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Minimum 5-Year Clinical and Return-to-Sport Outcomes After Primary Arthroscopic Scapulothoracic Bursectomy and Partial Scapulectomy for Snapping Scapula Syndrome

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Background: Snapping scapula syndrome (SSS) is a rare condition that is oftentimes debilitating. For patients whose symptoms are resistant to nonoperative treatment, arthroscopic surgery may offer relief. Because of the rarity of SSS, reports of clinical outcomes after arthroscopic SSS surgery are primarily limited to small case series and short-term follow-up studies.

Purpose: To report minimum 5-year clinical and sport-specific outcomes after arthroscopic bursectomy and partial scapulectomy for SSS and to identify demographic and clinical factors at baseline associated with clinical outcomes at minimum 5-year follow-up.

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

Methods: Patients who underwent arthroscopic bursectomy and partial scapulectomy for SSS between October 2005 and February 2016 with a minimum of 5 years of postoperative follow-up were enrolled in this single-center study. Clinical outcome scores, including the 12-Item Short Form Health Survey (SF-12), American Shoulder and Elbow Surgeons (ASES) Shoulder Score, shortened version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH) score, Single Assessment Numeric Evaluation (SANE), and visual analog scale (VAS) score for pain, were collected at a minimum 5-year follow-up. Additionally, it was determined which patients reached the minimal clinically important difference. Bivariate analysis was used to determine whether baseline demographic and clinical factors had any association with the outcome scores.

Results: Of 81 patients eligible for inclusion in the study, follow-up was obtained for 66 patients (age 33.6 ± 13.3 years; 31 female). At a mean follow-up of 8.9 ± 2.5 years (range, 5.0-15.4 years), all of the outcome scores significantly improved compared with baseline. These included the ASES (from 56.7 ± 14.5 at baseline to 87.2 ± 13.9 at follow-up; $P < .001$), QuickDASH (from 38.7 ± 17.6 to 13.1 ± 14.6; $P < .001$), SANE (from 52.4 ± 21.2 to 82.7 ± 19.9; $P < .001$), SF-12 Physical Component Summary (from 39.7 ± 8.3 to 50.3 ± 8.2; $P < .001$), SF-12 Mental Component Summary (from 48.2 ± 11.7 to 52.0 ± 9.0; $P = 0.014$) and VAS pain (from 5.2 ± 2.1 to 1.4 ± 2.0; $P < .001$). The minimal clinically important difference in the ASES score was reached by 77.6% of the patients. Median postoperative satisfaction was 8 out of 10. It was found that 90.5% of the patients returned to sport, with 73.8% of the patients able to return to their preinjury level. At the time of final follow-up, 8 (12.1%) patients had undergone revision surgery for recurrent SSS symptoms. Older age at surgery ($P = .044$), lower preoperative SF-12 Mental Component Summary score ($P = .008$), lower preoperative ASES score ($P = .019$), and increased preoperative VAS pain score ($P = .016$) were significantly associated with not achieving a Patient Acceptable Symptom State on the ASES score.

Conclusion: Patients undergoing arthroscopic bursectomy and partial scapulectomy for SSS experienced clinically significant improvements in functional scores, pain, and quality of life, which were sustained at a minimum of 5 years and a mean follow-up of 8.9 years postoperatively. Higher patient age, inferior mental health status, increased shoulder pain, and lower ASES scores at baseline were significantly associated with worse postoperative outcomes.

Keywords: snapping scapula syndrome; scapulothoracic bursectomy; clinical outcomes

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Snapping scapula syndrome (SSS) is an uncommon, painful, and debilitating shoulder girdle condition resulting from repeated inflammation of the bursae that facilitate articulation of the concave anterior scapula with the convex thoracic wall.[14,18,25] SSS may be caused by an anatomic anomaly that disrupts normal scapulothoracic articulation, may result from chronic overuse, or may be idiopathic.[1,4,7,16,20,27] Anatomic deviations, including anterior angulation of the medial scapula, excessive concavity of the scapula, Luschka tubercles, osteochondromas, elastofibromas, and posttraumatic changes, cause inflammation in subscapular bursae.[18,20,26,30] Repeated bursal inflammation produces clinical symptoms ranging from pain with scapulothoracic articulation to recalcitrant crepitus and clicking commonly seen with SSS.[30]

Nonoperative treatment is the mainstay of initial management for SSS and includes nonsteroidal anti-inflammatory drugs, corticosteroid injections, and physical therapy exercises focused on strengthening the subscapularis, serratus anterior, and periscapular muscles and correcting postural deficits.[9,16,20] However, in up to 50% of patients, nonoperative management fails or provides only temporary relief, necessitating operative treatment.[3,20,21] Until the introduction of an arthroscopic approach to the treatment of SSS in 1999 by Harper et al,[13] operative management of SSS was performed using an open approach. Subsequent advancements in surgical technique and arthroscopic equipment have resulted in decreased morbidity while allowing for thorough debridement of diseased bursal tissue and superomedial partial scapulectomy.[2,12,13,20,22,30] Additionally, the preservation of muscular attachments allows for quicker recovery and return to activity after arthroscopic SSS surgery.[12] Subsequently, the operative technique has been developed further, and superior clinical outcomes have been reported when an arthroscopic bursectomy is combined with a partial scapulectomy.[20,26] Despite these advancements, outcomes after SSS surgery are primarily limited to small case reports and short-term outcome studies, and complete resolution of symptoms has been reported in as few as 21% of patients.[¶]

