Clinical Outcome, PROM's, Power and Structural Integrity after Arthroscopic Subscapularis Tendon Repair

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Abstract

Purpose

The objective of this study is to assess tendon integrity, shoulder function and subscapularis (SCP) power in comparison to the contralateral normal shoulder after arthroscopic SCP repair using the SICK stitch technique.

Methods

This study assessed 32 patients with arthroscopically repaired SCP lesions. The mean age was 63.3 years. All patients were assessed with a clinical examination and ultrasound pre and postoperatively. Shoulder function was evaluated using specific clinical tests and established scoring systems. The muscular strength was measured using an Isoforce Control EVO2 device in two positions for SCP (standing and sitting).

Results

At a mean follow up of 18 months n=30 patients showed significantly improved range of motion and clinical scores (pre, post), Constant score (39.2, 66.7), subjective shoulder test (3.5, 92.32), subjective shoulder value (46.6, 88.2) and disabilities of arm, shoulder and hand score (69.3, 34). All tendons showed full integration in ultrasound and there was no significant difference for lesion size or additional SSP lesion. In comparison to the contralateral side a good restoration of power was observed.

Conclusions

After arthroscopic repair of the subscapularis tendon using the SICK-stitch technique, patients show a good restoration of shoulder function and power accompanied by good patient satisfaction. Additionally treated lesions did not significantly affect the surgical outcome.

Introduction

Musculus subscapularis as a multiplanar muscle has a fundamental role as a dynamic stabilizer of the shoulder.¹ The collagen fibers and tendinous insertion being parallel and overlapping with the middle and inferior glenohumeral ligament as well as the anterior joint capsule also provide passive stability. This is especially relevant in lower abduction angles and in a hanging arm position.²⁻⁴ All SCP fibers as a whole function as the main internal rotator of the shoulder joint and also assist in abduction and adduction depending of the joint position.^{1,2} (Fig. 1)

In the past SCP lesion were believed to be rare but recently a number of studies have underlined, that SCP lesions make up a considerable part of rotator cuff tears (RCT) that impair the shoulder function significantly⁵⁻⁹. Throughout the years many open and arthroscopic refixation approaches have been presented.^{6, 10-18} We hypothesized that the arthroscopic repair with conventional vertical mattress sutures are likely to cut through the tendon because they are in line and not perpendicular to the direction of forces and orientation of the fibers. The use of interlocking stitches has been shown to be biomechanically superior to conventional and other stitch configurations.^{19, 20}

Therefore, the SICK-stich technique for arthroscopic SCP reconstruction was developed, in order to increase pullout strength and avoid cutting through the horizontally oriented fibers. It consists of a running interlocking stitch and a vertical mattress suture using a double-loaded suture anchor.²¹ The purpose of this study is to determine the outcome after arthroscopic SCP reconstruction using the SICK-stich technique in terms of clinical function, range of motion, tendon integrity and strength in comparison to the contralateral side.

Material And Methods

In the past two years, 32 Patients with symptomatic SCP tendon tears (n=9 isolated SCP lesions, Fox Romeo II-IV²²; n=21 with additional SSP lesion) were treated by arthroscopic repair using the SICK-stich technique²¹. Twelve of the patients (40%) had a history of trauma. Inclusion criteria consisted of SCP lesions treated with arthroscopic repair with a minimum follow up of 1 year. Patients with irreparable and massive rotator cuff tears, fatty infiltration (Goutallier > 2) as well as glenohumeral osteoarthritis, previous operations and fractures were excluded. The mean age was 63.3 years (range, 45-80 years) at the time of surgery. The study was approved by the ethics committee and patients signed informed consent. All methods were performed in accordance with the relevant guidelines and regulations.

Preoperative assessment included range of motion (ROM), lift-off test, belly press test as well as bear hug test. Each patient underwent pre and postoperative evaluation with the disabilities of the shoulder and arm score (DASH), simple shoulder test (SST), simple shoulder value (SSV) and ultrasound (static and dynamic testing with passive external rotation). The postoperative assessment consisted of the preop workup plus power testing using the Isoforce Control EV02 device (F_{start} , F_{max} , F_{end} and F_d) in two positions (pos 1: standing, pos. 2: sitting) for SCP and one position for SSP (standing). (Figure 2A,B)

Measurements were performed three times; average values were used. The first and senior author of this study performed all clinical assessments.

SPSS® software (IBM SPSS Statistics for Windows, Version 21.0; IBM Corp., Armonk, NY, USA) was used for statistical analyses. The statistical significance level was set at 5% (p values < 0.05). The Wilcoxon rank test was used to compare pre- and postoperative values for ROM and scoring systems. The Mann-Whitney test was used to assess cofactors (gender, age, history of trauma, size of tendon lesion, additional SSP surgery). The Spearman's rank test was used to measure the correlation between strength and clinical scoring systems.

