Arm Function After Arthroscopic Decompression of the Suprascapular Nerve at the Spinoglenoid Notch and Suprascapular Notch in Volleyball Players

Roman Brzoska,* MD, PhD, Hubert Laprus,*† MD, PhD, Patryk Klaptocz,* PT, PhD, Shahbaz S. Malik,‡ BSc, MBBCh, MSc, LLM, Wojciech Solecki,* MD, and Adrian Blasiak,* MD, PhD

Investigation performed at St Luke's Hospital, Bielsko-Biala, Poland

Background: Suprascapular nerve (SSN) entrapment in volleyball players leads to infraspinatus (ISP) muscle atrophy and weakness of abduction and external rotation (ER) of the shoulder.

Purpose: To assess functional outcome after arthroscopic extended decompression of SSN in the spinoglenoid notch and suprascapular notch in a group of volleyball athletes.

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

Methods: Volleyballers who underwent arthroscopic SSN decompression were analyzed retrospectively. Assessment tools consisted of range of motion and ER strength on Lovett scale and postoperative ER strength measured by dynamometer, Constant-Murley score (CMS), and visual evaluation of ISP muscle recovery by assessing muscle bulk.

Results: The study included 10 patients (9 male and 1 female). The mean age was 25.9 years (range, 19-33) and mean follow-up was 77.9 months (range, 7-123). The mean range of postoperative ER at 90° of abduction (ER2) was 105.6° (88°-126°) and 108.5° (93°-124°) for the contralateral side, while ER2 strength was 8 ± 2.6 and 12.65 ± 2.8 kg ($P < .01$) respectively. Mean CMS was 89.9 (84-100). In 5 cases, there was complete recovery of ISP muscle atrophy whereas 2 patients had partial recovery and 3 had none.

Conclusion: Arthroscopic SSN decompression in volleyball players improves shoulder function, but results of ISP recovery and ER strength are variable.

Keywords: arthroscopic nerve decompression; infraspinatus atrophy; suprascapular nerve entrapment

Suprascapular nerve (SSN) entrapment in the spinoglenoid notch results in injury to the terminal branch of this nerve, which manifests clinically as infraspinatus (ISP) muscle atrophy, and was described in 1959 by Thompson and Kopell[46] and later in 1981 by Ganzhorn et al.[15] Functionally, this results in decreased shoulder strength in external rotation (ER) and abduction. In the general patient population, the most common mechanism causing this pathology is a posterior labral tear with a cyst that compresses the SSN.[42,50]

In volleyball players, ISP muscle atrophy without any concomitant pathologies is a common finding, reported by many authors.[§] Several theories have been proposed for this pathology, but the most popular was presented in 1984 by Guo and Xu,[19] who described the injury as a result of traction with stretching in the spinoglenoid notch.[13,31] SSN entrapment is estimated to affect about 30% of professional indoor and beach volleyballers.[25] Ferretti et al[13,14] previously described the natural course of ISP muscle atrophy and results after surgical treatment. However, the results of these operations were not encouraging when it came to the muscle bulk improvement. Ghodadra et al[17] and Plancher and Petterson[34] described arthroscopic release of SSN in the spinoglenoid notch in 2009 and 2014, respectively. Later, arthroscopic nerve release using direct posteromedial (PM) portal was published.[27,30] More recently, anatomic and epidemiological studies as well as case reports considering SSN entrapment and SSN decompression have been published.[12,33]

As a result of the complexity of the movements in volleyball and the unclear cause of ISP atrophy, we treat SSN entrapment with extended release from the level of the suprascapular notch to the spinoglenoid notch, with full nerve release to ensure the maximum possible conditions

§References 1, 4, 5, 9, 10, 11, 13, 14, 19, 22, 30, 31, 33, 41, 45, 47, 49, 51.

