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ORIGINAL ARTICLE

Open repair of isolated traumatic subscapularis tendon tears with a synthetic soft tissue reinforcement

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Abstract
Background Missed or chronic subscapularis tendon ruptures may have muscle atrophy and tendon retraction resulting in a large defect with high risk of re-tear after a surgical repair. To improve the clinical results of this challenging surgery, the repaired tendon could be augmented with endogenous or exogenous materials. The purpose of this study was to evaluate the structural tendon integrity and clinical outcomes after an open subscapularis tendon repair with a synthetic soft tissue reinforcement.
Materials and Methods Ten patients were managed with an open repair of the subscapularis tendon with augmentation by means of SportMesh, a readily available synthetic degradable poly(urethaneurea) scaffold. Clinical findings were assessed for all patients preoperatively and postoperatively with use of the visual analog scale for pain and the DASH scoring system. All patients had an ultrasonographic study at the latest follow-up.
Results The visual analog scale for pain (mean ± standard deviation) improved significantly ($P < 0.01$) from 7.9 ± 1.1 preoperatively to 1.95 ± 1.85 at the latest clinical follow-up evaluation. The mean DASH score at the latest clinical follow-up was 12.63 %. Ultrasound imaging revealed a structural intact repair at follow-up in 9 shoulders (90 %) with average 5.4 mm in thickness (4.3 mm in the contralateral healthy side).
Conclusions At a median follow-up of 23 months, 80 % (8 of 10) of patients had a good or excellent result after an open subscapularis tendon repair with a soft tissue reinforcement. As a synthetic material, SportMesh Soft Tissue Reinforcement eliminates the risk of collagen reactions, which may result from collagen or dermis patches. Although the follow-up is relatively short, our series shows a promising durable repair with a 10 % re-tear rate at an average of 23 postoperative months. *Level of evidence* Case Series, Treatment Study, Level IV.

Keywords Subscapularis tear · Rotator cuff augmentation · Synthetic scaffold

Introduction

Rotator cuff tears are a common cause of shoulder pain and dysfunction. Tears typically occur in the supraspinatus tendon and extend posteriorly into the infraspinatus tendon. Although the overall incidence of complete subscapularis tears is low compared with supraspinatus and infraspinatus tears, subscapularis tears are being increasingly recognized as a cause of shoulder pain. Given the rarity of diagnosis of subscapularis tendon tears, it is reasonable to assume that many of these tears are missed. Missed or chronic subscapularis tendon ruptures may have muscle atrophy and tendon retraction resulting in a large irreparable defect [1–10].

In an attempt to improve the clinical outcome, and avoid the incidence of re-ruptures and other complications in these challenging rotator cuff repairs, a reinforcement

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patch can be used to create a stronger repair. The reinforcement should improve the strength of the repair during the initial healing period and provide long-term support for remodeling the maturing tissue [11, 12].

The purpose of this study was to evaluate the structural tendon integrity and clinical outcomes after an open subscapularis tendon repair with a synthetic soft tissue reinforcement.

Materials and methods

Patients

Between April 2009 and May 2011, ten open repairs of the subscapularis tendon were performed by the senior author (D.P.) with augmentation by means of a synthetic soft tissue reinforcement in eight men and two women with an average age of 61 years at the time of surgery (range 51–68 years). Five patients had a tear involving the superior two-thirds of the tendon, and five had complete separation of the subscapularis from its insertion on the lesser tuberosity. In all cases, it was an isolated lesion of the subscapularis tendon. Seven shoulders had sustained an acute injury with the arm in abduction and external rotation and three a minor injury in a chronic degenerative pattern. After the trauma, the initial diagnosis was in all cases unrecognized. The dominant arm was involved in eight cases (80 %). Preoperative magnetic resonance imaging was performed in all patients to determine the extent of the rotator cuff tear and to document the state of the subscapularis. The average interval from the onset of symptoms to the time of surgery was 8 months. Informed consent was obtained in all patients before surgery.

