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Arthroscopic repair of isolated subscapularis tears: clinical outcome and structural integrity with a minimum follow-up of 4.6 years

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Background: After isolated subscapularis repair, improvement in shoulder function has been reported at short-term review. The purpose of this study was to determine whether arthroscopic subscapularis repair provides durable improvement in objective and subjective shoulder function with a low structural retear rate.
Methods: All patients treated with arthroscopic repair of an isolated subscapularis tear between August 2003 and December 2012 with a minimum follow-up period of 4.6 years were identified from our database. A number of patients in our study cohort underwent a prior complete midterm assessment, which allowed a subgroup analysis to detect changes in structural integrity and corresponding function. Clinical and radiographic outcomes, including outcomes on conventional radiography and magnetic resonance imaging or ultrasound, were assessed.
Results: The study enrolled 36 shoulders with a mean patient age of 57.7 years (range, 31-75 years; standard deviation, 10.6 years). The mean follow-up period was 8.6 years (range, 4.6-13.9 years; standard deviation, 2.44 years). Internal rotation to the thoracic vertebrae was achieved in 94% of cases and was significantly improved ($P < .001$) compared with the preoperative situation. The mean relative Constant score improved from 68% preoperatively to 93% at final follow-up ($P < .001$). Magnetic resonance imaging evaluation showed a rerupture rate of 2.7% (1 of 36 shoulders). Twenty patients underwent previous complete midterm assessment (mean, 2.9 years; range, 1-4.5 years), with comparisons between midterm and long-term follow-up showing comparable results without statistically significant deterioration.
Conclusions: Functional and subjective improvements in shoulder function are maintained at a mean follow-up of more than 8 years after isolated subscapularis repair and are associated with a low structural failure rate of the repair.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Rotator cuff; isolated subscapularis tear; arthroscopic repair; clinical outcome; long term; structural integrity

Approval from the responsible ethical committee was obtained (KEK-ZH-Nr. 2017-00660).

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Isolated subscapularis tears are less common than superior or combined rotator cuff tears but can be associated with disabling pain and a distinct pattern of functional impairment.[12,17,18] Isolated subscapularis repairs account for approximately 4% of all arthroscopic cuff repairs.[13,26]

Functionally, the subscapularis muscle is the dominant internal rotator of the arm. It acts as both a static stabilizer and dynamic stabilizer of the glenohumeral joint and forms the anterior segment of the transverse force couple.[6,22,37,38]

For subscapularis tears in symptomatic patients at working age with a preserved subscapularis muscle belly, negligible osteoarthritis, and absence of capsulitis, operative repair is usually considered. Open repair of isolated subscapularis tears has yielded excellent and durable clinical results that are superior to the natural history of the condition.[3,12,14,15,17] A number of studies have presented similar short-term results after arthroscopic surgery,[1,4,5,7,8,26-28,31,34,36] with a relatively small number of results of isolated subscapularis repairs.[2,3,5,24,26,32]

A recent study of 17 patients indicated that the long-term functional and structural outcome after arthroscopic repair of isolated subscapularis lesions is comparable with short-term and midterm results.[35] Longitudinal studies after superior rotator cuff tendon repair have documented a linear retear rate over the first 6 months and a subsequent exponential increase in the frequency of retears in the midterm to longer term.[25,30] A retear of the superior rotator cuff compromises the functional long-term outcome, although improvement over the preoperative state is often maintained.[23,39] It is not known whether subscapularis repairs show a similar linear early and/or late retear rate.

Our hypothesis was that arthroscopic subscapularis repair would be durable and that mean objective and subjective functional improvement would be seen at midterm to late-term review. In addition, subgroup analysis would be expected to show an increasing retear rate with time with a corresponding decrease in function compared with short-term follow-up.

Materials and methods

This was a retrospective case series with no comparison group. Informed consent was obtained from all patients. A database search was conducted to identify patients who had undergone arthroscopic repair of an isolated subscapularis tear from December 2003 to December 2012 (n = 57). The exclusion criteria included tears combined with the supraspinatus or infraspinatus tendon, fatty muscle infiltration of the subscapularis greater than Goutallier stage 2, bony avulsion of the subscapularis, osteoarthritis (3 patients), additional surgical procedures except biceps tenodesis or tenotomy, acromioclavicular (AC) joint resection or acromioplasty (2 patients), prior shoulder surgery (2 patients), prior or subsequent proximal humeral fracture (3 patients), and wheel chair dependence (1 patient). Patients with preoperative capsulitis with substantial loss of passive glenohumeral range of motion and patients with inflammatory arthropathy were also excluded.