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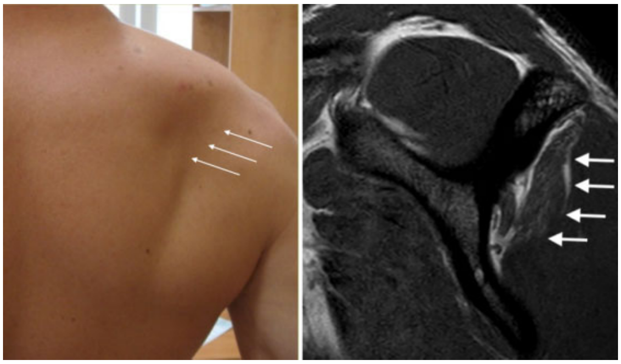

Figure 1. Photograph showing substantial atrophy preoperatively and corresponding sagittal view on preoperative magnetic resonance imaging scan. Arrows indicates infraspinatus muscle and its atrophy.

for muscle regeneration and to minimize the risk of subsequent nerve compression.

The aim of this study was to report outcomes after arthroscopic, extended release of the SSN in the spinoglenoid notch and suprascapular notch in competitive-level volleyball players belonging to teams from the amateur division to the national team. To our knowledge, this is the largest case series of professional volleyballers undergoing arthroscopic SSN release. We also performed a literature review of surgical treatment of SSN entrapment in volleyball players to establish what results should be expected after decompression of SSN.

METHODS

The study protocol was approved by the local ethics committee. From 2008 to 2014, 10 volleyball players with substantial, clinically visible, atrophy of the ISP muscle of the dominant hand underwent arthroscopic SSN release. All 10 players were involved in volleyball at a competitive level, from the amateur division to the national team. The indication for surgery was poorly explained posterior shoulder pain with decreased range of ER and ISP muscle wasting. Surgery was performed only after failed rehabilitation for a minimum of 6 months focused on improvement in the kinetics of the scapula during arm movement as well as strengthening and electrostimulation of the ISP muscle. All patients underwent preoperative magnetic resonance imaging (MRI) in which substantial atrophy of the ISP muscle was confirmed (Figure 1) and those patients with substantial concomitant pathologies, such as rotator cuff tear, supraspinatus (SSP) muscle atrophy, or paralabral cyst, as a source of the symptoms were excluded.

TABLE 1
Modified Lovett Scale for Postoperative External Rotation Strength

Points	Strength
0	Lack of muscle activity
1	Inability to maintain the weight of the limb
2	Partial ability to maintain the weight of the limb
3	Full ability to maintain the weight of the limb
4	Ability to maintain partial weightbearing
5	Ability to maintain full weightbearing

Outcome measures included pre- and postoperative range of motion on the operated and contralateral side, pre- and postoperative strength in ER as per the modified Lovett scale (Table 1).[28] Postoperative strength for the operated shoulder was measured with the Beslands SF-500 dynamometer; the selected unit was kilograms, which is more familiar to patients. The measurements were taken after a few minutes of warm-up, and the result was the arithmetic mean of 3 measurements. Strength was measured and compared with the contralateral side in 3 positions: ER with the arm at the side (ER1), ER with the elbow flexed to 90°, the arm abducted to 90° in the scapular plane, the forearm pronated (ER2), and Jobe test position.[23] Objective shoulder functional was assessed with the Constant-Murley score (CMS).[8,44] At the final follow-up, all athletes underwent radiological assessment with an ultrasound and a radiograph (anteroposterior and Y views). Last, muscle bulk was assessed visually and described as either having no improvement in atrophy, partial improvement, or complete recovery.

Surgical Technique

All patients had a general anesthetic with an interscalene block and were positioned in the beach-chair position with the arm in an arm holder with 1 kg traction. In draping, the entire scapula was exposed (Figure 2). A standard posterior portal (PP) was used as a viewing portal for joint exploration and subacromial space. Two further portals were utilized: The first working portal was posterolateral (PL), 3 cm lateral to the PP, and the second was a standard anterolateral (AL) portal.