Surgical technique

Under interscalene block and general anesthesia, the patient was placed in a beach-chair position with the arm draped, ensuring free mobility of the injured shoulder. A deltopectoral approach was utilized. The repair of the ruptured subscapularis tendon was technically difficult but was achieved in all cases; the final decision for the augmentation of the tendon was made intraoperatively. The subscapularis tendon was grasped with heavy non-resorbable sutures, and the musculotendinous unit was mobilized with extensive release from its adhesions at the base of the coracoid process, the brachial plexus, and the subscapularis fossa. The lesser tuberosity was prepared for reinsertion of the tendon removing the scar tissue and the residual tendon flap. Strands of the stitches were brought through the synthetic biodegradable scaffold, SportMesh (polyurethaneurea polymer; Biomet Sports Medicine, Warsaw, IN, USA). Once the scaffold was tightly sutured over and on the periphery of the tendon, this was reattached to the footprint using a knotless technique with suture anchors (Versalock, DePuy Mitek, Raynham, MA, USA).

Associated lesions of the tendon of the long head of the biceps (subluxation, dislocation, and partial-thickness tears) were addressed by tenodesis.

Postoperative rehabilitation

For the first 5 weeks after surgery, the patients were required to wear a sling and were advised to follow a course of exercises. Elbow range of motion exercises and Codman's pendulum were started immediately postoperative. These exercises were extended to include passive forward elevation and passive internal–external rotation with the arm at side 2 weeks after surgery. At 6 weeks, the sling was removed and the patients were encouraged to use their arm, but only at waist level. Approximately 3 months postoperative, the patients started strengthening of the rotator cuff muscles and performed normal daily activities.

Clinical assessment

Clinical findings were assessed for all patients preoperatively and postoperatively with use of the visual analog scale for pain and the Constant and Murley score and DASH scoring system for shoulder function. Clinical assessment was completed evaluating the power of specific subscapularis tests (lift-off, belly-press, and bear-hug). During the strength test, the participants were standing up. The resistance of an electronic handheld dynamometer, Lafayette Manual Muscle Test System (Lafayette Instrument Company, Lafayette, IN) was applied to the wrist, and three consecutive measurements of a duration of 3 s were averaged to measure the strength. To ensure reliability, the muscle powers of both shoulders were evaluated consecutively.

Radiographic assessment

Preoperatively and postoperatively, standardized anteroposterior radiographs with the arm in neutral rotation and axillary lateral radiographs were made of all ten shoulders. Preoperative and postoperative glenohumeral osteoarthritic changes were assessed on standard radiographs with use of the classification system of Samilson and Prieto. Preoperatively and postoperatively, the acromiohumeral distance from the undersurface of the acromion to the humeral head was measured on the anterior radiograph with the arm in neutral rotation, and anteroposterior subluxation of the humeral head was assessed on the axillary lateral radiograph. Subluxation was defined as either an anterior or a posterior shift of the center of the humeral head from the midpoint of the glenoid.

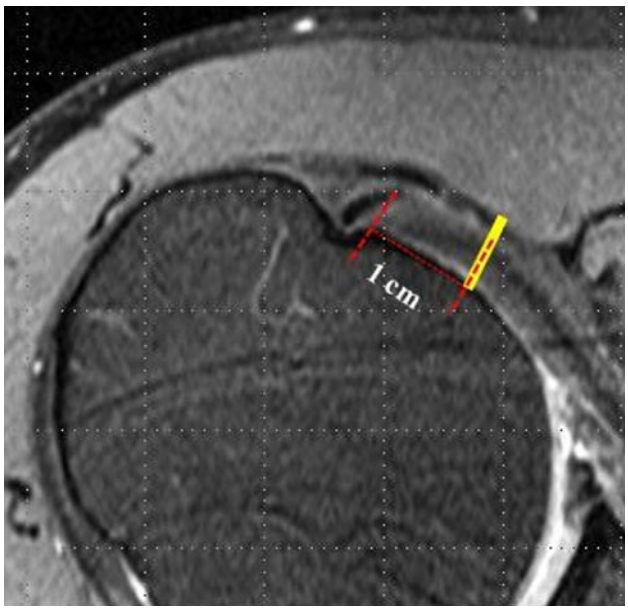

Fig. 1 MRI transverse view after subscapularis repair. The subscapularis tendon thickness was performed on the sonographic long axis view 1 cm medial to the bicipital groove