The purpose of this study was to report minimum 5-year clinical and return-to-sport (RTS) outcomes after arthroscopic bursectomy and partial scapulectomy for SSS and to identify demographic and clinical factors at baseline associated with clinical outcomes at 5-year follow-up. It was hypothesized that patients would experience improvements in clinical and sport-specific outcomes after arthroscopic bursectomy and partial scapulectomy for SSS that would be sustained through minimum 5-year follow-up.

[¶]References 1, 2, 6-8, 12-14, 19, 20, 22, 25, 27, 29.

METHODS

This study was approved by the institutional review board (Vail Health Hospital No. 2022-124) and was a retrospective evaluation of prospectively collected data. Patients within our institutional data bank were assessed for eligibility if they underwent arthroscopic treatment of SSS with a single surgeon (P.J.M.). Patients were included if they underwent primary arthroscopic bursectomy with partial scapulectomy as treatment for SSS between October 2005 and February 2017. We excluded patients who (1) had undergone previous rib, scapular, or sternoclavicular procedures; (2) had undergone only scapulothoracic bursectomy or scapulothoracic injection; or (3) were <18 years of age at the time of follow-up. Patients who proceeded to revision surgery for SSS were considered to have experienced treatment failure. Those patients were reported and included in the risk factor analysis.

Indications

Typical presentation of SSS includes pain at the superomedial angle of the scapula, often accompanied by audible scapular crepitation or snapping. Arthroscopic scapulothoracic bursectomy with partial scapulectomy as treatment for SSS was indicated only after failure of nonoperative treatment. Nonoperative treatment, typically conducted for an interval of 6 to 12 weeks, included rest, anti-inflammatory medications, scapulothoracic injections, and physical therapy aimed at improving scapular kinematics and periscapular strength. Advanced imaging, such as magnetic resonance imaging and/or computed tomography scan, was performed in all cases preoperatively. Patients with suspicious soft tissue masses were referred to orthopaedic tumor specialists for diagnosis and treatment.

Surgical Technique

The arthroscopic technique was performed in all patients as previously described.[12,20] After receiving general anesthesia, patients were positioned prone with appropriate

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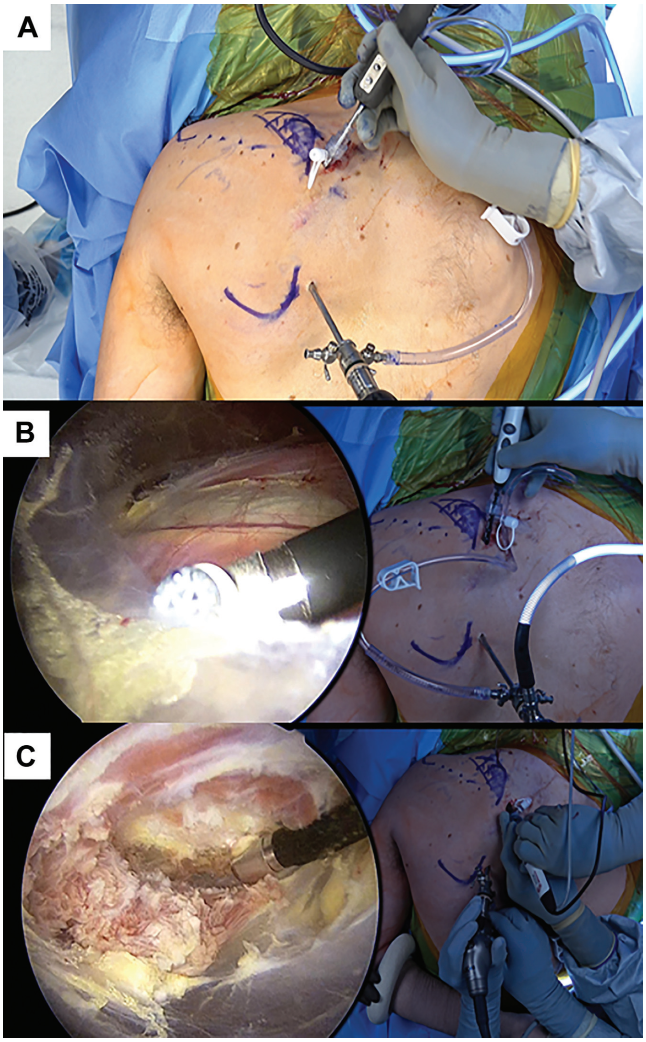

Figure 1. A patient positioned in a prone, chicken-wing position undergoing arthroscopic surgery for the left scapulothoracic joint. (A) Portals are created in a standard fashion, with a viewing portal created 3 cm medial to the inferomedial edge of the scapula and a working portal 3 cm medial to the scapula just caudal to the scapular spine. The procedure consists of (B) the bursectomy, which is performed with a radiofrequency device and a shaver, and (C) a partial scapulectomy, which is performed with a bur.

