a worker's compensation claim. Eight patients (57.1%) had a partial tear of the upper third of the SSC and 6 patients (42.9%) had a full-thickness tear. Surgical findings and procedures are summarized in Table I. Notably, in 2 cases the LHB spontaneously ruptured prior to surgery.

Clinical outcomes

Details on each patients included into the outcome analysis are provided in Supplementary Table S1. Table II summarizes the PRO scores at a minimum 10-year (mean: 12 years, range: 10-15 years) follow-up. The mean ASES and SF-12 scores were significantly improved at minimum 10-year follow-up compared to preoperatively ($P = .001$, $P = .004$, respectively). The median satisfaction was 10 (range 6-10), indicating "very satisfied with the operative outcome." For this patient cohort, there was no correlation between age at time of surgery and clinical outcome (Table III). The postoperative SF12-PCS was significantly lower in patients with a workers compensation claim compared to patients without workers compensation claims (SF12-PCS 53.8 ± 5.2 vs. 40.9 ± 1.8, $P = .044^{*}$), whereas there was no significant difference in any of the other clinical outcome scores; details are provided in Supplementary Table S2. There was no statistically significant difference in any of the outcomes scores depending on the tear type (partial thickness vs. full-thickness); details are provided in Supplementary Table S3.

Preoperatively, patients reported moderate to severe pain with ADL (median 2.5 out of 3, range 2-3). Postoperatively, this improved to an average score of 0 out of 3 (range 0-2), indicating no pain with ADL ($P = .004$). Preoperatively, pain with sleep was affected severely (median 3, range: 2.75-3) which significantly improved at follow-up (median 0, range: 0-1) ($P = .006$). Regarding pain with work, the average pain preoperatively was rated as moderate (median 2, range: 2-2) and postoperatively as no pain (median 0, range:0-1) ($P = .005$). All patients reported severe pain preoperatively with recreational activities (median 3, range: 3-3). This

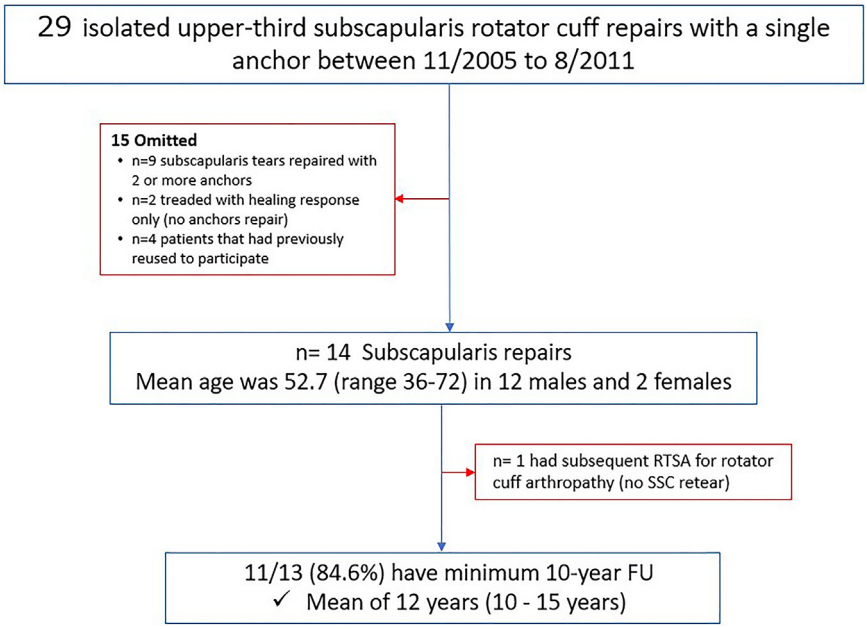

Figure 3 Patient selection and demographics of the study population.

Table I Surgical findings and procedures

Characteristic	
Partial-thickness tear of the upper third SSC	8/14
Full-thickness tear of the upper third SSC	6/14
Knotted 1 anchor repair	10/14
Knotless 1 anchor repair	4/14
Subacromial decompression	14/14
Biceps tenodesis	12/14
Biceps tenotomy	2/14

SSC, subscapularis.
The reported concomitant procedures (subacromial decompression, biceps tenodesis/tenotomy) were not part of the exclusion criteria.

