

# Split Pectoralis Major and Teres Major Tendon Transfers for Reconstruction of Irreparable Tears of the Subscapularis

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## ■ ABSTRACT

Isolated ruptures of the subscapularis and anterosuperior rotator cuff lesions are encountered more rarely than supraspinatus or anteroposterior rotator cuff tears. In certain circumstances, reconstruction of the tendon may not be possible due to fatty degeneration and atrophy of the subscapularis muscle or poor tendon quality. Tendon transfer may represent the only surgical option for treatment. A pectoralis major tendon transfer is an acceptable salvage option for irreparable subscapularis tendon ruptures. Although limited functional goals may be expected in most cases, the majority of patients obtain a good pain relief, which improves their function below chest level. Addition of the teres major component to the transfer may be beneficial in cases where both the upper and lower portion of the subscapularis muscle is irreparable.

Isolated ruptures of the subscapularis and anterosuperior rotator cuff lesions are encountered more rarely than supraspinatus or anteroposterior rotator cuff tears.<sup>1</sup> Because unspecific complaints like pain and weakness without loss of function are in most cases the only sub-

jective signs associated with subscapularis tears, diagnosis and treatment occurred often with delay (Fig. 1). In certain instances, such as chronic tears or subscapularis insufficiency after previous surgery, reconstruction of the tendon may not be possible due to fatty degeneration and atrophy of the subscapularis muscle or poor tendon quality. Tendon transfer may represent the only surgical option for treatment.

## ■ HISTORICAL PERSPECTIVE

Isolated subscapularis tendon tear was first reported by Gerber and Krushell.<sup>2</sup> The authors observed that clinical diagnosis remains a challenge and described the so-called lift-off sign as a very specific sign for subscapularis insufficiency. In a subsequent follow-up of his experience, Gerber reported on his results of repair of the subscapularis tendon.<sup>3</sup> He observed that repairs performed for chronic subscapularis tears had a much poorer outcome than repairs performed in an acute setting.

The anterosuperior cuff tear configuration, which represents a tear of the subscapularis in combination with the supraspinatus and sometimes the infraspinatus, was not recognized as a discreet entity before Warner et al presented their series.<sup>4</sup> They observed, as did Gerber, that tears involving the subscapularis often had a delayed

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**FIGURE 1.** Unspecific subjective complaints and compensated shoulder function usually lead to a delay in diagnosis of a subscapularis tear.

diagnosis, which resulted in late presentation of the patient for shoulder surgery. As this tear configuration occurs usually in younger and active patients, treatment in the chronic situation after delayed diagnosis is challenging, because recovery of function and strength is essential to this high demanding group of patients.

Few studies have dealt with the management of irreparable subscapularis tendon tears. In 1997 Wirth et al reported good to excellent results with pectoralis major transfer.<sup>5</sup>

In the original descriptions of the technique of pectoralis major tendon transfer, the upper portion of the pectoralis major tendon was transferred.<sup>5</sup> Others, like Resch, have described a technique in which the upper

portion of the pectoralis major is rerouted underneath the conjoined tendon.<sup>6,7</sup> In their opinion, this would give a more favorable line of action for the transfer compared with the traditional pectoralis major transfer. However, major concerns with this approach are transfer close to the musculocutaneous nerve, especially in the setting of failed prior surgery with extensive scarring, and the acute angle of the tendon transfer around the conjoined tendon. Although the complication rate with this tendon does not seem to be higher than with the conventional transfer, short-term results do not seem to be better than those of Wirth and Rockwood.<sup>8</sup>

To improve the line of action of the transferred pectoralis major without jeopardizing the musculoskeletal



**FIGURE 2.** Lift-off test. This test is positive when the patient is unable to maintain the raised position of the hand behind the back.



**FIGURE 3.** Belly-press test. The patient exerts an internal rotation force on his belly, with the elbow forward and anterior to the midline of the trunk. In the case of a subscapularis rupture, the patient is unable to keep his hand on his stomach, with the elbow forward.

nerve, the senior one of us (Dr Warner) modified the original pectoralis tendon transfer by rerouting its sternal head underneath the clavicular head before fixation to the lesser tuberosity (split pectoralis major transfer, SPM transfer).<sup>9</sup>

Recently, the anatomic and biomechanical basis of a new tendon transfer combining the split pectoralis major tendon and the teres major tendon (SPM-TM transfer) has been proposed by one of us (Dr Gerber). The rationale of this combined tendon transfer is to replace the upper and lower portion of the subscapularis muscle with the split pectoralis major and teres major, respectively. Surgical feasibility has been tested in 20 fresh cadaver shoulders (unpublished data); in all cases the teres major could be mobilized and fixed to the lesser tuberosity without jeopardizing its main neurovascular pedicle or the axillary nerve. Furthermore, a 3-dimensional force vector analysis showed that the orientation of the transferred teres major is similar to the lower portion of the subscapularis (unpublished data).