padding. A small bump under the anterior aspect of the operative shoulder was used to increase the space in the scapulothoracic space. The operative extremity was prepared in the typical sterile fashion. The operative extremity was internally rotated and placed in the chicken-wing position to open the scapulothoracic space. A standard 30°, 4-mm scope was used for the procedure (Figure 1). The first portal created was 3 cm medial to the inferomedial edge of the scapula. Depending on the size of each patient's scapula, this portal was repositioned as needed in the inferosuperior direction to have the tip of the scope in the appropriate location close to the superomedial scapula. The working portal was made 3 cm medial to the scapula just caudal to the scapular spine to protect the dorsal scapular nerve. The procedure began with a diagnostic arthroscopy of the scapulothoracic joint. The bursectomy was performed with a combination of shaver and radiofrequency device. Attention was then turned to the superomedial scapula. A spinal needle was used to locate the edge of the superomedial scapula. The electrocautery device was used to remove the soft tissue and muscular attachments at the edge of the scapula. The spinal needle was then removed from the scapulothoracic space but not taken out of the skin. To perform the partial scapulectomy, the surgeon inserted a bone-cutting shaver or bur and removed approximately 2 × 3 cm of the superomedial scapula while contouring the resection with the remaining scapula. The spinal needle was reinserted into the scapulothoracic space, and resection was confirmed. Typically, final resection was 2 cm in the anteroposterior direction and 3 cm in the mediolateral direction. Once the procedure was complete, a dynamic examination was performed to evaluate the decompression. The portal sites were closed, and the patient was awakened from anesthesia. The patient's arm was placed in a sling. Typically, patients began range of motion exercises as tolerated immediately after surgery and returned to full activities by 8 weeks.

Clinical Outcomes

Clinical outcome measures included the 12-Item Short Form Health Survey Physical Component Summary (SF-12 PCS) and Mental Component Summary (SF-12 MCS), American Shoulder and Elbow Surgeons (ASES) Shoulder Score, Single Assessment Numeric Evaluation (SANE), shortened version of the Disabilities of the Arm, Shoulder and Hand (QuickDASH) score, and visual analog scale (VAS) score for pain, which were collected preoperatively and at a minimum follow-up of 5 years postoperatively. The percentage of patients who reached a distribution-based minimal clinically important difference (MCID) was calculated using the MCID threshold for the ASES score previously established for the arthroscopic treatment of SSS (11.3 points).[24] Patients who had proceeded to revision surgery were categorized as not having reached MCID, irrespective of the scores before revision. Those patients were not routinely followed up in relation to the index surgery that had failed. To assess the effect of pain as the cardinal symptom of SSS in more detail, patients were also asked to rate the effect of pain on their activities of daily living (ADLs) and sleep on a scale of (0) none, (1) mild, (2) moderate, or (3) severe.

Return to Activity

To evaluate the patients' ability to return to their sport of choice, we asked them to rate their ability to participate in sports with respect to their shoulder using the following response options: (1) at or above preinjury level, (2) slightly below preinjury level, (3) moderately below preinjury level, (4) significantly below preinjury level, (5) unable to participate in their usual sport, or (6) unable to participate in

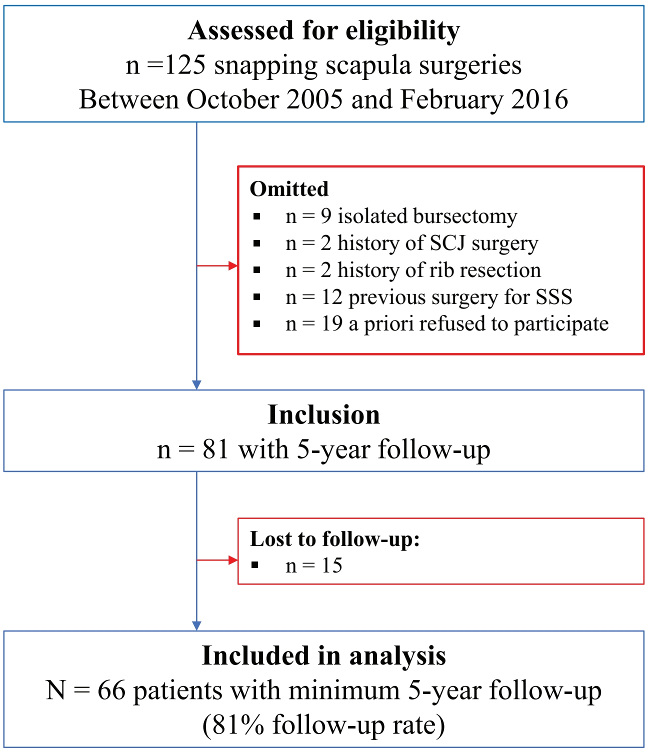

Figure 2. Flowchart of the patient population for this study after accounting for inclusion criteria, exclusion criteria, treatment failures, and loss to follow-up. SCJ, sternoclavicular joint; SSS, snapping scapula syndrome.

any sports. RTS was defined as selecting options 1 through 4, whereas a successful return to approximately the preinjury level was considered selecting option 1 or 2. To assess qualitative RTS parameters, we asked patients pre- and postoperatively to rate their ability to compete or participate in their usual sport compared with their preinjury level using the following options: (1) same or better than preinjury level, (2) 75% to 99% of preinjury level, (3) 50% to 74% of preinjury level, (4) 25% to 49% of preinjury level, (5) <25% of preinjury level, or (6) unable to participate in any sports.