Table II Patient-reported outcome scores, reported as mean ± standard deviation

Outcome	Preoperative	Postoperative	*P* value
ASES score	54.3 ± 16.2	92.2 ± 13.7	**.001**
SANE score*		90.3 ± 10.5	
QuickDASH*		14.6 ± 15.5	
SF-12 PCS	39.4 ± 7.1	49.2 ± 6.6	**.004**

ASES, American Shoulder and Elbow Surgeons; *SANE*, Single Assessment Numeric Evaluation form; *QuickDASH*, Quick Disabilities of the Arm, Shoulder and Hand; *SF-12 PCS*, Short Form 12 physical component summary.
* Preoperative scores for SANE and QuickDASH were not available for the majority of patients, so only postoperative scores are reported.
Bold values are statistically significant.

improved to a median of 1 (range: 0-1) indicating mild pain postoperatively ($P = .004$). Table IV summarizes the preoperative and postoperative responses for pain questionnaires, and Table V summarizes the responses for additional questions on sports, recreational activities, and daily activities.

Failure and survivorship

The presented cohort demonstrated a 100% survivorship rate maintained at 10 years. There were no revision SSC repairs or conversions to RTSA due to a symptomatic SSC retear. Additionally, no revision surgery for failure of the biceps tenodesis has been reported. One patient did undergo a conversion to RTSA for a RCT that did not involve the SSC tendon. This male patient, aged 64 at time of index surgery, had a partial-thickness SSC tear repaired with 1 anchor. Additionally, the patient had a SLAP tear and partial-thickness supraspinatus tear which were débrided during the index surgery. The patient later developed a traumatic massive rotator cuff tear of the supraspinatus and infraspinatus tendons with associated RCT arthropathy. He subsequently underwent an RTSA at 9 years postindex procedure. The SSC tendon was confirmed to be intact at the time of RTSA.

Discussion

The most important findings of this study are the excellent subjective functional outcomes, high PRO's, high patient satisfaction, and a 100% survivorship rate at minimum 10-year follow-up after arthroscopic SSC repair utilizing 1 anchor. Additionally, a significant decrease in pain and an increase in functional ability with ADL and recreational sports/activities were demonstrated at long-term follow-up.

Table III Spearman correlation (Rho) and *P* values between patient age and postoperative patient-reported outcomes demonstrating no correlation of patient age and clinical outcome ($P > .05$)

Outcome and age	Spearman rho correlation	*P* value
ASES score	−0.006	1.0
SANE score	0.078	.821
QuickDASH	0.233	.491
SF-12 PCS	−0.006	1.0

ASES, American Shoulder and Elbow Surgeons; *SANE*, Single Assessment Numeric Evaluation form; *QuickDASH*, Quick Disabilities of the Arm, Shoulder and Hand; *SF-12 PCS*, Short Form 12 physical component summary.

Table IV Responses to questions regarding pain during activities of daily living, sleep, work, and recreational activities

Activity pain	Preoperatively	Postoperatively	*P* value
ADL	2.5 (range 2-3)	0 (range 0-2)	**.004**
Sleep	3 (range 2.75-3)	0 (range 0-1)	**.006**
Work	2 (range 2-2)	0 (range 0-1)	**.005**
Recreational activities	3 (range 3-3)	1 (range 0-1)	**.004**

ADL, activities of daily living.
The pain scores were graded as: severe (3), moderate (2), mild (1), or none (0). Median scores and ranges are reported. All listed activities except toileting showed significant improvement postoperatively ($P \leq .05$).
Bold values are statistically significant.

The current literature on outcomes after arthroscopic isolated SSC repair with 1 anchor and an open subpectoral biceps tenodesis is scarce, with the majority of studies reporting short-term follow-up. Furthermore, differences in repair techniques and tear patterns in previous studies limit the comparability of their results. Kamijo et al reported minimum 2-year results for arthroscopic SSC repair using a single anchor repair or suture bridge procedure in 46 patients. The patient cohort showed improved clinical outcomes, with an increase in the mean ASES score from 56 ± 12 preoperatively to 89 ± 12 postoperatively.[14] The study looked at both small (Lafosse type I-III) and large (Lafosse type III-IV) tears and found a significant difference in postoperative ASES scores. For small tears, the results were superior with a mean postoperative ASES score of 93 ± 8.[14] Bartl et al reported on 21 patients in a 2-year follow-up study of SSC tears involving Lafosse type II, III, and IV tears (involving 25%, 50% and >50% of the tendon footprint) The study group reported an increased mean Constant score from 50.3 to 82.4 points.[1] Kim et al reported on 31 patients with an average follow-up of 27 months with a postoperative ASES of 96 ± 7.[17] Although the clinical results of these studies are favorable, comparison to the presented study is limited since different tear sizes were assessed.[1,14,17] The present study reports exclusively on the more common upper third SSC tears, which involve the largest footprint insertions on the humerus. The most comparable study to the current one is that by Katthagen et al, which analyzed the minimum 2-year results isolated Lafosse type I and type II tears repaired arthroscopically with 1 anchor. The study group reported significantly improved postoperative scores for ASES (90.8 ± 11.2), SANE (86.3 ± 17.9), QuickDASH (12 ± 14.5), and SF-12 PCS (52.4 ± 6.0).[15] Interestingly, the study group also found that type I repairs had inferior results than type II repairs.[15]