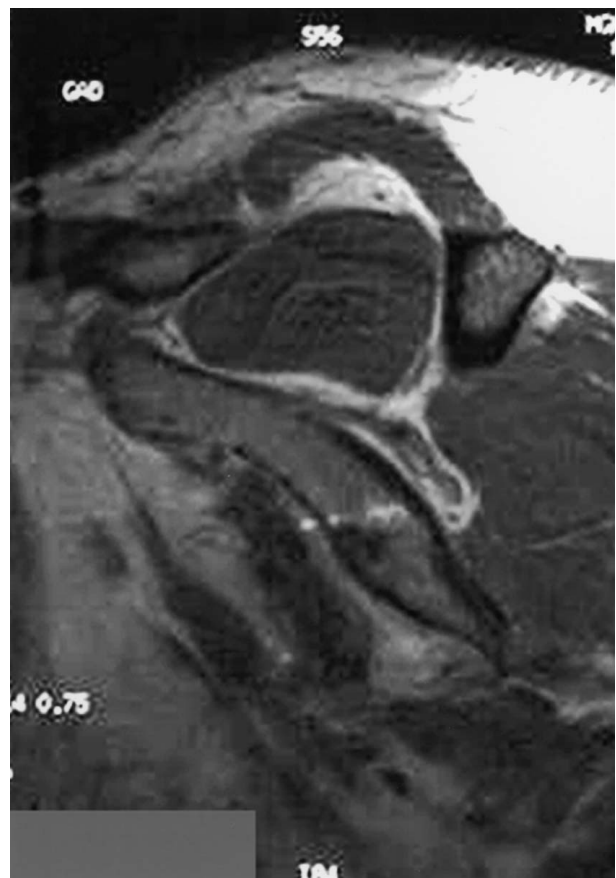
## ■ CLINICAL EXAMINATION AND IMAGING

History and clinical examination are essential to establish the diagnosis of a subscapularis tear. The lift-off test (Fig. 2) and the belly-press test (Fig. 3) have both been shown to be reliable clinical tests for subscapularis insufficiency.<sup>2,3</sup> Increased passive external rotation is another very specific test for subscapularis (Fig. 1). Furthermore, apprehension in abduction is a reliable clinical sign for a complete irreparable subscapularis tear.<sup>1</sup>

Advanced fatty degeneration and atrophy are the main features of irreparable rotator cuff tears<sup>10,11</sup> and can be determined and quantified by CT-scan and MRI. Therefore, preoperative assessment with CT-scan or magnetic resonance imaging is essential to define muscle quality and to design surgical treatment.<sup>12,13</sup> This is best

done on the sagittal oblique images obtained 2 cm medial to the coracoid process and on the axial views (Fig. 4).

Plain radiographs that demonstrate static anterior subluxation on the axillary view may also indicate an irreparable subscapularis tendon tear.<sup>14</sup>



**FIGURE 4.** MRI showing a subscapularis rupture associated with advanced fatty degeneration of the subscapularis muscle (parasagittal plane medial from the coracoid).



**FIGURE 5.** Beach chair setup with an articulated arm holder.

## ■ INDICATION/CONTRAINDICATION

Indications for reconstruction of irreparable subscapularis tears by way of tendon transfer are not yet clearly established. All considerations must be placed in the context of the patients' disability and their expectations for pain relief and functional recovery.

Many factors, like location of the tear (isolated subscapularis tears, anterosuperior tears), quality of the tendon tissue to repair, associated degenerative changes of the glenohumeral joint (cuff tear atrophy), number and nature of previous surgeries, and age and compliance of the patient, have to be considered prior to surgery.