Predictive Analysis

To investigate factors associated with long-term success of arthroscopic treatment of SSS, we assessed a potentially predictive role for successful postoperative outcomes for the following variables via bivariate analysis: age at surgery, workers' compensation status, symptom duration, injury at dominant arm, cause of injury, reason for seeking medical care, preoperative effect of shoulder pain on ADLs and sleep, preoperative grade of sports participation, sports intensity, and baseline patient-reported outcomes (PROs) (ie, SF-12 PCS, SF-12 MCS, ASES, SANE, QuickDASH, VAS pain). For the bivariate analysis, patients were stratified based on whether they reached a threshold for the ASES score, which previously was defined as

TABLE 1
Patient Characteristics and Clinical Details[a]

Variable	Value
Age at surgery, y	33.6 ± 13.3
Time to final follow-up, y	8.9 ± 2.5 (range, 5.0-15.4)
Injury at dominant arm	38 (57.6)
Sex	
Female	35 (53.0)
Male	31 (47.0)
Symptom duration, y	4.8 ± 6.5
Cause of injury	
Insidious	39 (59.1)
Traumatic	20 (30.3)
Repetitive	7 (10.6)
Receiving workers' compensation	6 (9.1)
Reason for seeking medical care[b]	
Pain	63 (95.5)
Weakness	44 (66.7)
Stiffness	36 (54.5)
Loss of shoulder function	21 (31.8)

[a]Categorical variables are presented as count and percentage. Other values are expressed as mean ± SD.
[b]This question allowed patients to select multiple answer choices.

a Patient Acceptable Symptom State (PASS) after shoulder surgery (81.0 points).[10]

Statistical Analysis

Using an a priori power analysis, performed with G*Power (Heinrich Heine University Düsseldorf),[5] we determined that a total sample size of 34 patients would be needed to detect a clinically relevant difference, such as an MCID of 13.1 points[24] in the ASES score, at a calculated effect size of 1.0 to achieve a statistical power of 0.8.

Statistical analysis was performed using SPSS Version 26.0 (IBM-SPSS). Continuous variables were reported as mean ± SD. Categorical variables were reported as count and percentage of the total sample. The distribution of continuous variables in the study collective was categorized via the Shapiro-Wilk test. According to their respective distributions, continuous variables were compared using a parametric unpaired t test or the nonparametric Mann-Whitney U test. Categorical variables were compared via the binary Fisher exact test or the chi-square test, as statistically appropriate. According to the distribution of the data, the parametric paired t test or the nonparametric Wilcoxon test for 2 related samples was used to compare pre- and postoperative values of each outcome parameter. The level of significance was set at $P < .05$.

RESULTS

A total of 125 patients who underwent arthroscopic bursectomy and partial scapulectomy of SSS during the study period were assessed for eligibility. Of those patients, 44

TABLE 2
Patient-Reported Outcome Measures Pre- and Postoperatively[a]

Variable	Preoperative	Postoperative	P	Mean Difference	95% CI[b]
SF-12 PCS	39.7 ± 8.3	50.3 ± 8.2	<.001[c]	9.97	6.8 to 13.1
SF-12 MCS	48.2 ± 11.7	52.0 ± 9.0	.014[c]	4.0	0.5 to 7.6
ASES	56.7 ± 14.5	87.2 ± 13.9	<.001[c]	31.0	25.5 to 36.5
QuickDASH	38.7 ± 17.6	13.1 ± 14.6	<.001[c]	–27.1	–34.0 to −20.1
SANE	52.4 ± 21.2	82.7 ± 19.9	<.001[c]	29.3	18.8 to 39.8
VAS pain	5.2 ± 2.1	1.4 ± 2.0	<.001[c]	–3.5	–2.8 to −4.1
VAS pain at worst	8.3 ± 1.8	3.9 ± 2.9	<.001[c]	–4.3	–3.4 to −5.3

[a]Values are expressed as mean ± SD. ASES, American Shoulder and Elbow Surgeons Shoulder Score; MCS, Mental Component Summary; PCS, Physical Component Summary; QuickDASH, shortened version of the Disabilities of the Arm, Shoulder and Hand score; SANE, Single Assessment Numeric Evaluation; SF-12, 12-Item Short Form Health Survey; VAS, visual analog scale.
[b]95% CI for the mean difference.
[c]Statistically significant improvement compared with preoperative ($P < .05$).

