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Original article

Repair failure increases the risk of developing secondary glenohumeral osteoarthritis: A long-term follow-up after open repair of large subscapularis tendon tears☆

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ABSTRACT

Background: The subscapularis musculotendinous unit provides a stabilizing effect on the glenohumeral joint and thus, enables normal active range of motion. As pathologies of the subscapularis tendon (SSC) are diagnosed with increased regularity, treatment strategies and their long-term consequences are of relevant interest. Therefore, the primary objective of this retrospective case series was to evaluate clinical and radiological long-term results after open repair of large SSC tears.
Hypothesis: Repair failure negatively influences clinical outcomes and the progression of secondary glenohumeral osteoarthritis (OA).
Methods: Between 1998 and 2007, 24 patients with traumatic large (Lafosse III and IV) SSC tears were treated with an open transosseous repair technique. Of those, 20 patients (83%) with a mean age of 55 ± 8 years (range, from 31 to 68 years) at the time of surgery were subjected to a long-term follow-up after a mean of 14 ± 3 years (range, from 10 to 18 years). The Subjective Shoulder Value (SSV), the Constant Score (CS), the University of California at Los Angeles (UCLA) Shoulder Score, and the American Society for Shoulder and Elbow Surgeons (ASES) Score were obtained. Magnetic resonance imaging (MRI) was performed to evaluate tendon integrity. The progression of secondary glenohumeral OA from pre- to postoperative was analyzed using the collective instability arthropathy (CIA) score.
Results: One patient (5%) had to undergo revision surgery due to a symptomatic re-tear of the SSC tendon. Besides that, the mean SSV of the affected shoulder was 83% ± 12, the CS 78 ± 10, the UCLA 32 ± 2, and the ASES 89 ± 14 points, respectively. MRI revealed a re-tear of the SSC tendon in 4 patients (29%). On the affected shoulder, glenohumeral OA progressed significantly from pre- (CIA, 0.3 ± 0.5) to postoperative (CIA, 1.7 ± 0.9; $p = 0.003$) and was significantly associated with repair failure ($p = 0.040$).
Conclusion: Open repair of large SSC tears yielded good clinical long-term results. Nevertheless, repair failure was common and, in the further course, negatively affected clinical outcomes and the progression of secondary glenohumeral OA.
Level of Evidence: IV; retrospective case series.

1. Introduction

With the development of arthroscopic procedures, subscapularis tendon (SSC) pathologies are recognized with increased regularity [1,2]. They are primarily based on acute injuries including either hyperextension and forced external rotation of the abducted arm or glenohumeral dislocation [3–6]. The SSC musculotendinous unit is an inevitable element in optimal shoulder function. Specifically, the SSC muscle ensures dynamic glenohumeral stability by forming the anterior portion of the transverse force couple [7,8]. As

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primarily described by Gerber and Krushell, disruption of the SSC causes muscular imbalance and subsequently, functional impairment as well as dynamic glenohumeral microinstability [9,10], what is further influenced by both the morphology and the severity of the underlying rotator cuff pathology [11].

Generally, early surgical repair is warranted to restore tendon integrity and to maintain normal shoulder function [12–14]. While arthroscopic procedures have recently proven to be clinically effective in the treatment of SSC pathologies, open repair techniques are still a reliable treatment option with good functional and patient-reported clinical outcomes [15–17]. However, current literature is devoid of data demonstrating the long-term efficacy of open repair for the treatment of large SSC tears.

Because first clinical long-term studies have demonstrated that repair failures after rotator cuff repair negatively affect shoulder function and are significantly associated with the progression of secondary glenohumeral osteoarthritis (OA) [18,19], the purpose of this retrospective case series was to evaluate the clinical and radiological results after open repair of large SSC tears at a minimum 10-year follow-up. It was hypothesized that a re-tear negatively influenced clinical outcomes and the progression of secondary glenohumeral OA.

2. Methods

2.1. Study population

We conducted a retrospective review of the institutional shoulder database dating back to 1998 in order to collect all patients who underwent open repair for traumatic large SSC tears, Lafosse type III and type IV [5]. The minimum follow-up was 10 years. Exclusion criteria were previous surgeries performed on the affected shoulder, concomitant glenohumeral pathologies other than a lesion on the long head of the biceps tendon (LHBT) and arthroscopic repairs. Prior to the beginning of this study, approval of the local ethical committee was obtained. Informed consent was obtained from all individual participants included in the study.