A standard diagnostic arthroscopy was performed first. After confirming the absence of intra-articular injuries, the subacromial space was inspected to perform suprascapular nerve release at suprascapular notch. Upon reaching the level of the suprascapular notch, a radiofrequency wand

†Address correspondence to Hubert Laprus, MD, PhD, St Luke's Hospital, Bystrzańska 94 B Street, 43-309, Bielsko-Biala, Poland (email: hubert.laprus@gmail.com).

*St Luke's Hospital, Bielsko-Biala, Poland.

‡Worcestershire Acute Hospitals NHS Trust, Worcester, Worcestershire, UK.

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Ethical approval for this study was obtained from the Medical University of Lodz (ref No. RNN/176/19/KE).

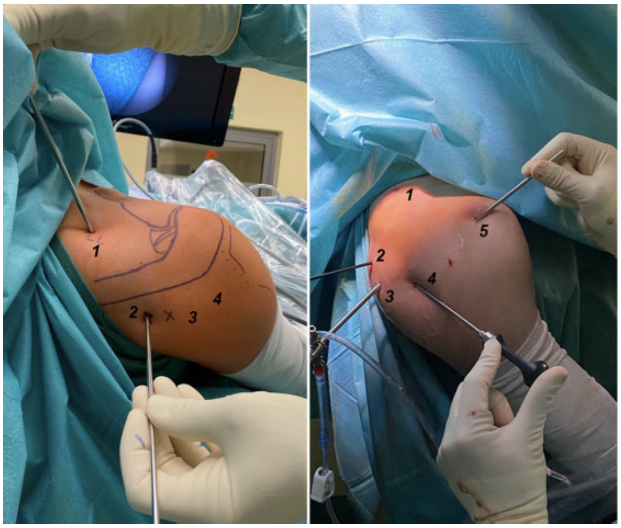

Figure 2. Posterior and posterolateral side views of patient preparing and draping. Shown are the Lafosse portal to suprascapular nerve release in the suprascapular notch (*1*), posteromedial portal (*2*), standard posterior portal (*3*), posterolateral portal (*4*), and anterolateral portal (*5*).

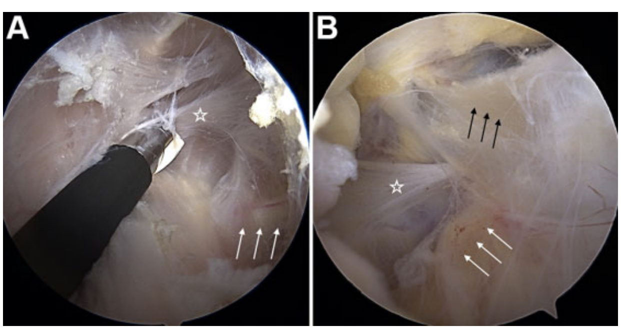

Figure 3. SSN release at the spinoglenoid notch. (A) Example of SSN decompression in case of no transverse ligament. (B) Decompression with ligament release. White arrows indicate the SSN, black arrows indicate the transverse ligament, and stars indicate retinaculum of the infraspinatus muscle. SSN, suprascapular nerve.

inserted through the AL portal served to retract the SSP muscle, and a Lafosse portal was made under direct visualization and safely nerve release was performed.[24] The nerve was then released posteriorly, up to the level of the scapular spine to achieve complete decompression. After that posterior joint capsule was dissected by radiofrequency inserted through PL portal and under direct visualization PM working portal was created 2-3 medial to the PP (Figure 2).

The PM portal was the main working portal, and the PP was the viewing portal. A blunt trocar was inserted via the working PM portal to create some space by teasing soft tissue up to the spinoglenoid notch without the risk of nerve injury. The blunt trocar was then used as the retractor, and a radiofrequency wand was adjusted through the same PM portal and used to dissect the tissues around the spinoglenoid ligament (if present) and around the nerve (Figure 3). In case of small patients, if more convenient, a blunt trocar was introduced as a retractor via the PL portal and the PM served as a portal for the radiofrequency wand. Complete dissection was performed to decompress the main trunk of the nerve and small branches to the ISP muscle.