TABLE 3
Details on the Effect of Pain Pre- and Postoperatively[a]

Parameter	Preoperatively	Postoperatively	P
Pain affecting activities of daily living			<.001
None	0 (0)	**31 (54.4)**	
Mild	10 (20.4)	19 (33.3)	
Moderate	**20 (40.8)**	7 (12.3)	
Severe	19 (38.8)	0 (0)	
Pain affecting sleep			<.001
None	1 (2)	**24 (42.1)**	
Mild	13 (26)	19 (33.3)	
Moderate	**19 (38)**	13 (22.8)	
Severe	17 (34)	1 (1.8)	

[a]Values are expressed as number of patients (percentage of patients with answers available). The analysis is limited to patients that had not failed at final follow-up. Boldface indicates the most commonly selected option within the respective subgroup.

patients were excluded for various reasons. The remaining 81 patients (age 33.6 ± 13.3 years; 31 female) were included in the final study cohort. Despite our best attempts to attain 100% follow-up, 15 patients (18.5%) were lost to follow-up. The remaining 66 patients were included for further analysis of clinical outcomes. A flowchart detailing the inclusion and exclusion process is provided in Figure 2. A detailed description of patient characteristics and surgical details is provided in Table 1.

Clinical Outcome

Preoperative scores were compared with scores at a final follow-up of 8.9 ± 2.5 years postoperatively (Table 2). Compared with their preoperative baseline, the study population significantly improved in postoperative SF-12 PCS ($P <$ .001) and MCS (P = .014), ASES score ($P < .001$), QuickDASH score ($P < .001$), SANE ($P < .001$), VAS pain score ($P < .001$), and VAS pain score at worst ($P < .001$). Median satisfaction was 8 out of 10, with 67.2% of patients

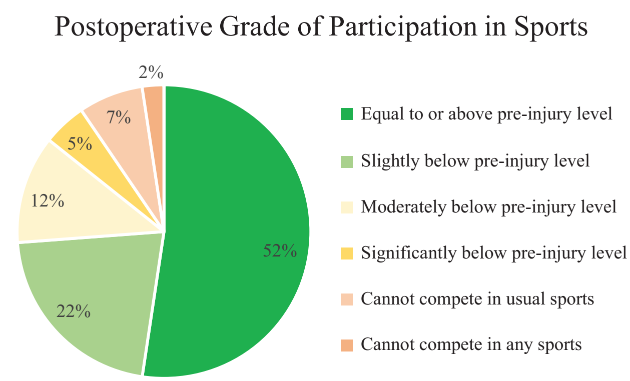

Figure 3. Graphic representation of the postoperative ability of patients to participate in sport.

achieving a postoperative satisfaction score of ≥7 out of 10. Eight (12.1%) patients had proceeded to revision surgery for recurrent symptoms related to SSS at final follow-up and were thus considered to have experienced treatment failure. Including those patients who underwent revision surgery, 77.6% of the patients reached the MCID. The patients who underwent subsequent revision reported the following scores: SF-12 PCS, 40.8 ± 7.9; SF-12 MCS, 47.2 ± 11.0; ASES, 68.6 ± 19.2; QuickDASH, 26.7 ± 21.3; and SANE, 57.8 ± 29.1. The median satisfaction score for the patients who underwent subsequent revision was 5 at a mean follow-up of 40.5 ± 29.4 months after revision surgery.

Postoperatively, the effect of patient-reported pain on ADLs ($P < .001$) and sleep ($P < .001$) improved significantly (Table 3).

Return to Athletic Activity

At the time of final follow-up, 42 patients self-reported participation in sports preoperatively and indicated their postoperative level of sports participation as depicted in Figure 3. Of these patients, 90.5% were able to return to their preoperative sports in any capacity. Of note, 73.8% of patients

TABLE 4
Sport-Specific Results[a]

Parameter	Preoperatively	Postoperatively	P
Level of participation in sports			
Equal to or above preinjury level	1 (4.5)	**22 (52.4)**	<.001
Slightly below preinjury level	1 (4.5)	9 (21.4)	
Moderately below preinjury level	**6 (27.3)**	5 (11.9)	
Significantly below preinjury level	2 (9.1)	2 (4.8)	
Cannot compete in usual sport	5 (22.7)	3 (7.1)	
Cannot compete in any sports	7 (31.8)	1 (2.4)	
Intensity in usual sport compared with preinjury level			
Same or better than preinjury intensity	2 (8.7)	12 (31.6)	.001
75%-99% of preinjury intensity	6 (26.1)	**13 (34.2)**	
50%-74% of preinjury intensity	0 (0)	3 (7.9)	
25%-49% of preinjury intensity	4 (17.4)	3 (7.9)	
<25% of preinjury intensity	5 (21.7)	4 (10.5)	
Can no longer compete at any intensity	**6 (26.1)**	3 (7.9)	

[a]Values are expressed as number of patients (percentage of patients with answers available). Boldface indicates most commonly selected option within respective subgroup. The analysis is limited to patients that had not failed at final follow-up.

indicated that they returned to their chosen sport above, equal to, or only slightly below their preinjury level.

After surgery, compared with preoperatively, the level of sports in which patients were able to participate significantly improved ($P < .001$). Also, the intensity at which the patients could compete in their usual sport improved compared with their preinjury level ($P < .001$). Detailed information is provided in Table 4.