Ultrasonographic studies were available for all patients to evaluate the structural integrity of the repair at the latest follow-up. One specialized radiologist (M.I.) with 10 years of experience with musculoskeletal ultrasonography performed all follow-up examinations using a MyLabClassC system (from Esaote Spa, Genova, IT). The sonographic evaluation of the subscapularis tendon was performed according to a standard protocol with the patients seated upright and the arm at the side. The thickness of the tendon was measured on the long axis view 1 cm medial to the bicipital groove (Fig. 1). Measurements were expressed as mean ± standard deviation and compared with the contralateral side. The ultrasound criteria for the diagnosis of full-thickness rotator cuff tears were as follows: (1) non-observation of the subscapularis tendon attributable to retraction under the coracoid process; (2) loss of normal subscapularis substance with exposure of a bare area of bone and cartilage between the edge of the subscapularis and the bicipital groove; and (3) coexistence of fluid in the subacromial–subdeltoid bursa and/or the presence of fluid in the sheath of the long head of biceps tendon.

Results

The median follow-up from the date of surgery to the last clinical evaluation was 23 months (range 12–34 months). The visual analog scale for pain (mean ± standard deviation) improved significantly from 7.9 ± 1.1 preoperatively to 1.95 ± 1.85 at the latest clinical follow-up evaluation. The mean relative Constant score increased from 47 % preoperatively to 69 % at the time of final follow-up. The mean DASH score at the latest clinical follow-up was 12.63 %. The DASH work score (8/10 patients) was 14.84 %; six patients (60 %) returned to their usual manual work after the operation. According to the DASH scoring system, there were 6 excellent (0–10 %), 2 good (10–30 %), 2 fair (30–50 %), and none poor (>50 %) results.

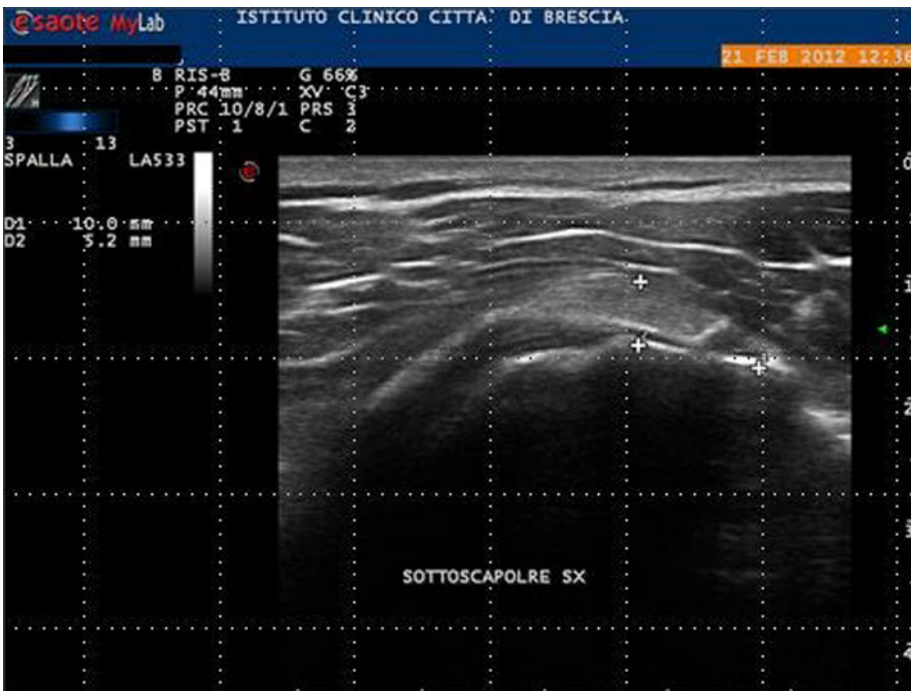

Fig. 2 Sonographic view of a repaired tendon

Table 1 Thickness of the tendon measured on the long axis view 1 cm medial to the bicipital groove

Patient	Treated shoulder	Contralateral side
1	5.1	4.2
2	8	4.8
3	5.4	4
4	5.3	4.3
5	5.2	5
6	4.5	4.8
7	5.9	4
8	3.2	5.8
9	5	2.4
10	6.6	3.5

The values are given as the mean in mm

There was a significant improvement in the scores for pain, activities of daily living, functional use of the arm, in mobility and in strength measured with electronic dynamometer. The mean values in kilograms for subscapularis tendon tests were as follows: belly-press test 6.76 ± 2.07; lift-off test 2.87 ± 1.37; bear-hug 5.51 ± 1.56. The lift-off test to identify an absence of subscapularis function was positive preoperatively in all ten shoulders. Postoperatively, the lift-off test remained positive in the patient with a documented re-tear.