The majority (10/14) of patients in the current cohort received SSC repair using a knotted construct, as the knotless technique was implemented later in the study period. Technically, Katthagen et al did not find differences between knotted and knotless repair constructs in terms of clinical outcomes.[15] Likewise, Sgroi et al could not illustrate a superior technique for knotted vs. knotless in a 2-year follow-up study.[27]

Although there is no agreed upon guideline for number of anchors used in SSC repair, 1 study group suggested that the number of anchors be based on the number of centimeters involved from proximal to distal.[30] This clinical principle seems to be validated by biomechanical findings that a single anchor is sufficient for SSC tears involving up to 50% of the tendon footprint.[20] The clinical results of the single anchor repair in the present cohort were durable, with a 100% survivorship rate maintained at 10 years. These results are mirrored by the 2-year follow-up study by Katthagen et al, which also showed excellent results utilizing 1 anchor in all patients.[15]

The standard treatment of care for partial and full-thickness tears of the SSC is still debated. Randelli et al reported a prospective randomized investigation comparing débridement to arthroscopic repair in partial, upper third

Table V Responses to questions regarding function during sports, recreational activities, and daily activities

Activity	Preoperatively	Postoperatively	*P* value
Your usual work	2 (range 1-2)	3 (range 3-3)	**.010**
Your recreational activities	1 (range 1-1)	3 (range 3-3)	**.005**
Your usual sports	1 (range 1-1)	3 (range 3-3)	**.023**
Put on your coat	2 (range 1-2)	3 (range 3-3)	**.009**
Wash your back/fasten bra	1 (range 0-3)	3 (range 3-3)	**.007**
Manage toileting	3 (range 1-3)	3 (range 3-3)	.102

The activity was graded as: normal (3), somewhat (2), very difficult (1), or unable to do (0). Median scores and ranges are reported. All listed activities except toileting showed significant improvement postoperatively ($P \leq 0.05$).
Bold values are statistically significant.

SSC tears.[22] The partial tears were treated in conjunction with posterosuperior supraspinatus tears and the LHB tendon. No difference was seen between the 9 patients with débridement and 11 patients with arthroscopic repair in terms of clinical outcomes or internal rotation strength.[22] A study by Gerhard et al found that both débridement and arthroscopic repair of SSC lesions resulted in improved SSC function and an improved Constant score.[13] Interestingly, significant functional deficits of the SSC existed after arthroscopic repair compared to the contralateral shoulder, but these deficits were not seen for patients who received débridement only. However, the study included SSC lesions of various sizes (Fox and Romeo type I-IV[10]), and the débridement group included only patients with small tears that were not suitable for repair. Additionally, clinical interpretation of the results of both Randelli et al and Gerhardt et al is limited by the additional supraspinatus lesions treated in these cohorts.[13,22]

Further randomized studies comparing treatment options for isolated SSC tears are needed. Based on the current literature and the results of the present study, however, arthroscopic repair of SSC lesions has demonstrated excellent clinical results and high survivorship. As the SSC is involved in numerous complex movements of daily life such as putting on a coat, washing the back, fastening a bra, and managing the toilet, restoring function to this muscle can have a substantial impact on patients' quality of life.

Limitations

The presented study has several limitations which should be considered in interpreting the data. Most notably, the study was limited by a relatively small cohort size. This is in part due to the long-term follow-up study design and the unique patient population. The patient population excluded the more common combinations of anterosuperior or posterosuperior tear patterns, which the authors believe could have confounded the presented results. Larger SSC tears were excluded for the same reason. Future studies with larger cohort sizes are needed to validate these long-term results and determine risk factors for success/failure at long-term follow-up. Another limitation of the study is the lack of SANE and QuickDASH scores preoperatively, preventing preoperative to postoperative comparison for these scores. Lastly, due to the frequency of biceps pathologies and subacromial impingement in combination with SSC tears, these treatments were not excluded. Therefore, the study could be subject to performance bias, as the improvements in postoperative scores could have resulted in part from these treatments rather than the SSC repairs. However, these treatments have been included in prior studies on SSC repair as well, and the results with these concomitant treatments accurately describe what the majority of patients presenting for SSC repair can expect.

Conclusion

Arthroscopic repair of upper third SSC tendon tears with subpectoral biceps tenodesis leads to improved clinical scores and high patient satisfaction at minimum 10-year follow-up. The procedure is durable, with no failures in the presented cohort.

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Supplementary Data

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