Predictive Analysis

Bivariate analysis was used to identify preoperative factors significantly associated with achieving PASS in the postoperative ASES score. Of the continuous variables, lower SF-12 MCS score (P = .008), lower ASES score (P = .019), and higher VAS pain score (P = .016) were found to be significantly associated with a superior postoperative outcome. Younger age at surgery (P = .044) was also correlated with achieving PASS in the ASES score; patients not achieving PASS had a mean age of 37.1 ± 14.1 years at the time of surgery, whereas patients who did achieve PASS had a mean age of 30.4 ± 12.1 years at the time of surgery. Patients with pain that affected ADLs more severely (P = .023) had outcomes inferior to those of patients with only moderate pain with ADLs. None of the other variables significantly influenced the propensity of patients to reach PASS. The comprehensive results of our bivariate analysis can be found in the Appendix (available in the online version of this article).

DISCUSSION

The most important finding of this study was that a clinically significant improvement in functional scores, pain, and quality of life in patients undergoing arthroscopic bursectomy and partial scapulectomy for SSS was sustained at a mean of 8.9 years. Furthermore, the procedure enabled 73.8% of athletic patients to RTS at a similar level compared with preinjury, and it significantly and substantially improved patients' ability to compete in most cases. Lower functional scores at baseline, higher pain at baseline, preoperative mental state, and older age were identified as predictors of inferior postoperative outcomes, insights that may be used to preoperatively manage patients' long-term expectations for this procedure.

SSS is a relatively uncommon shoulder condition but can be debilitating.[14,18,25] Although nonoperative therapy is the first-line treatment, approximately 14% to 50% of patients do not respond to nonoperative measures and require surgery.[3,11,21,30] Despite the technical advances in SSS surgical treatment with the adoption of arthroscopic techniques in recent years, outcomes for SSS remain inferior to other conditions of the shoulder girdle, with only approximately 22% of patients achieving a full resolution of symptoms.[17] Furthermore, current research literature on outcomes after SSS surgery is primarily limited to small case reports and short-term outcome studies.[#] The present study is one of the first to analyze the midterm outcomes after arthroscopic SSS treatment in a large cohort of patients, and we found promising results. Notably, patients reported significantly decreased pain after surgery, with improvements in pain affecting ADLs and sleep, and reductions in mean VAS pain score from 5.2 to 1.4 and VAS pain at worst from 8.3 to 3.9. This is comparable with minimum 2-year outcomes reported by Millett et al,[20] who found that VAS pain at worst was decreased from a median of 9 preoperatively (range, 5-10) to 5 postoperatively (range, 0-10). Additionally, the postoperative ASES, SANE, and QuickDASH scores for our study (means 87.2, 82.7, and 13.1, respectively) were superior to the results of Millett et al (median 73, mean 74, and mean 35, respectively), despite similar preoperative ASES scores for both populations (mean 56.7 for the present study, median 53

[#]References 1, 2, 6-8, 12-14, 19, 20, 22, 25, 27, 29.

for Millett et al).[20] The mean postoperative PROs achieved in the present study were also slightly superior to those reported in the sizable minimum 2-year outcome studies by Menge et al,[18] Featherall et al,[6] and Gambhir et al.[8] It is possible that the superior results in the present study are due to bony resection of the superomedial angle of the scapula in all cases; in comparison, patients in the study by Gambhir et al underwent only scapulothoracic bursectomy, and only some patients in the studies by Featherall et al and Menge et al underwent bony resection. Furthermore, we noted a median patient satisfaction of 8 at a mean of 8.9 years, which is similar to or higher than previously reported for minimum 2-year outcomes studies.[8,18,20] Given our outcomes in comparison with previous outcomes reported in the literature of patient populations undergoing only scapulothoracic bursectomy or patient populations with only some patients undergoing partial scapulectomy, it appears that sufficient excision of the scapula is key for a positive outcome.[6,8,19,21] Despite these promising outcomes, it should be noted that 12.1% of the patients underwent revision surgery for recurrent symptoms related to SSS. In revision cases, the proposed cause of failure is insufficient resection of the superomedial angle of the scapula; thus, more extensive resection was carried out in the revision setting.

A main focus of the current study was RTS in patients with SSS, as information on this topic is lacking in current literature. In the present study, patients indicated participation in a wide range of sport activities including tennis, baseball, softball, equestrian, and volleyball. Preoperatively, patients reported significant deficits in their ability to participate in sports. Postoperatively, 90.5% of patients successfully returned to sport, with the majority of patients (52.4%) returning at or above their preinjury level. An additional 21.4% returned to sport slightly below their preinjury level. On average, patients reported significant improvements in the level and intensity at which they could participate in sports at a minimum of 5 years postoperatively. These results compare favorably with those of Pavlik et al,[22] who reported on 9 athletes who underwent arthroscopic treatment of SSS. At a minimum follow-up of 1 year, 6 of the 9 athletes (67%) were able to return to their desired sport, of whom 4 (44%) returned to the same or higher level. In a more recent study, Gambhir et al[8] reported that 4 of 8 athletes were able to RTS at a level similar to their baseline at a minimum 2-year follow-up. Although further studies are needed to verify the long-term durability of arthroscopic treatment of SSS in athletes, the presented results highlight the mid- to long-term success in restoring function in an athletic population.