Postoperative Rehabilitation

The shoulder was immobilized in a 15° abduction brace for 3 weeks. Passive motion was permitted. Week 3 to 6 the patients were encouraged to gain active range of motion under shoulder height, with the supervision of a physiotherapist. External rotation was limited to 10° for the duration of 6 weeks. From week 7 postoperatively, unrestricted full range of motion was allowed. Movement and exercises against resistance were permitted at 3 months postoperatively. Full return to sports and heavy manual labor was allowed 6 months after surgery.

Results

The mean time of follow up time was 18 months (range, 12-23 months). The dominant side was affected in 17 patients (57%). Intraoperatively 17 (57%) patients had a Fox/Romeo²² grade 2 lesion, 10 (33%) grade 3 and 3

(10%) grade 4 lesion. A Pulley Lesion according to Habermeyer et al²³ Grade 2 was identified in 5 patients (16%), Grade 3 in 3 patients (10%) and 21 patients (70%) had a grade 4 lesion. Therefore, a tenotomy of the long head of the biceps tendon (LHBT) was performed in 19 cases (63%) and a LHBT tenodesis in 10 cases (33%).

The range of motion in the study group improved significantly (mean pre;post; p-value) for flexion (122.3°;167°; p<0.001), abduction (116.3°;167°; p<0.001), external rotation (28°;63°; p<0.001) and internal rotation (38°;66.7°; p<0.001). (Figure 3)

All clinical scores significantly improved from pre- to postoperative: CS (39.2;92.3; p<0.001), SST (3.5;10.4; p<0.001), SSV (46.6;88.2; p<0.001) and DASH (69.3;34; p=0.005). (Figure 4)

The DASH and SST score showed moderate correlation with power, whereas CS and SSV did not. (Table 1)

All patients had a normalization of preoperative positive lift-off, belly press and bear hug test respectively. There was no significant difference for gender, history of trauma, size of lesion (Fox/Rome grade) or additional SSP lesions.

Using the contralateral side for comparison, there was a good restoration of power in positions 1 and 2, with only F_{max} being significantly different (p<0.05). (Figure 5A,B)

All tendons showed a full integration during static and dynamic ultrasound testing.

All patients were very satisfied with the result and would have undergone the operation again.

One patient needed revision surgery due to infection six weeks after SCP repair after acute purulent bronchitis. Intraoperative specimens were positive for *Propionibacterium acnes*. One patient with a combined SCP and SSP repair at the time of index operation sustained a new trauma during a fall on the outstretched hand three month postoperatively. During revision surgery the SCP repair was found to be intact (Figure 6A-D) and the ruptured SSP tendon was arthroscopically repaired. Both patients were excluded from the follow-up examinations.

Discussion

The main finding of the study is the high rate of structural intact SCP repairs at the final follow-up which is accompanied by a good clinical function, return of power und subjective patient satisfaction as expressed by the used scorings and power measurements. All patients showed fully healed SCP tendons during standardized ultrasound examination and all patients with a preop positive lift-off test (n=18) had a normal lift-off test at the final follow-up. This is in contrast to the series of many other clinical studies (Table 2) where only Heikenfeld et al, Nove-Josserand et al. and Deutsch et al. reported about a complete normalization of the lift-off test in their series.^{5, 24, 25}

This may be attributable to the used technique of combining a running interlocking stitch with the first pair of suture strands that provide optimal reduction with excellent pullout strength and the second suture strand used to compress the entire construct onto the footprint at the lesser tuberosity.²¹ Other constructs such as mattress stitches have a tendency to cut through the tendon especially when there is a high amount of excursion of the humeral head, which tends to peel off the refixed tendon from the underlying bone. We observed this phenomenon frequently during combined SCP-SSP/ISP reconstructions when the SCP lesion was addressed at the beginning of

surgery. A thorough inspection revealed some insufficiency of the repaired SCP tendon-to-bone interface already just by the maneuvers necessary for postero-superior cuff reconstruction at the end of the procedure. This observation has led to the development of the very special technique used in this study. The technique is reproducible and easy with a steep learning curve for experienced shoulder surgeons at comparable technical demands and costs.

The high healing rate of the SCP tendons in contrast to many reports about SSP repair can be explained by the different anatomy. Whereas the SSP tendon is tight and under tension with the arm resting at the side and also after tendon repair the SCP tendon is rather relaxed and unloaded in a comfortable position with the arm at the side and in front of the trunk as in a sling after SCP repair. It becomes loaded and the reconstruction site under tension in forced external rotation and flexion and elevation, which are forbidden, in the immediate postoperative period. Over tightened SSP tendons have a high incidence of insufficiency and failure whereas an over tightened SCP may result in reduced ROM especially in ERO and therefore the therapeutic width may be higher before failure of the refixation construct.