Rehabilitation

Patients were immobilized in a shoulder sling for the first 2 weeks postoperatively. While in the sling, isometric deltoid exercises and passive ER, internal rotation (IR), and elbow flexion/extension exercises were performed twice a day. Active movements within painless range of motion were introduced from the second week. Starting from week 6, gradually forced active movements in closed kinetic chain were introduced to restore muscle strength and full range of motion with caution to avoid overstressing. Special attention was given to pain-free ER exercises. After week 12, isolated exercises for the ISP and SSP muscles were introduced. Patients were allowed to return to daily activities after 4 weeks and to the previous sport 3 months postoperatively if pain free.

RESULTS

A total of 10 patients underwent arthroscopic extended SSN decompression at both the suprascapular notch and the spinoglenoid notch levels. There were 9 men and 1 woman, with a mean age of 25.9 years (range, 19-33 years) at the time of surgery. The mean follow-up was 77.9 months (range, 7-123). There was no loss to follow-up, and all 10 patients were included for final analysis. Individual results for each patient are presented in Table 2. A clinical photograph and MRI scan are shown in Figure 4 as an example.

In ER1, the strength per the Lovett scale increased from a mean 2.4 (range, 2-3) preoperatively to 4.2 (range, 3-5) postoperatively, which was a statistically significant difference ($P < .01$). The range of ER1 in the affected shoulder increased from $44.5^\circ \pm 29.6^\circ$ preoperatively to $59.9^\circ \pm 18.8^\circ$ at the final follow-up ($P = .07$). Strength as measured by dynamometer in the ER1, ER2, and Jobe test positions was 5.1 ± 2.1 kg, 8.0 ± 2.6 kg, and 6.0 ± 2.5 kg, respectively, for the operated shoulder; and 7.3 ± 1.3 kg, 12.7 ± 2.8 kg, and 8.6 ± 1.4 kg, respectively, for the contralateral shoulder (Table 3). For all parameters, there was a statistically significant difference in strength between the operated and contralateral shoulder ($P < .01$ for all), indicating that the surgical treatment allowed for the regaining of 69.9% strength in the ER1 position, 63% in the ER2 position, and 69.8% in the Jobe test position in comparison with the contralateral shoulder. The mean postoperative CMS was 89.9 (range 84-100).

At the final follow-up, 5 of 10 patients had complete clinical recovery of the ISP muscle bulk, 2 patients had partial regeneration, and 3 patients had no signs of muscle regeneration. Furthermore, 3 out of 10 patients had tendinopathy of ISP muscle tendons seen on ultrasound during final

TABLE 2
Results of Strength Testing for Each Study Patient[a]

						Strength, ER1			Strength, ER2			Strength, Jobe Test Position		
Patient	Sex	Age, y	Follow-up, m	LS, Preop	LS, Postop	DM, kg, Affected	DM, kg, Contra	Contra, %	DM, kg, Affected	DM, kg, Contra	Contra, %	DM, kg, Affected	DM, kg, Contra	Contra, %
1	M	30	90	2	4	3.3	7.9	41.8	6.4	14.8	43.2	3.2	9	35.6
2	M	25	123	2	4	2.4	5.2	46.2	4.6	13.6	33.8	5.5	8.9	61.8
3	M	24	118	2	3	3.9	7.3	53.4	7.6	13	58.5	3	8.1	37
4	M	20	85	2	3	5.8	7.8	74.4	9.2	13.8	66.7	8.1	9.8	82.7
5	M	33	61	3	5	7.2	8.6	83.7	12.1	15.4	78.6	9.1	11	82.7
6	M	26	50	3	5	6.8	8.1	84	10.2	14.2	71.8	8	9.2	87
7	F	26	121	3	4	2.2	4.8	45.8	4	7.1	56.3	2.3	5.8	39.7
8	M	23	116	3	4	4.4	7.6	57.9	6.8	14.1	48.2	4.6	8.2	56.1
9	M	19	7	2	5	7.6	8.2	92.7	9.9	12	82.5	8.2	8.8	93.2
10	M	19	8	2	5	7.2	7	102.9	8.8	8.5	103.5	7.6	7.5	101.3
Mean	—	24.5	77.9	2.4	4.2	5.1	7.3	69.9	8.0	12.7	63	6.0	8.6	69.8

[a]Contra, %, percentage of contralateral strength; DM, dynamometer; ER, external rotation; ER1, ER with arm at side; ER2, ER in abduction; F, female; LS, Lovett scale; M, male; Postop, postoperative; Preop, preoperative.

