

Pectoralis major transfer for the treatment of irreparable anterosuperior rotator cuff tears

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Abstract The purpose of this study was to evaluate the outcome of subcoracoid pectoralis major transfer for the treatment of irreparable anterosuperior rotator cuff tears. This type of tear involves complete rupture of the subscapularis in combination with either the supraspinatus alone or the supraspinatus and infraspinatus. These ruptures are characterised by a poor quality of the rotator cuff that does not allow for a direct tendon-to-bone reconstruction. Between 2000 and 2006, 15 patients were treated using a deltopectoral approach and transfer of the clavicular part of the pectoralis major to the lesser tuberosity and to the anterior part of the greater tuberosity. After an average follow-up (follow-up rate 100%) of 37 months the average functional rating using the Constant and Murley score (CS) increased from 51.73 ± 16.18 to 68.17 ± 8.84 points ($p=0.005$). The mean subcategories of the Constant score for pain ($p=0.005$), activities of daily living ($p=0.008$) but not for range of motion ($p=0.9$), significantly improved. At follow-up 13 patients (87%) were available for magnetic resonance imaging (MRI) of the shoulder. Nine patients (70%) had an intact transferred pectoralis major muscle, two (15%) had one that was thin but intact and two patients a rupture (one complete). Two patients had postoperative haematoma and one patient developed cuff tear arthropathy.

The good results confirm that pectoralis major transfer is a reliable treatment option for irreparable anterosuperior rotator cuff injuries with significant improvement in pain and function.

Introduction

Rotator cuff tears mainly involve the supraspinatus tendon and usually occur after the age of 40 years [3]. Anterosuperior rotator cuff tears are characterised by a complete rupture of the subscapularis with either the supraspinatus alone or the supraspinatus and infraspinatus [23] and are less common [15, 29]. These massive tears are not always amenable to repair due to the size of the defect, tendon retraction and muscular atrophy and fatty degeneration of the cuff remnant. The most important problem with management of anterosuperior tears is the subscapularis component of the tear. The subscapularis is the most important muscle-tendon unit for both function and stability of the glenohumeral joint [8, 9, 17, 22, 30].

In cases of long-standing tears with fatty degeneration of the subscapularis muscle more than stage 2 according to Goutallier et al. [12], direct repair is not sensible. In these cases transfer of the pectoralis major has received the most attention as a salvage procedure and has proved to be an appropriate solution for improvement of pain and function in the shoulder [5, 9, 18, 19, 24]. However, limited information exists regarding surgical management of a combined irreparable rupture of the subscapularis and supraspinatus tendon.

The purpose of this article is to report our experience over a six-year period for the management of this unique pattern of injury treated by a pectoralis major transfer using the technique as described by Resch et al. [24].

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Material and methods

Between November 2000 and January 2006, 15 patients with a chronic irreparable anterosuperior rotator cuff tear were treated by the senior surgeon (P.H.) with transfer of the pectoralis major muscle as a salvage procedure [24]. All of the patients were right-handed and ten were men; ten cases involved the dominant arm and 11 patients could relate their symptoms to acute trauma. In four patients no causative factor could be found for the development of symptoms. The mean age of the patients was 61.92 ± 6.57 years (58.30 ± 8.31 for women and 63.73 ± 5.06 for men). Four patients had had an unsuccessful previous open rotator cuff repair with persistent disabling pain and limited function. All patients had pain and the perception of instability when the arm was placed either overhead or behind the plane of the body.

Inclusion criteria for the study were (1) rotator cuff rupture with retraction of the subscapularis and supraspinatus musculotendinous unit to the level of the glenoid (grade 3 according to Patte) (2) fatty infiltration of the two muscles of stage 3 or 4 according to Goutallier et al. [6, 12], (3) an intact infraspinatus musculotendinous unit and (4) a chief complaint of weakness. Patients with partial tears or partial repairs, stiff shoulder and glenohumeral arthritis were excluded from the study. A pathological condition of the biceps was not an exclusion criterion.