Because of the complex nature of SSS and the variability in outcomes, multiple studies have aimed to assess the effect of demographic, injury, and surgical factors on outcomes after SSS surgery.[18,20,23,28] Factors that have been reported to be significantly associated with outcomes include preoperative response to injection,[20,28] isolated arthroscopic bursectomy versus scapulectomy,[20] female sex,[20] acute or traumatic cause of injury,[18,23] and preoperative mental health status.[18,23] Mixed results have been reported for the effect of age on outcomes: Millett et al[20] reported decreased satisfaction and improvement in ASES scores in younger patients, whereas Menge et al[18] found that older age correlated with lower postoperative PROs. With a relatively large patient cohort of 66 patients, the present study performed a robust risk factor analysis. Factors that were predictive of achieving superior clinical outcomes included higher baseline pain and function scores. Notably, a higher preoperative mental health status, as measured by SF-12 MCS, was associated with a higher likelihood of achieving a satisfactory outcome ($P = .008$), similar to the findings of Menge et al. Also supporting the results of Menge et al, the present study determined that patients with inferior postoperative outcomes were significantly older compared with patients who met this cutoff ($P = .044$).[18] Unlike previous investigators, we did not find that symptom duration, traumatic versus atraumatic cause of injury, or preoperative response to injections was associated with the likelihood of achieving superior outcomes postoperatively.[18,20,23,28] Only patients with concomitant scapulectomy and bursectomy were included in this study, which may partially explain the superior clinical outcomes compared with previous studies that included patients with isolated bursectomy.[20] Tytherleigh-Strong et al[28] found that patients who had a more positive response to preoperative injections had an improved response to surgical treatment, but this relationship was not found in the present study (supplementary table). This could be a result of the present study using a graded scale (ie, worse, 0%-25% improvement, 26%-50% improvement, etc) to measure pain improvement within 30 minutes of the injection, whereas Tytherleigh-Strong et al used a binary scale (good response vs bad response) to measure the response 3 months after the initial injection.

There are several limitations to the present study. First, the external validity of these findings may be limited because the results represent the outcomes of patients from a single, high-volume surgeon. Second, there currently is no standard outcome measure to assess the extent of SSS, although the functional PROs used in this study have been used in numerous studies reporting outcomes after SSS surgery.[15,18,20,28] Attempts were made to reduce this limitation by collecting granular information on pain as the cardinal symptom of SSS that extends beyond functional scores. Third, regarding the RTS analysis, the results may be biased by factors such as natural decrease in sports participation with age and other confounding injuries or factors unrelated to the shoulder that could have affected the patients' ability to be active in sports at $\geq$5 years postoperatively. Fourth, the size of the study population was limited because some patients had previously refused to participate in research. These patients' preoperative data were excluded from final calculations to respect the patients' privacy and their decision to not participate in research. Exclusion of these patients may have biased the results of the study.

CONCLUSION

Patients undergoing arthroscopic bursectomy and partial scapulectomy for SSS experienced clinically significant improvements in functional scores, pain, and quality of life, which were sustained at a mean follow-up of 8.9 years postoperatively. Older patient age, inferior mental health status, increased shoulder pain, and lower ASES scores at baseline were significantly associated with postoperative outcomes.