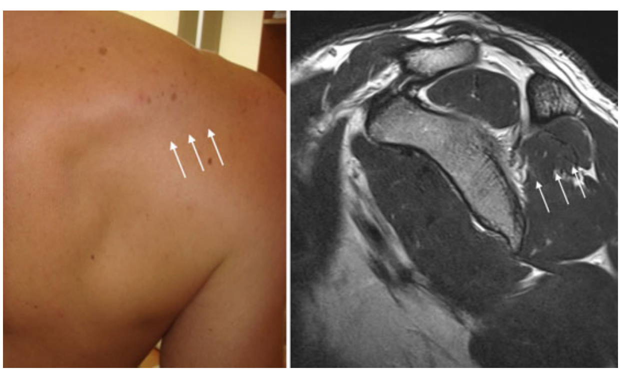

Figure 4. Photograph showing ISP 50 months postoperatively and corresponding sagittal view on postoperative magnetic resonance imaging scan. White arrows indicate regeneration of ISP. ISP, infraspinatus.

TABLE 3
Summary of ROM and Strength Measurements for the Different Positions[a]

Position	Mean (range)
ROM, deg	
ER1 preoperative	44.5 (0-90)
ER1 postoperative	59.9 (35-85)
ER1 contralateral	61.6 (33-90)
ER2 postoperative	105.6 (88-126)
ER2 contralateral	108.5 (93-124)
Strength, kg, affected vs contralateral	
ER1	5.1 (2.2-7.6) vs 7.3 (4.8-8.6)
ER2	8.0 (4-12.1) vs 12.7 (8.5-15.4)
Jobe test	6.0 (2.3-9.1) vs 8.6 (5.8-11)
IR	12.7 (7.6-18.1) vs 11.2 (7.2-16.4)

[a]ER, external rotation; ER1, ER with arm at side; ER2, ER in abduction; IR, internal rotation; ROM, range of motion.

TABLE 4
Patients With Muscle Regeneration

Muscle regeneration	No. of Patients (%)
Complete	5/10 (50)
Partial	2/10 (20)
None	3/10 (30)

examination. The results are summarized in Table 4. Postoperatively, there were no radiographic changes seen, and there were no intraoperative or postoperative complications. All 10 patients returned to sport at the same level as before their symptoms, and none reported pain during daily routines or sport activities.

DISCUSSION

This study has shown that arthroscopic extended decompression of the SSN, at both the spinoglenoid notch and the suprascapular notch levels, in a group of professional volleyball players, led to an improvement in shoulder function and relief of pain and allowed for a full return to competition. Furthermore, there was an increase in the range of motion and a partial improvement in strength in ER. However, compared with the contralateral side, there was a significant decrease in strength in ER in most patients, and recovery of muscle atrophy was inconsistent.

To explain SSN entrapment in the spinoglenoid notch in volleyball players, a number of different theories have been proposed that are neither structural nor constrictual due to ganglioma.[42,48,50] Most studies suggest traction of the nerve as the most likely mechanism.[7,13,14,18,39,43] Anatomic studies suggest that there are plenty of variations in morphology of suprascapular and the spinoglenoid notch,[35-38,52] as well as in the course and angle of the lateral trunk of the SSN.[12] Witvrouw et al[51] and Lajtai et al[25] found a significant difference in shoulder range of motion and scapular protraction between the dominant shoulder with and without ISP muscle atrophy, which supports the "stretch" theory in the pathogenesis of this pathology.