A detailed physical and neurological examination was performed preoperatively and the pathological condition of the rotator cuff tear assessed. Specific attention was directed to identification of subscapularis tendon retraction, because this condition can easily be missed [25]. The lift-off test [9], the belly-press test [8] and the internal rotation lag sign were used for all patients. This means that they were incapable of reaching and/or maintaining the raised position of the hand behind the back and when they exerted pressure on the stomach they were not able to maintain the elbow anterior to the midline of the trunk as viewed from the side. All patients were evaluated by the supraspinatus test according to Jobe and Patte and the starter test. Preoperatively an ultrasound examination of the rotator cuff was performed for all patients

The follow-up assessment included detailed clinical examination as above, imaging control with magnetic resonance imaging (MRI) of the treated shoulder and X-ray [standardised anteroposterior, axillary and outlet view radiographs and the Constant and Murley score (CS)] [4].

Standardised open MRI (ESAOTE E-scan XQ, Esaote SpA, Geneva, Italy) was done for all patients preoperatively and for 13 patients postoperatively. In the preoperative MRI the subscapularis and supraspinatus were judged to be irreparable based on their retraction to the level of the glenoid and advanced fatty infiltration (Goutallier stage 3–4) [12]. In

the postoperative MRI two independent examiners evaluated the tendon integrity of the pectoralis major. A tear or partial tear or an insufficient tendon transfer was noted if one or both of the examiners found a lack of continuity of the tendon in at least one slice in the coronal plane or anterior subluxation of the humeral head in the axial plane. This was also confirmed by clinical examination, palpating the superior clavicular portion of the pectoralis major and confirming the palpable contraction of the muscle.

Preoperative and postoperative function was assessed with active and passive movement of the arm in all planes and measured with a goniometer. External rotation was assessed with the patient standing, the arm adducted and the elbow flexed to 90° . Strength testing was performed with three consecutive measurements for a duration of five seconds using the ISOBEX dynamometer (Cursor AG, Bern, Switzerland) in a sitting position with the arm abducted to 90° in the plane of the scapula and internally rotated.

Statistical analysis

The analysis was carried out with the Statistical Package for the Social Sciences (SPSS 13.0, Chicago, IL, USA) for descriptive statistics with a level of significance at $p < 0.05$. The Wilcoxon signed rank test was also used to assess differences in function and in the range of motion pre- and postoperatively.

Operative technique

The pectoralis major transfer was performed using the technique as described by Resch et al. [24]. All operations were done while the patient was under general anaesthesia combined with a supplemental interscalene block in a beach chair position. The arm was supported on a Mayo table. An extended deltopectoral approach was used in all cases.

After identifying the cephalic vein and the conjoined tendon complex, the deltoid muscle was carefully mobilised laterally and protected. With a self-retaining retractor it was possible to maintain retraction of the deltoid and pectoralis major. Fifteen shoulders had complete avulsion of the subscapularis tendon from the lesser tuberosity and of the supraspinatus tendon from the greater tuberosity. In all patients an attempt was made to mobilise both the musculotendinous units with extensive release of adhesions and an attempted repair of both tendons was performed and turned out not to be amenable for repair. In all of the patients the long head of the biceps was either dislocated anteriorly (ten cases) or completely degenerated (five cases). In the first condition the tendon was tenotomised and the distal portion was sutured to the intertubercular groove and in the second condition the tendon was simply tenotomised.

The lateral border of the conjoined tendon was identified and the entire conjoined tendon was dissected. The space between the pectoralis minor and the conjoined tendon was entered by blunt dissection with the index fingers. The musculocutaneous nerve and its entrance into the muscle were identified. Thus, the space for the transferred muscle between the nerve and the conjoined tendon could be assessed.

The pectoralis major tendon was isolated at its insertion onto the lateral aspect of the bicipital groove of the humerus. The superior two thirds of the tendon were detached from the humerus and were released in its entirety from the humerus and mobilised medially. The muscle fibres of the detached section of the tendon were split by blunt dissection between the clavicular and the sternal portions in order to use only the clavicular part for the transfer. Care was taken not to mobilise more than 8 cm from the lateral border of the muscle in order to protect the lateral pectoral nerve [20]. The transferred tendon was grasped with three to four non-resorbable number 3 Ethibond sutures (Ethicon, Johnson and Johnson, Westwood, MA, USA) using a modified Mason-Allen technique [10, 11] and was passed from medial to lateral, behind the conjoined tendon but anterior to the musculocutaneous nerve. In all of the cases the interval between the nerve and the conjoined tendon was large enough for the muscle to be passed without tension between the two structures. Hence, there was no need to release the nerve or protect it with an instrument.