In total, 24 patients fulfilled the inclusion and exclusion criteria and were enrolled for final follow-up examination in 2016. Four patients (17%) were lost to follow-up, as one was confirmed to have died and three could not be reached due to lacking contact information at the time of final follow-up. Thus, 20 patients (83%) formed our study population. There were 4 females (20%) and 16 males (80%) with a mean age at the time of surgery of 55 ± 8 years (range, from 31 to 68 years). The dominant arm was affected in 73% of the study population. A traumatic onset of symptoms was recorded in all patients (100%) with a high impact sport accident in 6 patients (30%) and with a low impact accident in 14 patients (70%). None of the patients reported on any shoulder complaints of the affected arm prior to injury. The mean interval from trauma to surgery was 4.7 ± 3.5 months (range, from 0.6 to 16.0 months). Half of the patients ($n = 10$) suffered from a pseudoparalytic shoulder prior to surgery, which was significantly associated with a type IV SSC lesion ($p = 0.040$). The average follow-up period was 14 ± 3 years (range, from 10 to 18 years).

2.2. Surgical procedure

From 1998 to 2007, two shoulder-experienced surgeons were involved in the surgeries of the study population. For open repair of the rotator cuff, the patients were placed in a beach chair position with the affected arm draped free. In 7 patients, a diagnostic arthroscopy prior to planned open surgical repair was performed to completely delineate all pathologies. The deltopectoral approach was applied as the standard approach for addressing both the SSC and supraspinatus tendon (SSP) lesions as well as LHBT pathologies. If the SSP tear extended to the infraspinatus tendon, a double approach with an additional superolateral 'delta-splitting' incision was used.

Prior to reconstruction, scar tissue as well as subacromial bursa was debrided. After extensive release of the rotator cuff to ensure tension-free repair, the LHBT pathology was treated with either soft-tissue tenodesis ($n = 14$) or tenotomy ($n = 1$). If fraying or wear changes on the undersurface of the anterolateral acromion as well as the coracoacromial ligament were noted, a slight acromioplasty was performed ($n = 5$). The rotator cuff was reconstructed using a transosseous suture technique. The amount of non-absorbable sutures (Nr. 2 Ethibond excel suture, Ethicon Inc., Somerville, NJ; or Nr. 2 FiberWire suture, Arthrex Inc. Naples, FL) was dependent on tear size. After surgery, the affected arm was secured using a shoulder sling for 4 weeks. During this time, the shoulder was passively mobilized with external rotation until 0 degrees. After 4 to 6 weeks, active-assisted range of motion with progressive increase was permitted.

2.3. Tear characteristics

Tear morphology as well as pathologies of the LHBT were confirmed by preoperative MRI and classified intraoperatively, revealing a type III SSC lesion in 35% ($n = 7$) and a type IV SSC lesion in 65% ($n = 13$). A concomitant full-thickness tear of the SSP was evident in 9 patients (45%) involving either the anterior aspect (44%) or the entire tendon footprint (56%). The LHBT was pathologic in 75% ($n = 15$) of the patients with static medial luxation in 8 patients and a partial lesion with incomplete loss of tendon continuity and without static luxation in 7 patients.

2.4. Preoperative radiographic assessment

All patients underwent conventional radiographic imaging ("true" anteroposterior view, axillary lateral view, scapular "Y" view) to preclude any bony lesion. Furthermore, glenohumeral OA was assessed according to the Samilson and Prieto classification system [20]: grade 0 (normal), no osteophytes; grade 1 (mild), osteophytes at the glenoid and/or humeral head with an extent of < 3 mm; grade 2 (mild), osteophytes with a cumulative diameter between 3 and 7 mm and slight joint irregularity; and grade 3 (severe), osteophytes exceeding 7 mm in total combined with joint narrowing and sclerosis. Overall, 15 patients (75%) were classified as grade 0 and 5 patients (25%) as grade 1.

2.5. Postoperative clinical and radiographic assessment

At final follow-up, all patients were asked to rate their satisfaction with the surgery (very satisfied, satisfied, rather satisfied, rather unsatisfied, and unsatisfied) and to specify any complications or revision surgeries obtained up to final evaluation. Those with further revision surgery on the affected shoulder were excluded for final evaluation but recorded as complications. Standardized physical examination was performed by the principal investigator and included assessment of active range of motion of both the affected and non-affected arm. Furthermore, bilateral strength assessment was performed in (1) scapular plane elevation as well as (2) external rotation and (3) internal rotation with the arm in an adducted position using a handheld isometer (IDO, Innovative Design Orthopaedics Limited, Redditch, and Worcestershire, UK). Additionally, the subjective and objective clinical outcomes were determined using the Subjective Shoulder Value (SSV) [21], the Constant Score (CS) [22], the University of California at Los Angeles Shoulder Score (UCLA) [23], and the American Society for Shoulder and Elbow Surgeons (ASES) Score [24].