Patients were contacted, and an "opt in" method of enrollment was used. Further dropout occurred owing to 3 patients who died after short-term follow-up and 8 patients who declined long-term review. This left 36 shoulders (35 patients) for personal, clinical examination and imaging. Of these, 20 underwent a complete clinical and radiographic midterm assessment because a review of isolated subscapularis repairs had been conducted at our institute previously. This allowed a subgroup analysis at 2 postoperative time points to track fatty infiltration (FI) and functional deterioration with time.

Indication, surgical technique, and postoperative care

The clinical suspicion of a subscapularis tendon tear was confirmed by magnetic resonance imaging (MRI). Patients of working age who had pain and impairment of shoulder function, minimal osteoarthritis, no capsulitis, and fatty muscle infiltration of grade 2 or lower[16] were considered for repair. Arthroscopy was performed with the patient either under general and interscalene anesthesia or under interscalene anesthesia alone in the beach-chair position with the arm in a dedicated arm holder (Spider; Tenet Medical Engineering, Calgary, AB, Canada). All operations were performed by an experienced shoulder surgeon. Most cases were operated on with the scope in the standard posterior portal with the aid of a 70° lens. The musculotendinous unit was mobilized to allow re-creation of the footprint without significant tension. After débridement of the bony footprint, double-loaded titanium anchors (Smith & Nephew Twinfix anchors, 6.5 mm, with Ultrabraid suture [Andover, MA, USA] or Karl Storz anchors, 6.5 mm [Tuttlingen, Germany]) were placed in the footprint. The number of anchors depended on the size of the tear: One anchor was used for lesions confirmed as grade I or II. With 1 exception, 2 or 3 anchors were used for grade III or IV lesions. To aid repair, No. 1 polydioxanone suture was often used as a stay suture to exert traction and allow temporary tendon reduction during passage of a clever hook (Fig. 1). The sutures were passed through the tendon using the clever hook. A shuttle technique with No. 1 polydioxanone suture was used if it was not possible to penetrate the tendon with the clever hook. For the reconstruction, simple stitches or mattress stitches were used. For the most superior suture, a loop technique was performed. To avoid overtensioning, retracted tears were repaired to the medial aspect of the footprint. No double-row techniques were used.

During diagnostic arthroscopy, the visible aspect of the long head of the biceps tendon (LHBT) was described and its stability tested. If the LHBT was either subluxated or inflamed, biceps tenotomy or tenodesis was performed before the subscapularis tendon repair. On the basis of clinical findings, an additional acromioplasty and/or AC joint resection was performed.

Postoperatively, patients wore a 2-strap sling for 6 weeks and performed exercises with a physiotherapist. Passive rotation from a resting internal rotation position to neutral, as well as passive abduction in internal rotation, was allowed before 6 weeks. Active mobilization was started at 6 weeks, with strengthening exercises after 12 weeks. Manual labor and sports involving the upper limb were restricted for 4 months postoperatively.

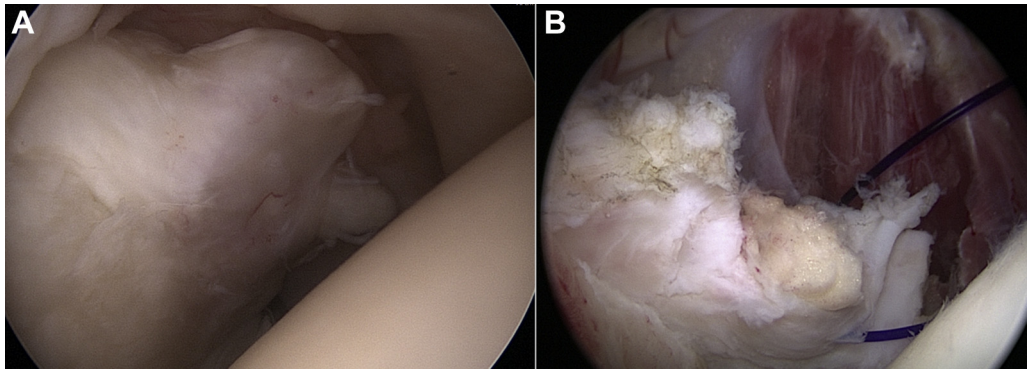

Figure 1 (**A**) Arthroscopic view of a full-thickness subscapularis lesion (grade IV[26]) in a right shoulder. (**B**) Stay sutures were applied to bring the retracted tendon back to the footprint.

Chart review

In addition to reviewing prospectively collected data, we conducted a retrospective chart review. The cause of the tendon tear was recorded; if trauma had occurred, the delay between the incident and surgery was recorded. Other variables included the intraoperative size of the subscapularis lesion, additional surgical procedures performed, and postoperative complications. Finally, smoking status and prior regional steroid treatments around the shoulder were noted.

Clinical assessment

The follow-up clinical assessment was performed with a structured interview and a detailed physical examination. Each patient underwent preoperative and postoperative evaluation with the Constant score (CS)[10] and Subjective Shoulder Value (SSV).[19] The physical examination included the lift-off test, Jobe test, palm-up test, and range-of-motion assessment. Patients were asked about their ability to work and satisfaction with current shoulder function.