At the time of final follow-up, the mean acromiohumeral distance measured on a true anteroposterior radiograph with the forearm in neutral rotation was 10.5 mm (range 6–17 mm) and had not changed significantly from the preoperative value (10.4 mm; range 7–17 mm). On the preoperative axillary lateral radiograph, the humeral head appeared centered in eight of the ten shoulders and the head appeared slightly subluxated anteriorly in two. At the time of follow-up, the head appeared centered in seven of the ten shoulders. None of the shoulders had clinical signs or symptoms of instability, and osteoarthritic changes also did not increase.

Ultrasound imaging revealed a structurally intact repair (Fig. 2) at follow-up in 9 shoulders (90 %) and absence of the tendon (re-tear) in one case. The average thickness of the repaired tendon was 5.4 ± 1.26 mm (4.3 ± 0.92 mm in the contralateral healthy side) (Table 1). In the patient with re-tear (Fig. 3), the MRI examination (Fig. 4) had revealed an advanced stage of muscle atrophy.

There were not postoperative complications, including infections or rejections.

Discussion

Subscapularis tendon tears are much less common than other rotator cuff tears [7]. Traumatic complete subscapularis tears can retract far medially and be difficult to mobilize for repair. In addition, the tendon tissue is usually exceedingly thin and, even when repaired, may not function properly. Early surgical treatment is considered essential for acute traumatic tears, and tendon augmentation can provide a stronger construct.

Warner et al. [13] reported on 19 patients with subscapularis tendon tears in combination with supraspinatus and infraspinatus tendon tears. This group represented only 4 % of those who underwent rotator cuff surgery over a 6-year period. Patients treated <6 months after onset of symptoms had a mean Constant score of 99 % of normal, whereas those treated >1 year after the onset of symptoms had a mean score of 49 %. Authors also found that severe fatty degeneration on preoperative MRI correlated with poor tendon quality during surgery.

Di Schino et al. [2] retrospectively analyzed 22 patients (23 shoulders) treated by open transosseous reinsertion of supraspinatus and subscapularis tendons. They observed durable functional improvement and limited degenerative articular and muscular changes in most patients 4–10 years after open repair of anterosuperior cuff tears provided that healing of the cuff is obtained.

Bartl et al. [1] reported a structurally intact repair at 46 months (range 25–72 months) follow-up in 28 shoulders of thirty consecutive patients (93 %) after open tendon reconstruction with a suture anchor technique via a deltopectoral approach. The mean delay between trauma and surgery was 4 months.

In order to obtain a good functional outcome with a low re-rupture rate and allow return to sport/work activities, we combined an open repair with a synthetic soft tissue augmentation using a synthetic scaffold, SportMesh (polyurethaneurea polymer). In our study, the average interval from the onset of symptoms to the time of surgery was 8 months. At a median follow-up of 23 months, 80 % (8 of 10) of patients had a good or excellent result. All patients were satisfied with their shoulders at the latest follow-up evaluation with a mean DASH score of 12.63 %.

Augmentation strategies include the use of many different biomaterials [14–22]. In the last few years, many new tissue engineered materials have been introduced: artificial polymers, biodegradable films, and biomaterials derived from animals or human, using a combination of principles of engineering and biology [23, 24]. Synthetic scaffolds are manufactured from chemical compounds, which permit better control of the chemical and physical properties leading to stronger mechanical strength and consistency in quality. Cole et al. [15, 18] investigated the biological response to a novel polycarbonate polyurethane patch (Biomerix RCR Patch, Fremont, CA) used for tissue augmentation in open rotator cuff repair. By 6 and 12 months, using subjective and objective outcome