Tendon integrity of the affected shoulder was evaluated with standardized magnetic resonance imaging (MRI) using a 1.5 Tesla MR system (Ingenia, Philips, Amsterdam, Netherlands). The radiological assessment was performed by one musculoskeletal trained radiologist. The rotator cuff tendons were classified as:

- intact or;
- re-ruptured if a fluid-equivalent signal or nonobservation of the tendons was found on at least one T2-weighted section.

Furthermore, secondary glenohumeral OA of the affected shoulder was assessed. The collective instability arthropathy (CIA [25]) score was then calculated to estimate the progression from pre- to postoperative.

2.6. Statistics

All statistical analyses were performed using SPSS Statistics 21.0 (IBM, Armonk, New York, USA). The investigated parameters were tested for normal distribution using the Kolmogorov-Smirnov test. The Mann–Whitney-U test was used to compare continuous variables, and the Fisher's exact test for dichotomous variables. To compare the clinical and radiological differences from pre- to postoperative, the Wilcoxon test was used. The Spearman's correlation coefficient was calculated for correlations between parameters. All significance tests were two-sided and conducted at the 0.05 level of significance.

3. Results

3.1. Revision surgeries

One patient (5%) had to undergo revision surgery three months after surgery due to a symptomatic repair failure of the SSC and was further treated with a pectoralis major transfer because of insufficient tendon quality and therefore, was excluded from final follow-up examination.

3.2. Clinical results

A high level of subjective patient satisfaction was observed, with 13 patients (69%) reporting that they were very satisfied, 5 patients satisfied (26%) and 1 patient (5%) moderately satisfied with their outcome. At final follow-up, active range of motion of the affected shoulder significantly improved when compared to the preoperative state (Table 1). Generally, open repair reversed preoperative pseudoparalysis in all patients. Although no significant strength deficit of the affected shoulder was detected when compared with the non-affected shoulder, a tendentially decreased muscle strength on the affected side was observed (Table 1). Functional assessment including the CS, SSV, ASES and UCLA is summarized in Table 2. No significant correlation was found between the collected outcome scores and time interval from trauma to surgery (CS: R = 0.438, $p = 0.069$; SSV: R = 0.277, $p = 0.266$; ASES: R = 0.304, $p = 0.221$; UCLA: R = 0.460, $p = 0.055$).

3.3. Radiographic results

While 14 patients (74%) completed radiographic evaluation of the affected shoulder, 5 patients (26%) refused the examination due to either contraindication (pacemaker, $n = 2$; claustrophobia, $n = 1$) or unwillingness to participate ($n = 2$).

The overall re-tear rate of the SSC was 29% (4 out of 14) and 50% for the SSP (4 out of 8). Two of whom with an asymptomatic re-tear of the SSC reported a major trauma prior to radiologic evaluation without further treatment. Repair failure was not associated with the time interval between trauma and surgical reconstruction (SSC: $p = 0.358$; SSP: $p = 0.646$). Table 3 outlines the differences in clinical

Table 1
Pre- and postoperative range of motion and strength.

Variables[a]	Baseline	Follow-up		*p*-value*	*p*-value**
	Affected arm $n = 19$	Affected arm $n = 19$	Non-affected arm $n = 19$		
Flexion (°)	113 ± 55	160 ± 15	163 ± 11	0.007	0.063
Abduction (°)	99 ± 55	161 ± 13	160 ± 15	0.003	0.750
Internal rotation[b] (points)	2.5 ± 2.1	7.4 ± 1.8	8.3 ± 1.2	0.001	0.033
External rotation[b] (points)	7.9 ± 8	9.6 ± 0.8	9.7 ± 0.6	0.023	0.966
Elevation strength (kg)	n.e.	5.7 ± 2.7	7.2 ± 2.6	–	0.062
IRO strength (kg)	n.e.	8.7 ± 2.5	9.6 ± 2.5	–	0.119
ERO strength (kg)	n.e.	7.2 ± 2.2	7.4 ± 2.6	–	0.887

n.e.: not evaluated.
[a] Data are reported as mean ± SD.
[b] Constant Score points.
* Comparison of the outcome of the affected arm between baseline and final follow-up.
** Comparison between the affected and non-affected arm at final follow-up.