Imaging assessment

Radiographs including anteroposterior, axial, and Neer views were obtained in all patients preoperatively, postoperatively, and at any review. These were analyzed to determine the acromiohumeral distance and the position of the inserted anchors. All patients underwent a standardized MRI examination or ultrasound prior to surgery. Every patient underwent further soft-tissue imaging at any review. If MRI was refused by the patient (n = 5), an ultrasound was performed by an experienced musculoskeletal radiologist. The images were analyzed by an independent radiologist and a shoulder fellow (A.H.). The size of the tear was classified according to Lafosse et al[26] (Fig. 2). A consensus was achieved for all patients regarding rerupture and degree of fatty degeneration. Analysis for a retear of the tendon repair was assessed with established MRI criteria.[21,33] When a fluid-equivalent signal was found or the subscapularis tendon could not be visualized on 1 or more standard T2-weighted images or fat-suppressed proton density–weighted and T2-weighted images, the diagnosis of a retear was made. Intramuscular fatty degeneration was assessed with the criteria established by Goutallier et al[20] for computed tomography and adapted by Fuchs et al[16] for MRI on T1-weighted parasagittal scans.

The lengths of the subscapularis tendon and the muscle, as well as the location of the musculotendinous unit, were evaluated on axial scans (T1) as described by Meyer et al.[29] The most cranial axial slice on which the tendon was still depicted was used.

Statistical analysis

Calculations and illustrations were conducted with SPSS software for Windows (version 11.0; IBM, Armonk, NY,

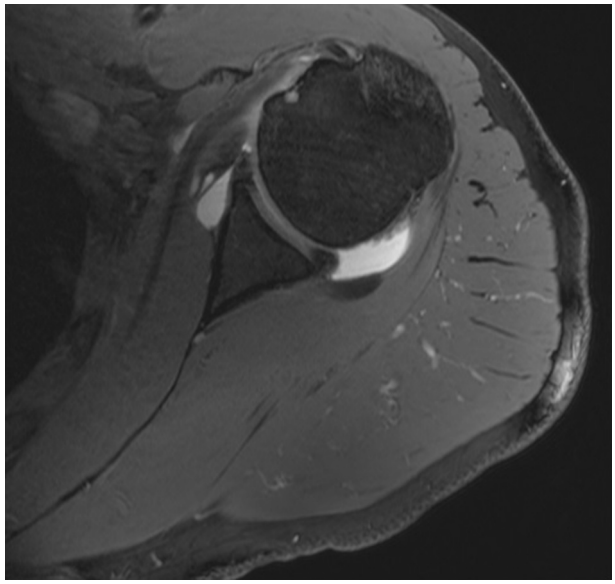

Figure 2 Axial magnetic resonance imaging shows a lesion of the subscapularis preoperatively.

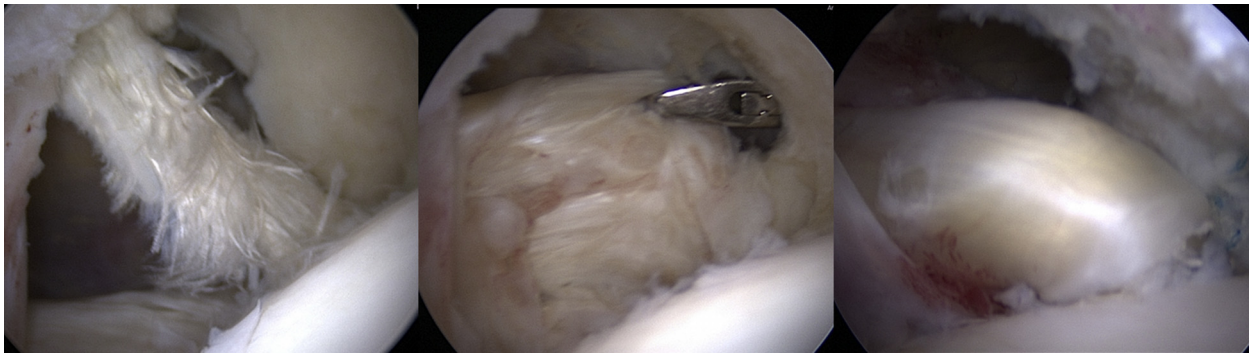

Figure 3 Arthroscopic views of a partially ruptured long head of the biceps tendon with a subscapularis tear in the upper third in a 58-year-old male patient. Biceps tenotomy and repair of the subscapularis tendon were performed with 1 anchor (Karl Storz anchor, 6.5 mm).