The stay sutures from the lateral part of the tendon were grasped with forceps, the muscle was advanced behind the conjoined tendon and the transferred tendon was attached to the lesser tuberosity and to the anterior part of the greater tuberosity with three suture anchors Corkscrew FT 5.5 (Arthrex, Naples, FL, USA). The stay sutures were placed through the remnants of the subscapularis and of the anterior part of the supraspinatus. If it was not possible, they were placed transosseously at the attachment site. At the end of the procedure palpation of the musculocutaneous nerve was performed with the index finger in order to be sure that there was no tension on the nerve (Fig. 1, Fig. 2, Fig. 3).

The patients stayed in the hospital for four nights. The shoulders were immobilised for three weeks in a 15° abduction pillow. Passive range of motion exercises were commenced the third day after surgery and limited to 30° of flexion and 80° of internal rotation for six weeks with gradual increase in flexion each week. External rotation was permitted only to the neutral position. Active range of motion exercises were begun after six weeks in all planes including external rotation. After 12 weeks full loading was permitted and strengthening of the rotator cuff muscles was started. Hydrotherapy was encouraged and strengthening exercises continued for a minimum of four months.

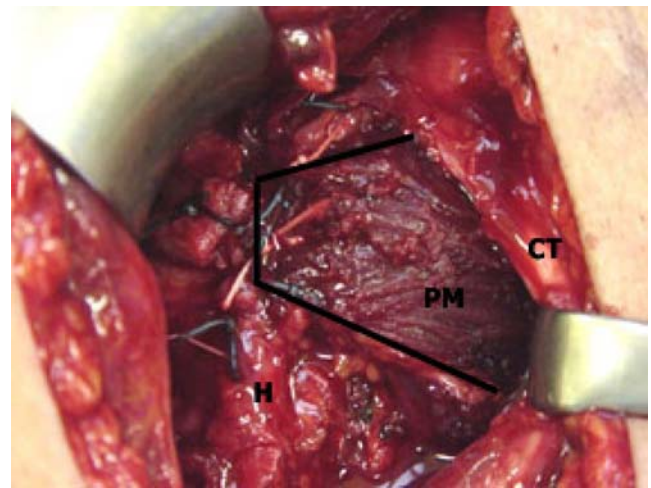


Fig. 1 Intraoperative view of a right shoulder after transfer of the upper part of the pectoralis major muscle (*PM*) to the lesser tuberosity at the humerus (*H*). The superior, lateral and inferior border of the transferred muscle is highlighted with a *black line*. The deltoid muscle with the cephalic vein is protected with a Roux retractor at the upper left corner and the conjoint tendon (*CT*) with a Langenbeck retractor

Results

Function

The mean preoperative CS significantly increased from 51.73 ± 16.18 to 68.17 ± 8.84 points postoperatively ($p=0.005$). The mean values for the subcategories of CS significantly increased from 8.2 ± 2.79 to 14.0 ± 1.81 points for pain ($p=0.005$) and from 12.13 ± 4.27 to 16.7 ± 2.16 points for activities of daily living ($p=0.008$). The change in range of motion from 27.73 ± 8.51 to 34.2 ± 4.94 and from 3.52 ± 4.53 to 3.27 ± 3.15 points for strength were not significant ($p=0.09$ and $p=0.832$).

Range of motion

The mean active flexion increased from 145.33 ± 41.2 preoperatively to 149.33 ± 38.81 postoperatively. The mean active abduction increased from 126.67 ± 49.23 to 135.33 ± 44.86 and the mean internal rotation from 76.67 ± 18.29 to 78 ± 18.21 . The changes in range of motion were not statistically significant.

Imaging evaluation

In the postoperative MRI review nine patients (70%) had an intact transferred pectoralis major tendon. Two patients (15%) had an intact but very thin tendon and two patients had a complete (one patient, 7.5%) or incomplete (one patient) avulsion of the pectoralis major tendon from the insertion site.

These two patients had a confirmatory clinical examination with positive lift-off test, internal rotation lag sign and belly-press test.