Table 2
Clinical outcomes at final follow-up.

Variables[a]	Follow-up		*p*-value
	Affected arm $n = 19$	Non-affected arm $n = 19$	
Constant Score (points)	78 ± 10	83 ± 8	0.044
Pain (points)	13 ± 2	13 ± 2	1.000
ADL (points)	18 ± 3	19 ± 2	0.039
ROM (points)	36 ± 4	37 ± 3	0.046
Strength (points)	11 ± 5	14 ± 5	0.062
UCLA Score (points)	32 ± 2	n.e.	–
ASES Score (points)	89 ± 14	n.e.	–
VAS (points)	1.1 ± 1.4	1.2 ± 1.5	1.000
SSV (%)	83 ± 12	88 ± 11	0.055

n.e.: not evaluated.
[a] Data are reported as mean ± SD.

Table 3
Differences in clinical results between patients with an intact repair and patients with a repair failure at final follow-up.

Variables[a]	Follow-up		*p*-value
	Subscapularis tendon		
	Intact repair *n* = 10	Re-tear *n* = 4	
Constant Score (points)	79 ± 10	75 ± 13	0.502
Pain (points)	14 ± 2	12 ± 3	0.318
ADL (points)	18 ± 3	16 ± 3	0.162
ROM (points)	36 ± 4	36 ± 3	0.811
Strength (points)	11 ± 6	11 ± 6	0.982
UCLA Score (points)	32 ± 3	32 ± 2	0.764
ASES (points)	90 ± 14	83 ± 14	0.378
SSV (%)	86 ± 12	75 ± 10	0.126

[a] Data are reported as mean ± SD.

outcome scores between patients with an intact repair and patients with a re-tear of the SSC.

Secondary glenohumeral OA progressed significantly from pre- (CIA, 0.3 ± 0.5) to postoperative (CIA, 1.7 ± 0.9; $p = 0.003$), as grade 0 was detected in 1 patient (7%), grade 1 in 6 patients (43%), grade 2 in 3 patients (21%) and grade 3 in 4 patients (29%) (Fig. 1). Furthermore, failure in tendon integrity was significantly associated with the progression of secondary glenohumeral OA ($p = 0.040$). The CIA of patients with an intact SSC at final follow-up was 1.3 ± 0.3, and the CIA of patients with a re-tear of the SSC was 2.8 ± 0.3 ($p = 0.014$). Neither patient age ($p = 0.547$) nor preoperative tear morphology ($n = 0.440$) were associated with the progression of secondary glenohumeral OA.

4. Discussion

Pathologies of the SSC are recognized with increased regularity and therefore, treatment strategies and their long-term consequences are of relevant interest. While some studies proved the satisfying long-term effect of SSC repair, to our knowledge, no studies exist investigating the progression of secondary glenohumeral OA with regard to the postoperative tendon integrity in traumatic large SSC pathologies. The major finding of our retrospective case series was that progression of secondary glenohumeral OA is a crucial long-term concern. While both patient age and tear morphology did not affect the degree of secondary glenohumeral OA at final follow-up, a significant correlation with repair failure was demonstrated. In addition, tendon integrity affected clinical outcomes, which have been proven to be in general acceptable at a minimum of 10-year follow-up.

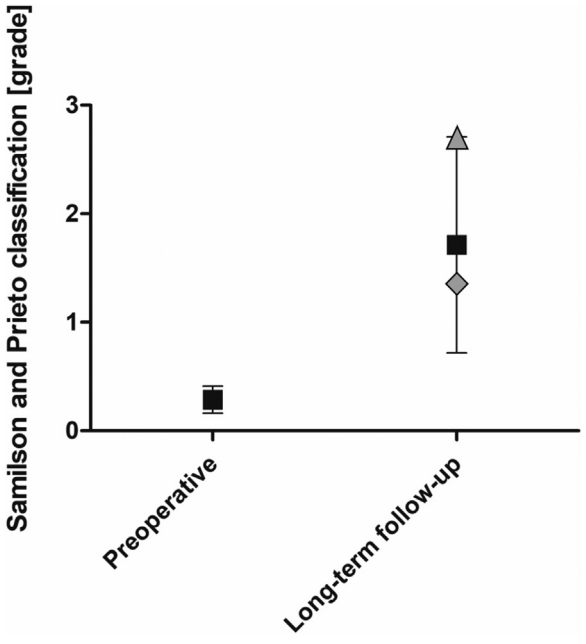

Fig. 1. Progression of secondary glenohumeral osteoarthritis (OA) from preoperative to final follow-up. The triangle marks the mean secondary glenohumeral OA grade (i.e. collective instability arthropathy, CIA) of patients with a repair failure and the rhombus the mean secondary glenohumeral OA grade (i.e. CIA) of patients with an intact subscapularis tendon.