USA). Continuous data were presented as means, ranges, and standard deviations. Data were tested for normality with the Shapiro-Wilk test, and normally distributed data were compared by use of a paired t test. Dichotomous variables were compared using the McNemar test. For the evaluation of correlations, we used either a Spearman rank-order correlation (between 2 ranked variables) or Pearson correlation (between 2 continuous variables). The level of significance was set at $P < .05$ for comparisons between 2 groups.

Results

Demographic data

The study included 36 shoulders (15 in women and 21 in men) with a mean patient age of 57.7 years (range, 31-75 years; standard deviation [SD], ±10.6 years). The mean follow-up period was 8.6 years (range, 4.6-13.9 years; SD, ±2.44 years). Twenty patients also underwent previous complete midterm assessment (mean, 2.9 years; range, 1-4.5 years).

The dominant side was involved in 24 cases (67%). In 19 shoulders (53%), a tear had been sustained during a clear traumatic event. In the traumatic group, the mean delay between trauma and surgery was 11.7 months (range, 0.9-125 months; SD, ±28 months).

Prior to surgery, 14 patients (39%) received at least 1 subacromial steroid injection and 4 patients (11%) received glenohumeral injections. Moreover, 6 patients (17%) were smokers.

Retrospectively, on the basis of the surgical report, the subscapularis lesion was classified according to Lafosse et al.[26] The subscapularis lesion was grade I or II in 23 cases, grade III in 4, and grade IV in 9.

The mean preoperative length of the subscapularis tendon[29] was 43 mm (range, 25-56 mm; SD, ±9 mm), and the mean muscle length was 97 mm (range, 78-121 mm; SD, ±14 mm). The musculotendinous junction was, on average, 3 mm (range, –20 to 15 mm; SD, ±11 mm) medial to the glenoid.

The LHBT was normal in 11 cases (30.6%), showed tendinopathy in 24 (66.7%), was partially or completely torn in 2, and was completely dislocated in 5 (13.9%). Of the shoulders, 20 (55.6%) underwent tenotomy of the LHBT and 5 (13.9%) underwent tenodesis (Fig. 3).

A mean of 1.6 anchors were used (range, 1-4 anchors). In addition, AC joint resection was performed in 9 shoulders and lateral acromioplasty was performed in 16 (Table I).

Clinical results preoperatively and at long-term review

At latest follow-up, 31 shoulders (86.1%) showed subjectively excellent results; 4 (11.1%), good; and 1 (2.7%),

Table I Concomitant procedures and number of anchors for all shoulders and by lesion type

	All shoulders (N = 36)	Type I or II (n = 23)	Type III (n = 4)	Type IV (n = 9)
Biceps tenotomy	20 (55.6)	11	2	6
Biceps tenodesis	5 (13.9)	3	0	3
Bony acromioplasty	16 (44)	12	2	1
AC joint resection	9 (25)	6	1	2
Mean No. of anchors	1.7	1.1	2.3	2.6

AC, acromioclavicular.
Data are presented as number (percentage) or number unless otherwise indicated.

disappointing. The average SSV improved from a mean of 40% (range, 0%-80%; SD, ±25%) preoperatively to 91% (range, 40%-100%; SD, ±13%) at final follow-up ($P <$ .001). The mean absolute CS improved from 60.6 points (range, 28-85 points; SD, ±14.1 points) to 81.0 points (range, 64-98 points; SD, ±8.5 points) ($P <$ .001), and the relative CS improved from 68.5% (range, 37.6%-91.5%; SD, ±14.4%) to 93.1% (range, 68.0%-108.0%; SD, ±9.3%) ($P <$ .001). All sections of the CS improved over time (Table II).

Preoperatively, the lift-off test was positive in 17 shoulders (50%) and negative in 17 (2 patients were not able to perform the test). At last follow-up, the test was positive in 4 shoulders (11.1%) ($P <$ 001). Preoperatively, the palm-up test was painful in 23 shoulders and negative in 13. At final review, a pain-free palm-up test was found in 35 shoulders ($P <$ .001).

Despite normal morphology of the supraspinatus on MRI and confirmation of integrity intraoperatively, the Jobe test was positive in 18 shoulders and negative in 17 (1 result was not recorded). At last follow-up, 2 patients had a positive test ($P <$ .001). We could not find a correlation between fatty degeneration of the subscapularis muscle and a positive Jobe test (preoperatively, $P =$ .666; postoperatively, $P =$ .093). FI did not correlate with abduction power preoperatively ($P =$ .417) or postoperatively ($P =$ .702).

Changes in flexion, abduction, and external rotation did not reach statistical significance from preoperatively to final follow-up. A more detailed analysis is presented in Table II.

Active internal rotation significantly improved from preoperatively to final-follow-up ($P <$ .001). Preoperatively and postoperatively, no significant correlations were found between the range of active internal rotation and fatty degeneration of the subscapularis muscle ($P =$ .619 and $P =$ .922, respectively) or the length of the subscapularis tendon ($P =$ .230 and $P =$ .061, respectively).