On the other hand, in some studies analyzing increased ER in overhead athletes,[2] no correlation between ISP atrophy and ER weakness was found.[21,22,41] However, the positive posterosuperior impingement signs noticed by Lajtai et al,[25] typical of the glenohumeral IR deficit (GIRD) syndrome described by Burkhart et al[6] as a thickening of the posterior capsule, which was also confirmed by Mihata et al,[29] could be responsible for this pathology. That said, Ferretti et al[13,14] and electromyographic analysis suggest that the mechanism of injury is correlated with the characteristic movement during "floating service," in which the player aims not for maximum speed, as in other throwing motions, but rather to launch the ball in a so-called floating trajectory.[40] This requires a much more intense stabilization of the shoulder than that provided by the external rotators; thus, the ISP muscle is activated much more intensely than in other throwing actions.

In this study, the most important parameter was ISP muscle strength in comparison with the contralateral side. ISP muscle strength was assessed by ER force measured by dynamometer with (1) the elbow at the side and (2) the elbow at 90° abduction. It has been shown previously that this means of assessment best reflects ISP muscle function.[16,26,32] A similar criterion together with dynamometric evaluation was used in only 2 other studies.[33,41] In their case report, Ozer et al[33] showed a small deficit in the diagonal pattern in peak torque and total work values (10% and 32%, respectively) of the operated shoulder. In our study, this deficit was higher, because strength regaining rate was 69.9% in the ER1 position and 63% in the ER2 position). However, the patient reported by Ozer et al[33] was only 18 years old, which may promote better recovery. Sandow and Ilic[41] reported an increase in ER strength from 50% of intact shoulder preoperatively to 80% to 90% postoperatively in 4 volleyball players. In other studies in which strength was assessed and compared with the unaffected side,[1,11,14,20] Lovett scores or the authors' own clinical scores were used as measurement tools, which can lead to increased risk of bias because methods of measurement were subjective. Among these 4 studies, Dramis and Pimpalnerkar[11] and Ferretti et al[14] reported total ER strength recovery in 4 out of 4 patients and in 1 out of 3 patients, respectively, whereas recovery was reported as partial in the other 2 studies.[1,20] Overall shoulder strength was evaluated in 6 other studies (totaling N = 24),[1,11,14,20,33,41] of which 8 (33.3%) cases achieved total recovery of ER strength.[11,14,33,41] Of the 24 patients, 15 (62.5%) showed partial improvement,[10,13,22,34] and 1 out of 24 patients (4.2%) lacked any improvement.

In our study, muscle bulk recovery was observed in 70% cases overall, and in 50% of cases, there was complete restoration of ISP muscle bulk. In other published studies, overall percentage of muscle volume enlargement were even higher, amounting to 43.5% for complete and 47.8% for partial recovery.[1,11,14,20] Sandow and Ilic[41] found that the best ISP muscle recovery results were achieved in younger patients (range, 24-28 years) in follow-up periods of >12 months. This may suggest that decompression at a younger age and longer rehabilitation are needed for good muscle regeneration, which was also noted in our study. This statement agrees with the hypothesis proposed by Ferretti et al,[14] who noticed a decrease in muscle atrophy only in the youngest patient and subsequently hypothesized that surgical treatment should be performed at an early stage of the neuropathy in young volleyballers to increase the likelihood of reinnervation. However, there is a paucity of data in the literature reporting improvement in ISP atrophy after arthroscopic decompression,[3,30,47] making any direct comparison difficult. In the technique presented in this study, extensive decompression of the SSN was performed at the level from the suprascapular notch to the spinoglenoid notch. It was assumed that extended release would minimize the risk of later microtraumas during volleyball training and promote better reinnervation of the ISP muscle. However, data published in this study do not support this assumption.