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REFERENCES

1. Andreoli CV, Ejnisman B, Pochini Ade C, Monteiro GC, Cohen M, Faloppa F. Arthroscopy of the scapulothoracic joint: case reports. *Rev Bras Ortop*. 2009;44(4):351-356.
2. Blønd L, Rechter S. Arthroscopic treatment for snapping scapula: a prospective case series. *Eur J Orthop Surg Traumatol*. 2014;24(2):159-164.
3. Carlson HL, Haig AJ, Stewart DC. Snapping scapula syndrome: three case reports and an analysis of the literature. *Arch Phys Med Rehabil*. 1997;78(5):506-511.
4. Dey Hazra RO, Elrick BP, Ganokroj P, et al. Anatomic safe zones for arthroscopic snapping scapula surgery: quantitative anatomy of the superomedial scapula and associated neurovascular structures and the effects of arm positioning on safety. *J Shoulder Elbow Surg*. 2022;31(10):e465-e472.
5. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39(2):175-191.
6. Featherall J, Christensen GV, Mortensen AJ, Wheelwright JC, Chalmers PN, Tashjian RZ. Arthroscopic scapulothoracic bursectomy with and without superomedial angle scapuloplasty: a comparison of patient-reported outcomes. *J Shoulder Elbow Surg*. 2023;32(9):1945-1952.
7. Freche S, Juch F, Nusselt T, Delank KS, Hagel A. Arthroscopic treatment of bilateral snapping scapula syndrome: a case report and review of the literature. *Acta Orthop Traumatol Turc*. 2015;49(1):91-96.
8. Gambhir N, Alben MG, Kim MT, Pines Y, Virk MS, Kwon YW. Outcomes after arthroscopic scapulothoracic bursectomy for the treatment of symptomatic snapping scapula syndrome. *JSES Int*. 2022;6(6):1042-1047.
9. Gaskill T, Millett PJ. Snapping scapula syndrome: diagnosis and management. *J Am Acad Orthop Surg*. 2013;21(4):214-224.
10. Gowd AK, Charles MD, Liu JN, et al. Single Assessment Numeric Evaluation (SANE) is a reliable metric to measure clinically significant improvements following shoulder arthroplasty. *J Shoulder Elbow Surg*. 2019;28(11):2238-2246.
11. Groh GI, Simoni M, Allen T, Dwyer T, Heckman MM, Rockwood CA. Treatment of snapping scapula with a periscapular muscle strengthening program. *J Shoulder Elbow Surg*. 1996;5(2):S6.
12. Hanson JA, Liles JL, Dey Hazra RO, Dey Hazra ME, Foster MJ, Millett PJ. Arthroscopic treatment of snapping scapula syndrome with scapulothoracic bursectomy and partial scapulectomy. *Arthrosc Tech*. 2022;11(7):e1175-e1180.
13. Harper GD, McIlroy S, Bayley JI, Calvert PT. Arthroscopic partial resection of the scapula for snapping scapula: a new technique. *J Shoulder Elbow Surg*. 1999;8(1):53-57.
14. Lehtinen JT, Tetreault P, Warner JJ. Arthroscopic management of painful and stiff scapulothoracic articulation. *Arthroscopy*. 2003;19(4):e28.
15. Lien SB, Shen PH, Lee CH, Lin LC. The effect of endoscopic bursectomy with mini-open partial scapulectomy on snapping scapula syndrome. *J Surg Res*. 2008;150(2):236-242.
16. Manske RC, Reiman MP, Stovak ML. Nonoperative and operative management of snapping scapula. *Am J Sports Med*. 2004;32(6):1554-1565.
17. Memon M, Kay J, Simunovic N, Ayeni OR. Arthroscopic management of snapping scapula syndrome improves pain and functional outcomes, although a high rate of residual symptoms has been reported. *Knee Surg Sports Traumatol Arthrosc*. 2018;26(1):221-239.
18. Menge TJ, Horan MP, Tahal DS, Mitchell JJ, Katthagen JC, Millett PJ. Arthroscopic treatment of snapping scapula syndrome: outcomes at minimum of 2 years. *Arthroscopy*. 2017;33(4):726-732.
19. Merolla G, Cerciello S, Paladini P, Porcellini G. Scapulothoracic arthroscopy for symptomatic snapping scapula: a prospective cohort study with two-year mean follow-up. *Musculoskelet Surg*. 2014;98(suppl 1):41-47.
20. Millett PJ, Gaskill TR, Horan MP, van der Meijden OA. Technique and outcomes of arthroscopic scapulothoracic bursectomy and partial scapulectomy. *Arthroscopy*. 2012;28(12):1776-1783.
21. Mozes GMD, Bickels JMD, Ovadia DMD, Dekel SMDP. The use of three-dimensional computed tomography in evaluating snapping scapula syndrome. *Orthopedics*. 1999;22(11):1029-1033.
22. Pavlik A, Ang K, Coghlan J, Bell S. Arthroscopic treatment of painful snapping of the scapula by using a new superior portal. *Arthroscopy*. 2003;19(6):608-612.
23. Pearse EO, Bruguera J, Massoud SN, Sforza G, Copeland SA, Levy O. Arthroscopic management of the painful snapping scapula. *Arthroscopy*. 2006;22(7):755-761.
24. Rupp M-C, Rutledge JC, Apostolakes JM, et al. Preoperative patient factors that predict clinically significant improvement following arthroscopic treatment of snapping scapula syndrome. *J Shoulder Elbow Surg*. Published online February 17, 2024. doi:10.1016/j.jse.2024.01.018
25. Sisto DJ, Jobe FW. The operative treatment of scapulothoracic bursitis in professional pitchers. *Am J Sports Med*. 1986;14(3):192-194.
26. Spiegl UJ, Petri M, Smith SW, Ho CP, Millett PJ. Association between scapula bony morphology and snapping scapula syndrome. *J Shoulder Elbow Surg*. 2015;24(8):1289-1295.
27. Tashjian RZ, Granger EK, Barney JK, Partridge DR. Functional outcomes after arthroscopic scapulothoracic bursectomy and partial superomedial angle scapulectomy. *Orthop J Sports Med*. 2013;1(5):2325967113505739.
28. Tytherleigh-Strong G, Gill J, Griffiths E, Al-Hadithy N. Prognosis after arthroscopic superior medial scapuloplasty for snapping scapula syndrome improves after a transient beneficial response with an ultrasound-guided subscapular cortisone injection. *Arthroscopy*. 2020;36(12):2965-2972.
29. van Riet RP, Van Glabbeek F. Arthroscopic resection of a symptomatic snapping subscapular osteochondroma. *Acta Orthop Belg*. 2007;73(2):252-254.
30. Warth RJ, Spiegl UJ, Millett PJ. Scapulothoracic bursitis and snapping scapula syndrome: a critical review of current evidence. *Am J Sports Med*. 2015;43(1):236-245.