The clinical results were evaluated regarding the size of the tear. With the sample size, we did not see a correlation between tear size and clinical outcome (Table III).

In terms of working status at final follow-up, 7 patients had manual jobs, 4 had nonmanual jobs, and 24 were retired (preoperatively, 20 had manual jobs, 10 had nonmanual jobs, and 6 were retired): 11 patients (30.5%) had returned to their previous employment without restrictions, whereas 24 patients (66.7%) were retired because they reached retirement age and not because of functional restriction. One patient had received a disability pension before and after surgery because of severe coronary artery disease 8 years before index shoulder surgery.

Table II Clinical parameters preoperatively and at long-term follow-up (range, 55-102 mo) for entire series (N = 36)

	Preoperative	Long-term follow-up	Comparison of preoperative vs. last follow-up: *P* value
SSV, %	40 ± 4	91 ± 12	<.001*
Constant score			
Absolute,† points	61 ± 14	81 ± 8	<.001*
Relative,‡ %	68 ± 14	93 ± 9	<.001*
Pain,§ points	6 ± 3	14 ± 2	<.001*
Activities of daily living,‖ points	7 ± 3	10 ± 2	<.001*
Active mobility			
Flexion, °	150 ± 22	156 ± 11	.148
Abduction, °	140 ± 31	151 ± 13	.052
External rotation, °	55 ± 16	60 ± 15	.143
Internal rotation¶	7 ± 3	9 ± 1	<.001*
Positive lift-off test	17 (50)	4 (20)	<.001*
Strength of abduction,# kg	9 ± 6	13 ± 6	.001*

SSV, Subjective Shoulder Value.

Continuous data are presented as mean ± standard deviation, and categorical data are presented as number (percentage).

* Statistically significant.

† The absolute score is the average of the points given according to the system of Constant and Murley.[10]

‡ The relative Constant score is the percentage of an age- and sex-related normal value according to Constant.[10,11]

§ Pain is measured on a visual analog scale on which 15 indicates no pain and 0 indicates intolerable pain.

‖ Rating of activities of daily living is performed on a scale from 0 to 10, on which 10 indicates a full activity level regarding daily living and/or work, as well as sport activities, and no sleeping problems.

¶ Internal rotation is measured as the level that can be reached by the thumb (0, greater trochanter; 2, buttock; 4, lumbosacral junction; 6, L3; 8, T12; and 10, T7).

Strength of abduction is measured with an electronic dynamometer with the arm in 90° of scapular abduction, the elbow extended, resistance applied at the wrist, and the forearm pronated.

Table III Clinical results in correlation to tear size by Lafosse classification

	Type I or II (n = 23)		Type III (n = 4)		Type IV (n = 9)	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
SSV, %	41 ± 24	90 ± 15	40 ± 56	90 ± 14	38 ± 25	92 ± 8
Constant score						
Absolute,* points	63 ± 11	81 ± 9	71 ± 20	79 ± 17	54 ± 16	80 ± 7
Relative,† %	71 ± 12	93 ± 10	78 ± 17	90 ± 16	62 ± 17	93 ± 7
Pain,‡ points	5 ± 3	13 ± 2	7 ± 4	11 ± 5	7.5 ± 4	14 ± 1

SSV, Subjective Shoulder Value.
Continuous data are presented as mean ± standard deviation.
* The absolute score is the average of the points given according to the system of Constant and Murley.[10]
† The relative Constant score is the percentage of an age- and sex-related normal value according to Constant.[10,11]
‡ Pain is measured on a visual analog scale on which 15 indicates no pain and 0 indicates intolerable pain.

Imaging results preoperatively and at long-term review

Radiographs at review excluded anchor displacement. The acromiohumeral distance did not significantly change from preoperatively (mean, 10.6 mm; range, 7-13.5 mm; SD, ±1.6 mm) to final follow-up (mean, 10.1 mm; range, 7-14 mm, SD, ±1.6 mm; $P = .19$).

For 31 of 36 shoulders (86.1%), the patients agreed to undergo follow-up MRI, whereas for 5 (13.9%), the patients refused because of claustrophobia but agreed to undergo an ultrasound evaluation. No full-thickness retears were found. In 1 shoulder (2.8%), a recurrent upper two-thirds tear of the subscapularis was noted (preoperative subscapularis grade IV, with Goutallier grade 2). The follow-up time for this patient was 11 years, and the tendon repair had been intact at 4 years, with stage 4 FI on MRI. Despite the poor muscle quality and the partial tear, this patient had a negative lift-off test and had internal rotation to the 12th thoracic vertebra. His clinical results were good, with an SSV of 80%, an absolute CS of 78 points, and a relative CS of 93% (Fig. 4).