Secondary glenohumeral OA is a well-known risk factor following traumatic shoulder dislocation as well as chronic instability of the shoulder joint [26]. Furthermore, rotator cuff pathologies are associated with glenohumeral instability. Thus, a lesion of the SSC might impair functional stability by disrupting the horizontal force couple. Marquardt et al. demonstrated the protective effect of the SSC on glenohumeral translation [27]. With increasing SSC tear size, the humeral head is prone to static anterosuperior subluxation. Recently, some clinical studies highlighted the long-term risk for glenohumeral OA after rotator cuff repair. The occurrence was primarily correlated with preoperative tear size and postoperative repair failure [18,19]. In our study, tendon integrity was the major contributing factor for progressive secondary glenohumeral OA. Although some progress was evident in the entire study population traced back to either the traumatic pathology onset or natural patient aging, those with a SSC re-tear suffered a significant progression of secondary glenohumeral OA within the follow-up period. Nevertheless, this finding might be influenced by individual risk factor profiles, as several studies have proven metabolic diseases to further cause osteoarthritic changes of the glenohumeral joint.

The re-tear rate of the SSC in our study population was 29%. Although half of them (2 out of 4) was probably based on traumatic re-injuries, the re-tear rate was tendentially higher compared to recent long-term studies describing a repair failure in 8% and 13%, respectively [14,28]. The noticeable difference might be explained by the initial tear size, as barely half of the study population reported by Seppel et al. was treated for isolated small (i.e. Lafosse I and II) SSC tears. [14]. Interestingly, Nové Josserand et al. reported on a repair failure in 7% after open repair for an anterosuperior RCT affecting only the upper part of the SSC (i.e. Lafosse I and II) compared with a re-tear in 30% with a tear involving the lower half of the SSC tendon (i.e. Lafosse III and IV) [28]. In addition to progression of secondary glenohumeral OA, tear recurrence negatively affected clinical outcomes at long-term follow-up. This finding is in accordance to Flury et al. [16]. Besides that, no negative impact of, for example, delayed surgery after initial trauma was found in our study. Several short- to mid-term studies declared that a longer time interval is correlated with worse outcomes [12,13]. Additionally, a positive effect of early surgical treatment was found in the long-term study by Seppel et al. [14]. All in all, we encourage to

timely repair a large SSC tear in order to conceivably reduce the risk of secondary glenohumeral OA by protecting disuse muscle atrophy and chronic humeral head micromotion.

Arthroscopic repair techniques have been considered to be equivalent for the treatment of small to medium SSC pathologies with regard to functional outcomes and repair integrity [15]. Nevertheless, those are technically demanding if the SSC tear involves the lower part of the tendon with complex visualization of the caudal musculotendinous insertion. Thus, open reconstruction is still a reliable treatment option when a large tear of the SSC is present. However, the invasiveness of open repair techniques must be taken into consideration. It was recently demonstrated that arthroscopic procedures reduce the potential risk of glenohumeral OA in the long-term follow-up [19].

Among others, our study is limited by the retrospective design. Thus, unavailable preoperative clinical and radiological data did not allow to evaluate a theoretical improvement in shoulder scores, or to correlate baseline values as fatty infiltration or muscle atrophy with outcomes. While the follow-up rate of 83% is acceptable, the small number of cases and incompleteness of radiological evaluation could have resulted in an underestimated re-tear rate. The strength of our study is that this is the first study demonstrating long-term outcomes after open transosseous repair for traumatic large SSC tears highlighting the consequences of repair failure.

5. Conclusion

Although open repair of large SSC tears yielded good shoulder function and a high rate of patient satisfaction level after a minimum of ten-year follow-up, repair failure is common. Moreover, tear recurrence negatively affected both clinical outcomes and the progression of secondary glenohumeral OA.

Disclosure of interest

The authors declare that they have no competing interest.

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None.

Authors' contribution

All listed authors have contributed substantially to this work (F.P., H.R., P.M. for the study conception and design; F.P., G.K., R.O., T.H. for the data collection; F.P., H.R., P.M. for the data analysis; F.P., H.R., P.M. for the data interpretation; F.P., G.K., R.O., T.H., P.M. for the drafting of the manuscript, the figures, and the literature research) and have approved the submission.

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