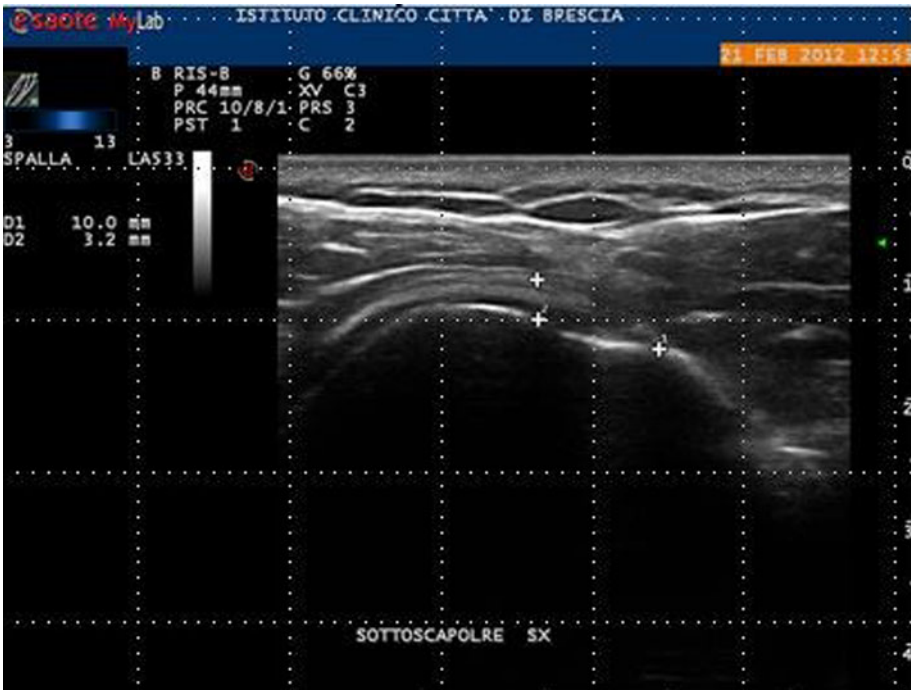

Fig. 3 Sonographic view of a full-thickness tendon tear: non-observation of the subscapularis tendon with exposure of a bare area of bone and cartilage between the edge of the subscapularis and the bicipital groove

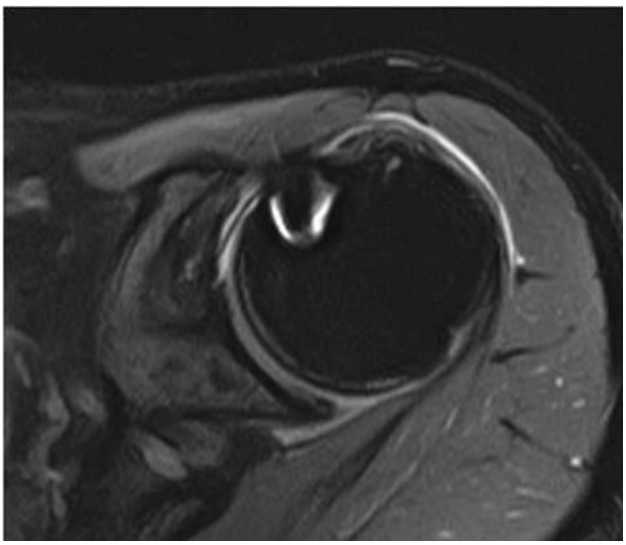

Fig. 4 MRI transverse view of the full-thickness tendon tear of the case in Fig. 3

measurements including MRI, the authors achieved a 90 % rate of healing with no inflammatory reaction. However, there is very limited information in the literature.

Several limitations to our study warrant review. First, the number of re-tears was small, and the follow-up was relatively short, which may lead to failure of differentiation between intact cuffs and re-tears. Second, although all patients were evaluated serially using ultrasonography by an experienced musculoskeletal radiologist, this modality is examiner dependent. Fotiadou et al. [25], in a recent study investigating the accuracy of ultrasonography for detection of rotator cuff tears, reported the accuracy of ultrasonography was as much as 98 % for full-thickness tears and 87 % for partial-thickness tears, which were comparable to the MRI results of 100 and 90 % for full-thickness and partial-thickness tears, respectively. Although some authors reported high accuracy of a surgeon interpreting office-based ultrasonography, we did not perform ultrasound examination by ourselves to avoid surgeon's prejudice [26]. Furthermore, without a control group, it is difficult to assess all evaluation measures, including the healing rate.

Conclusions

The intermediate-term results show that subscapularis tendon repair with a synthetic soft tissue reinforcement is a good option for the treatment of patients with missed or chronic subscapularis tendon tears. As a synthetic material, SportMesh Soft Tissue Reinforcement eliminates the risk of collagen reactions, which may result from collagen or dermis patches. Although the follow-up is relatively short, our series shows a promising durable repair with a 10 % re-tear rate at an average of 23 postoperative months.

Conflict of interest None.

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