In all other shoulders (97.2%), the subscapularis repair was healed. Fatty muscle infiltration was compared with the preoperative and midterm MRI findings. According to the Goutallier classification,[20] FI of the subscapularis increased significantly from a mean grade of 0.48 (range, 0-2; SD, ±0.66) preoperatively to a mean grade of 1.3 (range, 0-4; SD, ±0.93) at follow-up ($P < .001$). A significant progression of FI was also observed for the supraspinatus muscle (mean grade, 0.2 [range, 0-1; SD, ±0.43] vs. 0.8 [range, 0-2; SD, ±0.63]; $P < .001$) and infraspinatus muscle (mean grade, 0.3 [range, 0-1; SD, ±0.46] vs. 0.8 [range, 0-2; SD, ±0.65]; $P = .002$) (Table IV).

At last follow-up, the mean length of the subscapularis tendon[29] was 38 mm (range, 22-52 mm; SD, ±8 mm); the mean muscle length was 103 mm (range, 69-123 mm; SD, ±12 mm); and the musculotendinous unit was, on average, 0.5 mm (range, –15 to 18 mm; SD, ±7 mm) lateral to the glenoid. We found no significant changes in the mean length of the subscapularis tendon,[29] muscle length, and musculotendinous unit location from preoperatively to last follow-up ($P = .105$, $P = .332$, and $P = .208$, respectively).

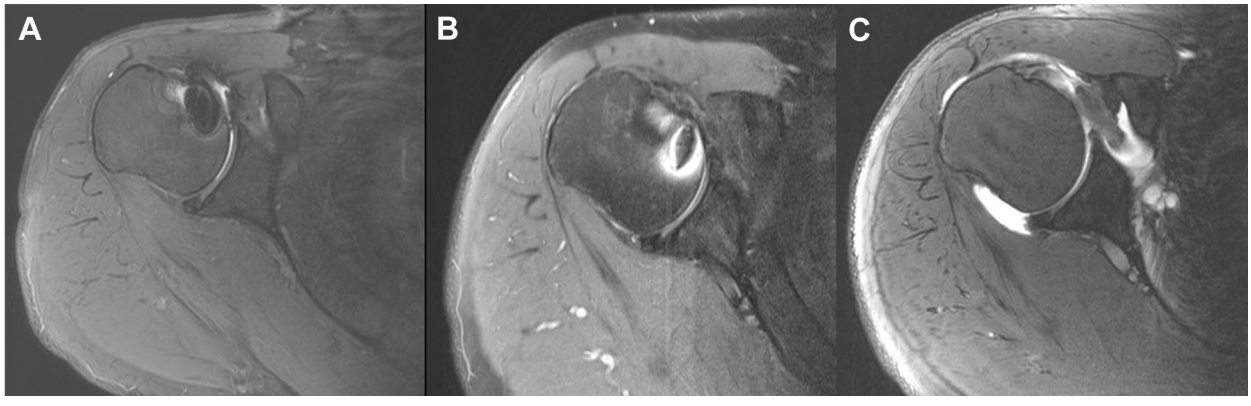

Figure 4 (**A**) Preoperative rupture. (**B**) Intact repair at 4 years. (**C**) Full-thickness upper-border tear at 11 years.[26]

Table IV Intramuscular fatty degeneration preoperatively and at long-term follow-up

	Preoperative (n = 35)	Long-term follow-up (n = 31)	Comparison of preoperative vs. last follow-up: *P* value
Subscapularis fatty degeneration	0.5	1.3	.001*
Supraspinatus fatty degeneration	0.2	0.8	.001*
Infraspinatus fatty degeneration	0.3	0.8	.002*

Continuous data are presented as mean values.
* Statistically significant.

Complications

One or more complications occurred in 6 shoulders (16.6%). As previously noted, 1 retear occurred. Adhesive capsulitis was diagnosed in 4 patients. After unsuccessful conservative therapy, 2 of the 4 patients underwent arthroscopic capsular release at 10 and 24 months. At final review, 3 of these patients had good to excellent long-term clinical outcomes. One patient with an intact repair continued to have pain (visual analog scale score, 8) associated with a relative CS of 68%. Further investigations were refused by the patient, and the residual pain remained unexplained.

In 1 patient who smoked and had type II diabetes mellitus, a deep infection with *Cutibacterium acnes* developed and arthroscopic joint lavage was performed. The infection resolved with intravenous and, later, oral antibiotic therapy. In this patient, the clinical outcome at last follow-up was excellent, with a relative CS of 101% and an SSV of 100% (Table V).

Subgroup analysis: midterm to long-term review

A subgroup of 20 shoulders (55.6%) had complete imaging and examination findings and shoulder scores available for comparison after 1 year (mean, 2.9 years; range, 1-4.5 years) and beyond 4.6 years (mean, 8.51 years; range, 4.6-13.9 years). The average period between the 2 reviews was 6.8 years (range, 2.3-8.0 years; SD, 1.7 years).