Functional results in our study were very good, with a mean CMS of 89.9 (range, 84-100) and no pain in all cases. CMS was used as a tool for functional assessment in 2 other studies.[3,47] Tsikouris et al[47] reported a mean CMS of 91 (range, 76-95), whereas in their case report, Baums et al[3] showed an increase in CMS from 72 preoperatively to 94 postoperatively. In 2 other studies, the Disabilities of the Arm, Shoulder and Hand score and the University of California, Los Angeles score were used,[33,47] and in both a noticeable improvement was observed postoperatively. The results reported by Tsikouris et al are particularly promising considering the fact that the article is a case series of 17 patients with SSN entrapment and accompanying lesions treated simultaneously. Our results are consistent with these studies.

Results from 9 studies after surgical treatment by decompression of the SSN in the spinoglenoid notch are summarized in Table 5.

Postoperatively, all of the patients returned to sports at the same level as before surgery. Postoperative return to sports was also possible in all of the patients among the studies included for analysis.

Strengths and Limitations

The strength of this study is that it is the largest, single-surgeon consecutive and uniform series published to date of professional volleyball players treated by arthroscopic extended decompression of the SSN at the level of both the spinoglenoid notch and suprascapular notch. The results published both in our study and in the literature so far are encouraging but inconclusive because of small number of heterogeneous cases available for analysis.[3,30,47] Furthermore, the biggest challenge with data available in the literature is the lack of consistency regarding the criteria for assessing the success of the treatment and inclusion criteria for surgery with concomitant pathologies.

This study has several limitations, including that the small group of patients analyzed could be associated with increased risk of bias. In addition, there were no preoperative dynamometer readings, thus the partially subjective Lovett and Martin[28] scale was used to gauge how much strength was gained. Moreover, there was lack of

TABLE 5
Summary of 9 Studies After Surgical Decompression of the SSN[a]

Lead Author (Year)	No. of Patients	Arthroscopic vs Open	Additional Procedures	Functional Improvement	Functional Scores	Strength Increase	Muscle Enlargement
Antoniadis (1996)[1]	8	Open	No	Yes	VAS	All partial	1 complete, 7 partial
Baums (2006)[3]	1	Arthroscopic	1 cyst	Yes	CMS, VAS	NR	NR
Dramis (2005)[11]	4	Open	No	Yes	VAS	Yes	Yes
Ferretti (1998)[14]	3	Open	No	Yes	VAS	1 full, 1 partial	1 partial, 2 none
Hama (1992)[20]	3	Open	No	Yes	VAS	All partial	2 complete, 1 partial
Ming (2018)[30]	1	Arthroscopic	No	NR	NR	NR	NR
Ozer (2007)[33]	1	Open	No	Yes	DASH, VAS	Yes	NR
Sandow (1998)[41]	5	Open	No	Yes	VAS	2 full, 3 partial	3 complete, 2 partial
Tsikouris (2018)[47]	17	Arthroscopic	17	Yes	UCLA, CMS, VAS	NR	NR

[a]CMS, Constant-Murley score; DASH, Disabilities of the Arm, Shoulder and Hand score; NR, not reported; SSN, suprascapular nerve; UCLA, University of California, Los Angeles shoulder score; VAS, visual analog sale.

homogeneous criteria used in the assessment of the postoperative outcomes, especially assessment of muscle bulk. These limitations render it challenging to make a complete and reliable comparison of the results of this study with the available literature. Last, we did not perform postoperative electromyography assessments or radiological follow-up with an MRI scan in every single case, which could potentially help objective assessment of muscle innervation and bulk, respectively. Further studies should focus on larger numbers of professional volleyball players, assessing the occurrence of GIRD, range of motion, positioning on the pitch, and the manner of serving the ball (floating or striking trajectory). Any possible impact on the incidence of ISP muscle atrophy and/or decrease in ER strength should be studied to understand the likely mechanism of injury.

CONCLUSION

This study has shown that arthroscopic extended decompression of SSN in a group of professional volleyball players is a safe and effective procedure likely to improve shoulder function. However, the results are not completely predictable when it comes to restoring the volume and strength of the ISP.

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