There was congruity in the glenohumeral joint (except one patient discussed in the “Complications” section) and there was no subluxation on the location of the centre of the humeral head with respect to the midpoint of the glenoid to the axial radiographs. Clinically there was no anterior glenohumeral translation with the arm in external rotation.

Complications

Two patients developed a postoperative haematoma on the second and the fourth postoperative day. Both underwent aspiration of the joint with negative cultures. No additional antibiotic prophylaxis was administered. One patient developed an advanced cuff tear arthropathy grade 4 according to Hamada et al. [14]. A reversed shoulder arthroplasty was suggested, but the patient did not wish to undergo another operation. Dysfunction of the musculocutaneous nerve was not observed in any case and there were no sensory or motor changes. There were no infections, wound healing problems or any defect in the anterior axillary fold that was cosmetically displeasing.

Discussion

Massive tears of the rotator cuff have been anatomically defined as lesions that have a maximum diameter of more than 5 cm [2] and functionally as lesions that involve two

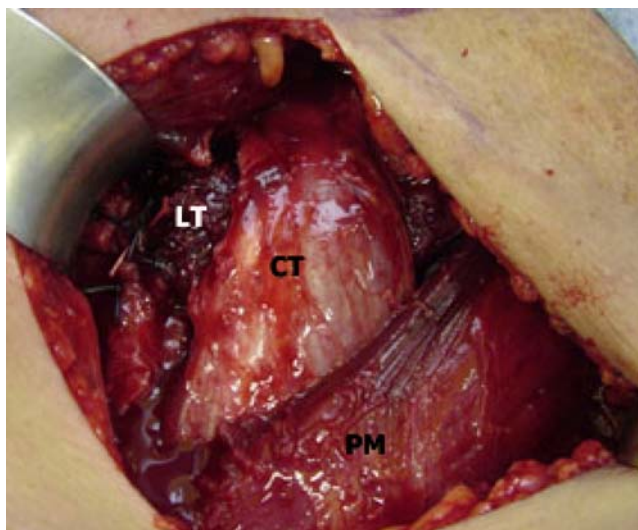


Fig. 2 Intraoperative view of the same right shoulder as in Fig. 1. Note the position of the muscle transplant under the conjoint tendon (CT) and refixation at the lesser tuberosity (LT). The lower part of the pectoralis major muscle (PM) is still in place at its anatomical origin at the bottom of the picture

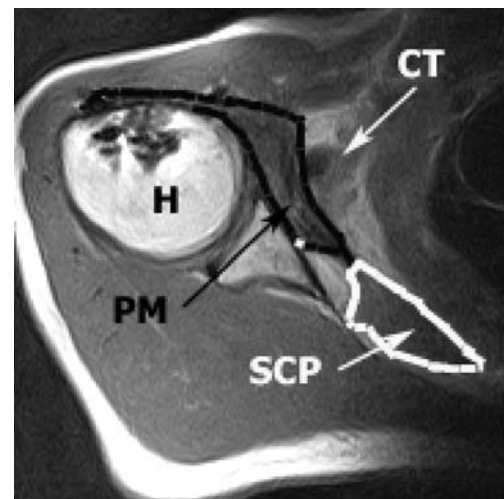


Fig. 3 Postoperative MRI scan of the right shoulder after pectoralis major transfer. The subscapularis muscle (SCP) is retracted (borders highlighted with a *white line*). The pectoralis major (PM) (borders highlighted with a *black line*) runs under the conjoint tendon (CT) to the lesser tuberosity at the humerus (H). Note the metal artefacts in the humeral head due to the titanium suture anchors

or more tendons [28]. Anterosuperior rotator cuff tears which combine complete rupture of both the subscapularis and supraspinatus tendon represent a rare injury and management poses a challenge to even the most seasoned shoulder surgeons [16]. However, considerable retraction of both tendons and fatty infiltration and atrophy of the muscles, especially true for long-standing tears, make a direct repair difficult and likely to fail [13, 26, 29, 31].