Table V Complications

Complication	Data
Retear of subscapularis*	1 (2.8)
Frozen shoulder	
Conservative treatment	2 (11.1)
Arthroscopy with capsulotomy	2 (11.1)
Infection†	1 (2.8)
Total	6 (16.6)

Categorical data as number (percentage).
* The patient had an intact tendon repair at 4-year follow-up and had a good clinical result at last follow-up with a Subjective Shoulder Value of 80%.
† A shoulder infection with *Cutibacterium acnes* developed. Arthroscopic joint lavage was performed, in addition to antibiotic therapy for 6 weeks.

Clinical results

Between the 2 time points, the clinical results were not significantly different: The mean SSV of 85% (range, 40%-100%; SD, ±19.7%) increased with time to 91% (range, 40%-100%; SD, ±13%; $P = .786$); the absolute CS of 77.5 points (range, 34-93 points; SD, ±16.8 points) increased to 81.2 points (range, 64-98 points; SD, ±8.5 points; $P = .239$); and the relative CS of 87.2% (range, 40%-105.2%; SD, ±18.6%) increased to 93.6% (range, 68.0%-108.0%; SD, ±9.3%; $P = .169$). Pain level and ability to perform activities of daily living were not significantly different. Active range of motion improved significantly between the 2 time points for external rotation ($P = .024$) and internal rotation ($P = .007$) but not for other movements (Table VI).

Imaging results

Although a significant increase occurred between preoperative and midterm follow-up, no progression of FI occurred between midterm and long-term follow-up for either the subscapularis, supraspinatus, or infraspinatus muscle (Table VII).

Risk analysis: further evaluation

Tenotomy vs. tenodesis

No significant difference in the outcome at last follow-up, based on the relative CS, was found between patients who underwent tenotomy and those who underwent tenodesis ($P = .682$).

Correlation between tendon length and clinical outcome

We could not find a correlation between tendon length, muscle length and location of the musculotendinous unit and the clinical outcome (relative CS) ($P = .172$, $P = .190$, and $P = .116$, respectively).

Table VI Subgroup analysis of clinical parameters at midterm to long-term follow-up (n = 20)

	Midterm follow-up	Comparison of midterm vs. long-term follow-up: *P* value
SSV, %	85 ± 19	.786
Constant score		
Absolute,* points	78 ± 16	.239
Relative,† %	87 ± 19	.169
Pain,‡ points	13 ± 4	.786
Activities of daily living,§ points	9 ± 1.5	.367
Active mobility		
Flexion, °	156 ± 26	.963
Abduction, °	152 ± 27	.873
External rotation, °	49 ± 13	.024‖
Internal rotation¶	6 ± 3	.007‖
Positive lift-off test	4 (20)	>.999
Strength of abduction,# kg	10 ± 6	.116

SSV, Subjective Shoulder Value.
Continuous data are presented as mean ± standard deviation, and categorical data are presented as number (percentage).
* The absolute score is the average of the points given according to the system of Constant and Murley.[10]
† The relative Constant score is the percentage of an age- and sex-related normal value according to Constant.[10,11]
‡ Pain is measured on a visual analog scale on which 15 indicates no pain and 0 indicates intolerable pain.
§ Rating of activities of daily living is performed on a scale from 0 to 10, on which 10 indicates a full activity level regarding daily living and/or work, as well as sport activities, and no sleeping problems.
‖ Statistically significant.
¶ Internal rotation is measured as the level that can be reached by the thumb (0, greater trochanter; 2, buttock; 4, lumbosacral junction; 6, L3; 8, T12; and 10, T7).
# Strength of abduction is measured with an electronic dynamometer with the arm in 90° of scapular abduction, the elbow extended, resistance applied at the wrist, and the forearm pronated.

Table VII Subgroup analysis of radiologic parameters at midterm and long-term follow-up: analysis of intramuscular fatty degeneration in patients with MRI (n = 16)

	Midterm follow-up	Comparison of midterm vs. long-term follow-up: *P* value
Subscapularis fatty infiltration	1.3	.317
Supraspinatus fatty infiltration	0.5	.317
Infraspinatus fatty infiltration	0.5	.157

MRI, magnetic resonance imaging.
Continuous data are presented as mean values. If MRI was available, intramuscular fatty infiltration was assessed using the criteria established by Goutallier et al[20] and adapted by Fuchs et al[16] for MRI.

Correlation between FI of subscapularis and clinical outcome

No significant correlation was found between the SSV or relative CS and FI of the subscapularis tendon ($P = .056$ and $P = .908$, respectively).