Regardless of which subtype of pectoralis major tendon is used for reconstruction, best functional outcome seems to occur in the younger compliant individual with a symptomatic chronic isolated subscapularis rupture, which is not due to failed previous surgery.<sup>5,6</sup> In more complex situations, like irreparable anterosuperior tears, subscapularis insufficiency after instability surgery, or arthropathy, outcome is less predictable in regard to function. However, it has been our experience that at least pain relief can be expected after tendon transfer when treating those conditions. In massive rotator cuff tears involving the anterosuperior and posterior parts of the cuff and associated with pseudoparalysis, tendon transfer surgery does not seem to be of any benefit and alternative options should be considered. Although tendon transfer for subscapularis rupture is not contraindicated in elderly patients, concomitant medical and social problems may bear on recovery and postoperative compliance with therapy.

Indication for the split pectoralis major and the combined split pectoralis major and teres major transfer is based on our growing clinical experience. Whereas we use the isolated split pectoralis major transfer to reconstruct irreparable tears of the cranial portion of the sub-

scapularis, it has been our impression that adding the teres major to reconstruct the lower portion of the subscapularis in case of loss of the complete subscapularis associated with anterior subluxation improves clinical outcome.

## ■ SURGICAL TECHNIQUE

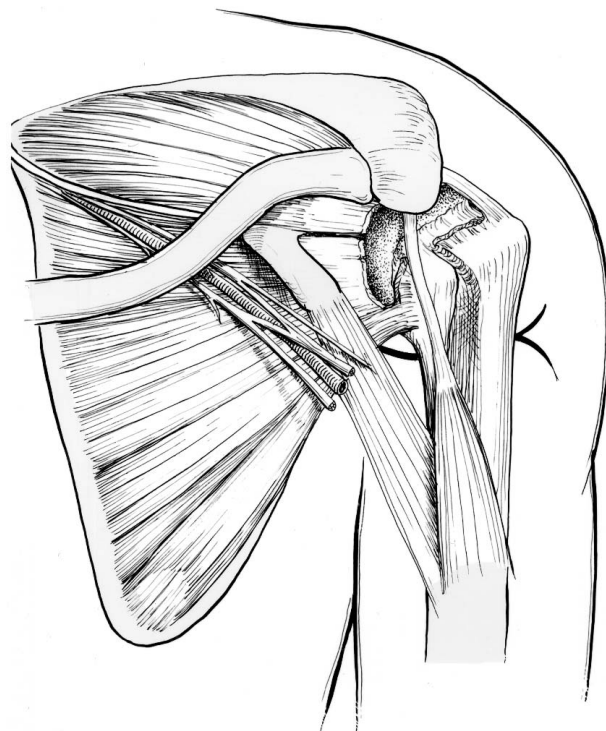
### Anesthesia and Positioning

Surgery is performed under a combined local regional and general anesthesia in most cases, allowing for optimal pain management and relaxation after extubation.

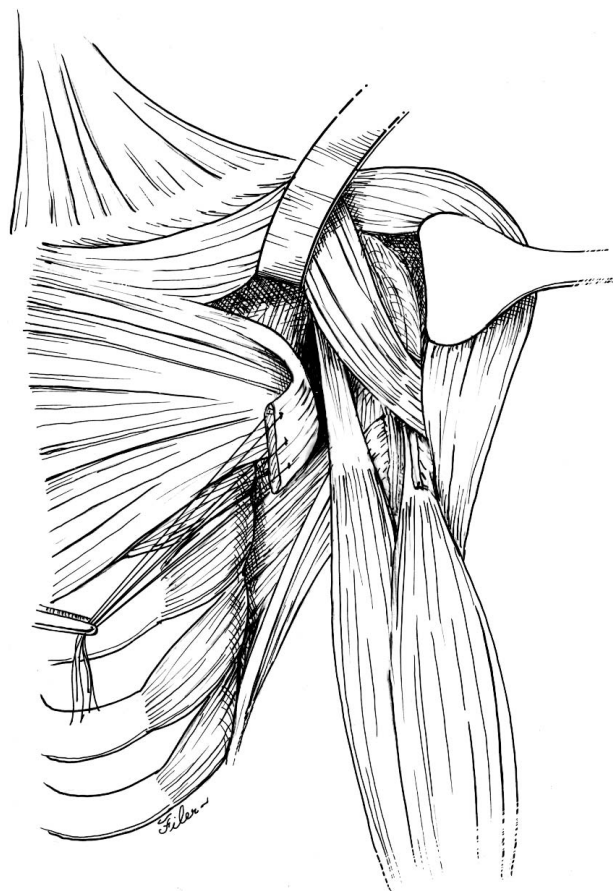
The patient is placed in the beach chair position using a beach chair device or a long beanbag that is contoured around the head and thorax of the patient to allow free access to the shoulder. The use of an arm holder is very helpful during the procedure, supporting the arm in the desired position during dissection and tendon transfer (Fig. 5).