Compared to other published studies this is the third largest patient cohort besides Edwards et al²⁶. and Lanz et al.¹⁶, who described the results of n=84 open and 46 arthroscopic SCP repairs. We still believe that there is a place for open cuff reconstruction especially in massive cuff tears but the technique used in our study is optimized for arthroscopic repair.

Few studies exist to test whether the strength of a successfully repaired SCP lesion can yield similar results as a normal and contralateral shoulder. We observed an excellent restoration of strength, which in some cases outperformed the contralateral side most likely due to training effects.

Seppel et al. used a force measuring plate that was worn on a strap around the neck for the belly-press test and mounted to the wall for the lift-off test.²⁷ They observed a reduction of strength on the affected side to 80% in the belly-press position and an improved strength for the lift-off position to 112% compared to the contralateral side at follow-up. The authors also observed a missing correlation between the size of the SCP lesion and the postoperative strength, pain and outcome scores like in our study.²⁷

The poor correlation between the Constant-Murley score and the subscapularis strength illustrates, that the CS may not be as valuable and useful to assess SCP lesions and SCP repair as it is for the SSP tendon.

Limitations

This study has a number of limitations that should be noted. One-year follow-up may not be enough to find late failures and compared to the longest follow up studies published so far by Nove-Josserand et al (47 months)²⁵ and Bartl et al (46 months)¹⁴. This may be a cause for concern, but on the other hand we provide an excellent follow-up rate. It appears to be very unlikely that the results for strength on the operated shoulder are going to deteriorate in the second year postoperatively and such an effect has never been described before.

We had a mixed group of traumatic (40%) and degenerative lesions as well as only 30% isolated SCP lesions. This fact should be noted when interpreting and comparing our results with other studies. We were unable to compare the power of the affected side pre to postoperatively mainly due to the clinical complaints and functional

impairment of the patients preop. We believe that the contralateral healthy shoulder is adequate to assess the restoration of strength after surgery and are not aware of any contradictory study.

Many surgeons might consider Ultrasound less valuable for the assessment of rotator cuff lesions compared to MRI. In a clinical multicenter study comparing Ultrasound examination by a trained shoulder surgeon and arthroscopy as the gold standard compared to reports by musculoskeletal radiologists using standard MRI we observed a high number of false-negative reports especially for smaller lesions.²⁸ The usefulness of ultrasound to assess SCP lesions is underlined by the study of Farin et al²⁹ who showed that dynamic sonographic imaging with the arm externally rotated and slightly abducted correlates with intraoperative findings of SCP lesions in 82% of the cases.

Conclusion

At final follow up 1 year after arthroscopic subscapularis tendon repair using the SICK-stich technique, we observed a generally very good restoration of shoulder function, power and high patient satisfaction. The additionally treated SSP lesions did not significantly affect the outcome.

SCP specific clinical examination and strength testing appear to be useful to fully assess the shoulder function if it is affected during surgery

Declarations

Contribution:

research design: JK, MF, KS

acquisition, analysis or interpretation of data: JK, KS, MF

drafting the paper or revising it critically: JK, MF, AH

approval of the submitted and final versions: JK, MF, AH

This study was presented at the annual SECEC-ESSSE congress 2017 in Berlin.

All authors have read and approved the final submitted manuscript.

All authors declare that they have no conflict of interest.

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Tables

Table 1

Correlation analysis for Constant-Murley Score (CS), Simple Shoulder Value (SSV), Disabilities of the Arm, Shoulder and Hand Score (DASH) and Simple Shoulder Test (SST) with the average power in the sitting position (Pos1) and standing position (Pos2) for F_{start} , F_{max} , F_{end} and F_d . Coefficient of correlation according to Spearman (r), level of significance $p < 0.05$.

		Pos1 F _{start}	Pos1 F _{max}	Pos1 F _{end}	Pos1 Fd	Pos2 F _{start}	Pos2 F _{max}	Pos2 F _{end}	Pos2 Fd
CS	r	0.11	0.09	0.18	0.15	0.19	0.10	0.09	0.16
	p	0.59	0.64	0.36	0.46	0.36	0.64	0.67	0.43
SSV	r	0.25	0.19	0.20	0.15	0.31	0.20	0.17	0.22
	p	0.23	0.39	0.35	0.49	0.16	0.37	0.44	0.31
DASH	r	-0.44	-0.45	-0.39	-0.44	-0.47	-0.45	-0.44	-0.49
	p	0.02	0.02	0.05	0.02	0.02	0.02	0.02	0.01
SST	r	0.62	0.60	0.57	0.62	0.71	0.70	0.67	0.72
	p	0.00	0.00	0.00	0.001	0.001	0.001	0.001	0.001