Discussion

The current literature supports repair of symptomatic isolated subscapularis tears in appropriate patients. Open repair has yielded excellent and durable clinical results,[3,12,14,15,17] and several publications have suggested that similar results can be obtained with arthroscopic subscapularis tendon repair.[2,5,24,26,32]

Our study describes the clinical and structural results of one of the largest series of arthroscopic repairs of isolated subscapularis tendon tears with a relatively long minimal follow-up period. It has documented that the clinical state (CS, SSV) of the shoulders is significantly and durably improved and that the procedure is associated with a very high degree of patient satisfaction. Our clinical and subjective findings corroborate the results of open subscapularis repairs,[3,12,14,15,17] as well as shorter-term arthroscopic subscapularis repairs.[2,5,24,26,32] In our longitudinal analysis, no decrease in functional scores occurred at the 2 time points postoperatively, indicating durable improvements in function over time.

Several reports on open and arthroscopic subscapularis tendon repairs have described postoperative subscapularis deficiency in 15% to 20% of patients.[1,14,17] In our series, 4 shoulders (11.1%) had a positive lift-off test in internal rotation postoperatively. MRI review of these shoulders showed that the subscapularis was intact and showed FI with a mean Goutallier grade of 1.7 (range, 1-3). Conversely, our single case of subscapularis partial failure on review had a negative lift-off test. These findings may indicate that the lift-off test is not a reliable marker of tendon integrity after repair and further imaging may be required if repair integrity is in doubt.

Longitudinal series on patients who have undergone superior cuff repair have shown a linear increase in the tendon retear rate in the first 6 months and exponential increases in tear rates in longer-term studies.[9,25,30] Our series showed a low retear rate in the first 6 months (0%) and 1 retear after 4 years among all 36 cases. Similarly to observations in superior cuff tendon retears, in which clinical improvement occurs despite retears, especially if the retears are smaller than the original tears, functional improvement over the preoperative state was seen in our patient with a partial retear: Our single retear was a tear of only the upper border, with the caudal tendon intact, and this similarly may explain the functional improvement.

The effect of tendon repair on fatty muscle infiltration remains controversial. Whereas progression of FI after

open or arthroscopic tendon repair has been noted,[32] Lafosse et al[26] did not observe any progression after arthroscopic repair after an average follow-up period of 29 months (range, 24-39 months) on computed tomographic arthrograms. Our analysis concurs with the results of Fuchs et al,[15] who observed significant progression of FI in all rotator cuff tendons after a mean follow-up period of 38 months (range, 24-53 months). An interesting finding was that, between midterm and long-term follow-up, no significant further progression of the FI occurred; neither, however, did a single case of improvement or recovery from FI of the subscapularis occur, even after clinically and structurally successful repair.

To our knowledge, data regarding return to work after arthroscopic subscapularis repair have not yet been reported. In our series, all patients at working age were able to return to their employment, and the dropout from employment was related to reaching the retirement age but not residual clinical problems with the shoulder. One patient had received a disability pension before and after surgery because of severe coronary artery disease 8 years before index shoulder surgery.

This study has some limitations. First, it is a retrospective clinical series with its corresponding shortcomings. At our institution, data are prospectively collected, digitized, and stored in a standardized fashion; this includes clinical as well as imaging data. As such, the preoperative data were nearly complete and easily accessible. Unfortunately, the belly-press test was not completely documented preoperatively and therefore could not be used. Chart review was still required to add data of interest and targeted follow-up data, and final clinical and imaging follow-up was carried out specifically for the purpose of this study. We believe that our hypothesis that repair would provide a durable improvement in objective and subjective shoulder function and would be associated with a durable structural outcome can be confirmed with this study design. We acknowledge that the study does not document any superiority over other treatment methods; however, with a large experience in open subscapularis repairs, it rules out inferior results of open repairs in the same institution. The number of patients is relatively small, but isolated, symptomatic subscapularis tears are relatively rare and our study is the largest in the literature. Another limitation is the use of different imaging modalities (magnetic resonance arthrography at the time of diagnosis and ultrasound as well as MRI without arthrography at follow-up). The literature suggests that full-thickness tears can be diagnosed with comparable reliability using standard MRI scans, magnetic resonance arthrography, and ultrasound.[11] Our research board deemed it unethical to expose asymptomatic patients to repeated arthrography without a clear benefit to the patients or to the study, so MRI without arthrography was performed whenever possible, with ultrasound as a backup for claustrophobic patients.

Despite the aforementioned limitations, our study documents a substantial and lasting benefit for patients with symptomatic, disabling subscapularis tears and confirms the integrity of the repair in the large majority of patients at a mean follow-up of more than 8 years.

Conclusion

Arthroscopic repair of isolated subscapularis tears yields good to excellent objective and subjective functional results and a low retear rate with durable structural integrity. No deterioration in function or muscle degeneration is seen from midterm to long-term follow-up in these patients.

Disclaimer

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