### Approach and Subscapularis Mobilization

An extended deltopectoral approach is required to expose the lower border of the pectoralis major and the latissimus dorsi tendon. Identification of the anterior structures can be very difficult in revision surgery and requires meticulous dissection. First, all adhesions between the humeral head and the deltoid are released. The



**FIGURE 6.** Subscapularis rupture. The lower portion of the subscapularis is often intact or can be repaired.



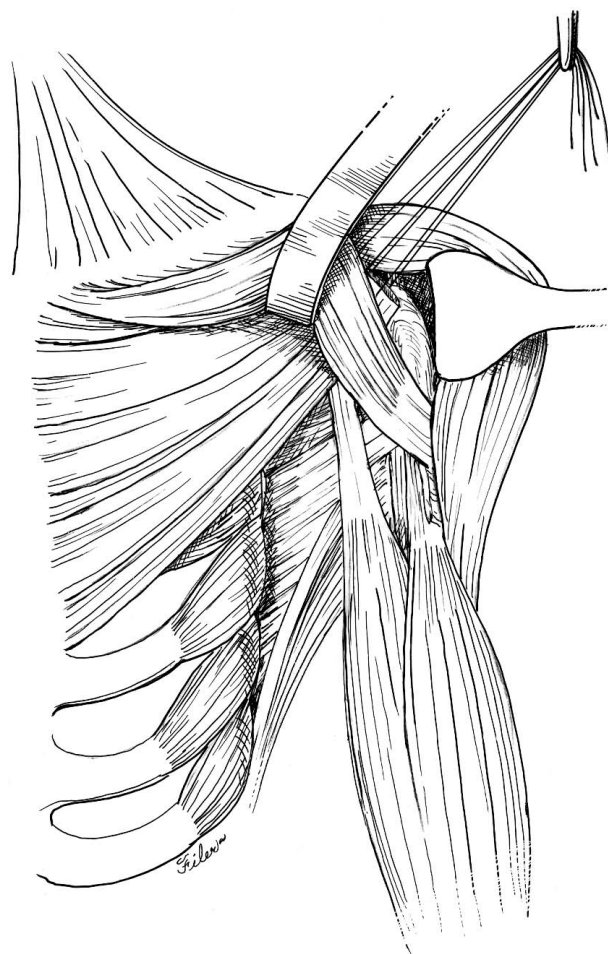
**FIGURE 7.** The sternal portion of the pectoralis major is detached from the humerus.

interval between the conjoined tendon and the pectoralis major is developed. The lesser tuberosity is usually covered by scar tissue that is not the subscapularis tendon, which is retracted medially, deep to the conjoined tendon. The scar tissue is detached from the lesser tuberosity, and a humeral head retractor is used to displace the humeral head posteriorly facilitating dissection. The biceps tendon, if still intact, is invariably medially dislocated and degenerated and is tenotomized. Braided number-2 sutures are passed through the retracted edge of the subscapularis tendon. The circumflex vessels and the axillary nerve are identified. The vessels are controlled with suture ligature, and a vessel loop is placed around the nerve. A retractor is then placed between the nerve and the underlying subscapularis muscle. The tendon of the subscapularis is mobilized. It is imperative that all necessary steps for subscapularis mobilization be performed before the tendon is considered to be irreparable. This includes inferior dissection and mobilization after identification and protection of the axillary nerve. In all cases, an attempt should be made to mobilize the subscapularis so that even if the inferior portion is the only