The biomechanical importance of a balanced fulcrum for the function of the rotator cuff has been well described by Burkhart [1]. The role of the subscapularis is critical to shoulder function in patients with lesions of the supraspinatus and infraspinatus [8, 9]. A missed subscapularis tendon tear may leave a portion of the humeral head uncovered after surgical repair of the posterolateral part of the rotator cuff lesion. This may result in a poor outcome after surgery.

When the subscapularis is irreparable, the reconstruction options available to restore its function are limited [27]. Different tendons have been transferred in order to replace its function, but the pectoralis major is the most successful [27]. Many authors transfer the pectoralis major for subscapularis insufficiency using different techniques with similar outcomes [5, 19, 24, 27, 30]. In this study we retrospectively reviewed 15 patients with pectoralis major transfer using the technique described by Resch et al. [24] for anterosuperior irreparable rotator cuff tears.

Resch et al. [24] were the first to report this technique of subcoracoid transfer of the pectoralis major to the lesser tuberosity. They rerouted the pectoralis tendon deep to the

conjoint tendon in order to replace more closely the vector of the subscapularis tendon. In their group of 12 patients with a minimum follow-up of two years, the mean Constant score improved from 22.6 points preoperatively to 54.4 points postoperatively and most of the patients had marked improvement of pain. Four of the patients with preoperative instability regained stability after the specific operation. Galatz et al. [7] reported on 14 patients with subcoracoid transfer of the pectoralis major for anterosuperior subluxation of the humeral head due to a massive rotator cuff tear. In their study with a minimum follow-up of 17.5 months there was significant improvement in pain using the visual analogue scale and the American Shoulder and Elbow Surgeons functional score. Eleven patients had satisfactory and three unsatisfactory results.

According to a recent biomechanical study [21], the transfer of the pectoralis major tendon into subscapularis-deficient shoulders can partially restore normal glenohumeral kinematics. Specifically, a transfer underneath the conjoint tendon better mimics glenohumeral kinematics (the maximum abduction angle as well as the external rotation angle and humeral translations at maximum abduction) that are closer to those in the intact shoulder than a transfer above the conjoint tendon.

A subcoracoid pectoralis major muscle transfer contracts in phase with the subscapularis and represents an appropriate substitute for this muscle. In this study we transferred the superior two thirds of the pectoralis major to the lesser tuberosity and to the anterior part of the greater tuberosity, for the combined anterosuperior irreparable lesion of the rotator cuff.

The Constant score at follow-up (68.17 ± 8.84) was significantly improved and also its subcategories, except for strength and range of motion. Although there was a significant improvement in function, the lift-off test [9] was negative in only three of the 15 patients and the belly-press test was negative in only six of the 15 patients. This illustrates that the transferred muscle fully substitute the subscapularis function as the powerful internal rotator in some patients only.

In contrast to the studies of Jost et al. [19] and Resch et al. [24], external rotation in our study did not significantly decrease after the operation. Probably, the superior two thirds of the pectoralis major are not sufficient to provide full replacement of an irreparable subscapularis and supraspinatus defect. We did not decide to transfer the whole pectoralis major muscle, because our primary goal was the relief of pain and the alteration of a dysfunctional rotator cuff to a partially functional unit, which restores the normal glenohumeral kinematics of the shoulder [1].

The strength did not improve postoperatively but actually showed an insignificant slight decrease. Nor, with the pectoralis major transfer was it possible to restore full

active anterior elevation which is in accordance with other studies [19, 24, 30]. We therefore believe that the patients should be informed that full recovery of active mobility and significant improvement of strength cannot be expected after this type of surgery but improvement of pain and activities of daily living. They should also be informed that their contribution to the postoperative rehabilitation is very important to obtain a satisfactory result for this unique type of injury.

The main reported complication of this procedure is injury to the musculocutaneous nerve [7, 19], but we did not observe any dysfunction of the nerve in our series.

In conclusion, anterosuperior rotator cuff tears represent a separate and unique challenging entity of rotator cuff injuries based on differences of the mechanism of injury, clinical presentation, operative treatment and outcome. Subcoracoid pectoralis major transfer seems to be a reliable option for irreparable combined tears of the subscapularis and supraspinatus tendon with regard to pain relief, function and stability of the glenohumeral joint. Special attention of the surgeon should be directed to the brachial plexus and the musculocutaneous nerve to avoid compression or nerve injury.

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