Table 2

Published results after open and arthroscopic subscapularis tendon repair. (Type – arthroscopic or open surgery, LOE – level of evidence, FU m – follow period in months, Age y – age at surgery in years, time to surgery in months, Trauma % - percentage of patient with traumatic event as reason for surgery, time to surgery – time from trauma or clinical presentation until operation in months, pre CS – preoperative Constant-Murley Score, post CS – postoperative Constant-Murley Score, lift-off pre n – number of patient with positive lift-off test before operation, lift-off post n – number of patient with positive lift-off test after the operation)

Author	Type	LOE	n	FU m	Age y	Trauma %	time to surgery	pre CS	post CS	lift- off pre n	lift- off post n
Farkhondeh Fal et al. 2020	arthroscopic	IV	30	18 (12-23)	63 (45-80)	40		39.2 (3-76)	92.3 (67.5-100)	18	0
Seppel et al. 2016	arthroscopic	IV	17	98	46 (13-73)	71	5 (0.3-26)	47.8 (32-57)	74.2 (30-95)		3
Grueninger et al. 2014	arthroscopic	IV	11	12	45 (32-65)	90	3.7	43.5	89.3	11	7
Heikenfeld et al. 2012	arthroscopic	IV	20	24	42 (31-56)	95		39.7	81 (61-95)	13	0
Lanz et al. 2013	arthroscopic	IV	46	24	62 (45-81)			46.2	77.3	31	14
Nove-Josserand et al. 2012	arthroscopic	IV	22	35.7 (25-49)	55 (46-74)			66.4	85.2 (70-95)	4	0
Nove-Josserand et al. 2012	open	IV	13	47.8 (36-57)	49.5 (22-62)			67.7	88.4 (54-96)	2	
Mancuso et al. 2014	arthroscopic	IV	10	17.7				37.3	86.7		
Bartl et al. 2011	arthroscopic	IV	21	27 (24-36)	44 (18-61)	91	6 (0.2-14)	50.3 (39-62)	82.4 (65-98)	16	1
Bennett et al. 2003	arthroscopic	IV	8	(24-48)	57 (32-76)			43.3 (32-51)	74.2 (66-88)		
Lafosse et al. 2007	arthroscopic	IV	17	29 (24-39)	47 (29-59)	77	24 (3-44)	52	84.9		
Bartl et al. 2011	open	IV	30	46.2 (25-72)	43 (15-64)	100	6 (0.2-15)	51.3 (39-62)	82.2 (65-98)	17	3
Fuchs et al. 2006	open	IV	10	38 (24-53)	59 (40-75)			51.8	72.9		
Edwards et al. 2005	open	IV	84	45.2 (24-132)	53 (23-77)	68	13 (0-108)	55 (14-84)	79.5 (25-101)	60	17
Kreuz et al. 2005	open	IV	16	36 (24-48)	46 (27-64)	100		44 (35-65)	88.7 (79-98)	13	

Deutsch et al. 1997	open	IV	14	24 (19-48)	38 (18-64)	100			14	0
Gerber et al. 1996	open	IV	16	43 (24-84)	50 (33-60)	100	15 (1-56)	82	13	3

Figures

Figure 1

T2-weighted MRI of a right shoulder in the frontal plane illustrating the course of the subscapularis muscle almost horizontally to the footprint at the lesser tuberosity. Note the several tendinous parts that confluence at the insertion zone (white arrows).

Figure 2

Assessment of SCP strength using the using the Isoforce Control EVO2 device in the standing (2A) and sitting (2B) position. Measurement of F_{start} , F_{max} , F_{end} and F_d .

Figure 3

Box plot diagram illustrating pre- and postoperative range of motion in degree (y axis) Flexion, Abduction, External and Internal rotation (x axis) (horizontal lines display median and the first and third quartiles and vertical lines indicate maximum and minimum values).

Figure 4

Box plot diagram illustrating PROM's in points (y axis) for Constant-Murley Score, Simple Shoulder Test, Simple Shoulder Value, DASH score (x axis) (horizontal lines display median and the first and third quartiles and vertical lines indicate maximum and minimum values).

(a)

(b)

Figure 5

Box plot diagram illustrating strength in N (y axis) for Fstart, Fmax, Fend and Fd (x axis) in the sitting (Figure 5A) and standing position (Figure 5B) (horizontal lines display median and the first and third quartiles and vertical lines indicate maximum and minimum values).

(a)

(b)

(c)

(d)

Figure 6

MRI scans in transverse (6a) and frontal plane (6b) and intraoperative arthroscopic view in neutral rotation (6c) of a patient with revision surgery 6m after SCP and SSP repair who sustained another fall and trauma to the operated shoulder. The pictures show an intact subscapularis tendon insertion (white arrow) whereas the retorn supraspinatus tendon (6d) needed revision refixation.