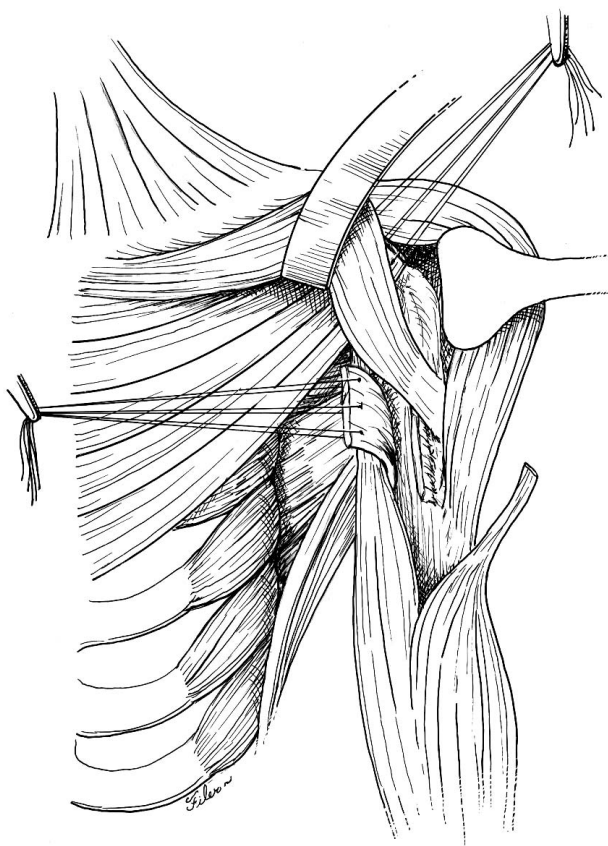
remaining component that can be repaired, it is repaired. This may improve stability of the humeral head, and thus may increase efficiency of the transfer (Fig. 6).

### Tendon Transfer

**SPM Transfer.** The pectoralis major tendon is identified at its humeral insertion. The plane between the sternal and the clavicular head can be found easily at the humeral insertion and is developed. The tendon of the sternal head, which inserts to the humerus underneath the clavicular head, is carefully dissected and sharply released from the bone humerus (Fig. 7). Number-2, braided, nonabsorbable sutures are placed through the end of the pectoralis tendon using modified Mason-Allen stitches. The sternal head of the pectoralis major muscle is dissected medially so that it can be oriented laterally and cranially. Medial dissection should not exceed 10 cm to avoid denervation of the sternal part. After dissection it is pulled underneath the clavicular portion of the muscle (Fig. 8). If the lower portion of the subscapularis



**FIGURE 8.** The sternal head of the pectoralis tendon is transferred underneath the clavicular portion of the muscle.



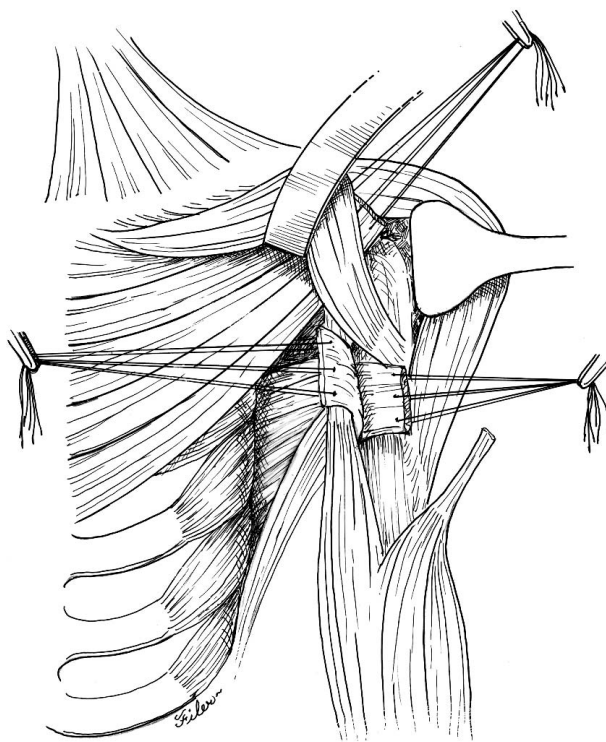
**FIGURE 9.** The latissimus dorsi tendon is detached from the humerus to expose the teres major tendon.

is still intact or has been repaired, the transferred tendon is fixed to the lesser tuberosity. This is performed using transosseous sutures or anchors. To complete the repair, the leading edge of the transferred pectoralis major is sutured to the leading edge of the supraspinatus to close the rotator interval. Adequate tensioning of the transfer requires surgical experience. As a rule the transfer should already be tight in neutral rotation, but still allowing 30° of passive external rotation. Depending on the length of the transfer, fixation of the tendon laterally from the bicipital groove may be necessary to achieve adequate tension.

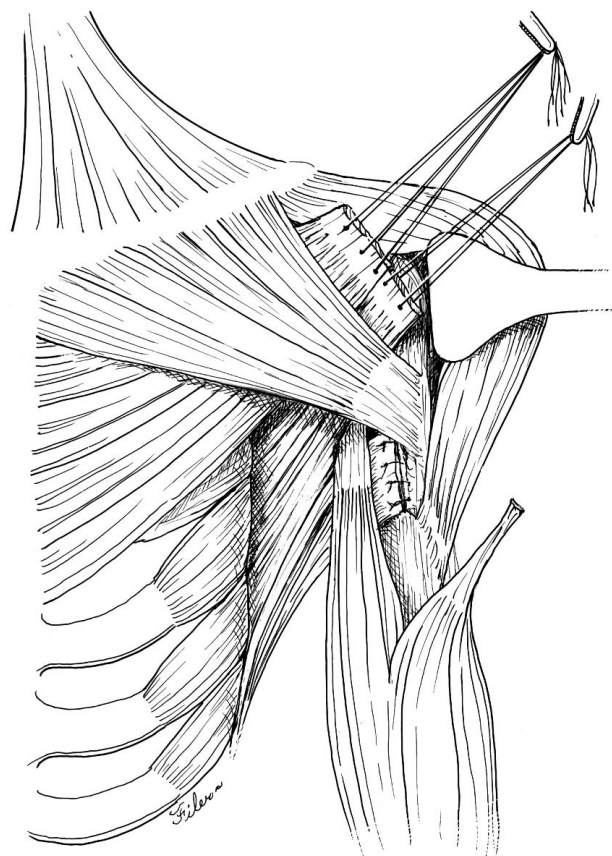
**Combined SPM–TM Transfer.** In the presence of a complete irreparable subscapularis tear, the teres major is added to the split pectoralis major transfer. Dissection of the teres major tendon is performed prior to fixation of the SPM transfer.

The technique of dissection was developed by one of us (Dr Gerber) after careful cadaveric dissections (unpublished data). With the arm in maximal external rotation, the tendon of the latissimus dorsi is exposed. The upper and the lower border are dissected before the tendon is released from the humerus. To allow refixation of

the latissimus tendon at the end of the procedure, a 1cm large cuff of tendon is left at the humeral shaft. The release tendon is reflected medially after 3 number-2 braided non-absorbable sutures have been placed in the tendon (Fig. 9). The plane between the latissimus dorsi and the teres major tendons is well defined laterally, close to their humeral insertion. Medially the plane becomes less clear and dissection must be meticulous to avoid any damage to the short tendon of the teres major muscle. After exposure of the upper and lower border of the teres major muscle, the tendon is elevated subperiosteally from the humeral shaft and 3 sets of number-2 braided non-absorbable sutures are placed through the tendon in a modified Mason-Allen configuration (Fig. 10). The teres major tendon is then mobilized by releasing adhesions to the latissimus dorsi. Dissection at the upper border of the teres major should be performed carefully to avoid any damage to the axillary nerve and the posterior circumflex vessel. Furthermore, medial dissection between latissimus dorsi and teres major should not exceed 7 cm from the humeral end of the teres major tendon to save the main pedicle of the transfer. Usually adhesions limiting cranial mobilization are found between the lower edge of the teres major and the latissimus dorsi and must be released. Before doing so, the surgeon should be aware of the exact location of the



**FIGURE 10.** The teres major tendon is detached from the proximal humerus. All adhesions to the latissimus dorsi are released.



**FIGURE 11.** Both tendons are transferred to the lesser tuberosity.

radial nerve and the deep brachial artery. Finally the tendon is transferred to the lower portion of the lesser tuberosity. The latissimus is repaired to the humeral shaft (Fig. 11).

After both the SPM and the TM has been transferred, both tendons are fixed to the lesser tuberosity, using transosseous sutures or anchors (Fig. 12). The TM is fixed first, using the criteria defined above for tensioning. Then the SPM is fixed to the upper lesser tuberosity, adjusting tension accordingly. Finally the rotator interval between the leading edges of the supraspinatus and SPM and the interval between the leading edges of the SPM and TM are sutured to improve stability of the fixation.

At the end of the procedure, passive motion is measured, especially for external rotation, to guide postoperative rehabilitation.

## ■ POSTOPERATIVE MANAGEMENT

The shoulder is immobilized in a sling for 6 weeks. Strict passive range of motion is mandatory for the first 6 weeks following surgery. After 6 weeks the sling is removed and gentle active-assisted motion is initiated. In general, the postoperative therapy program goes much

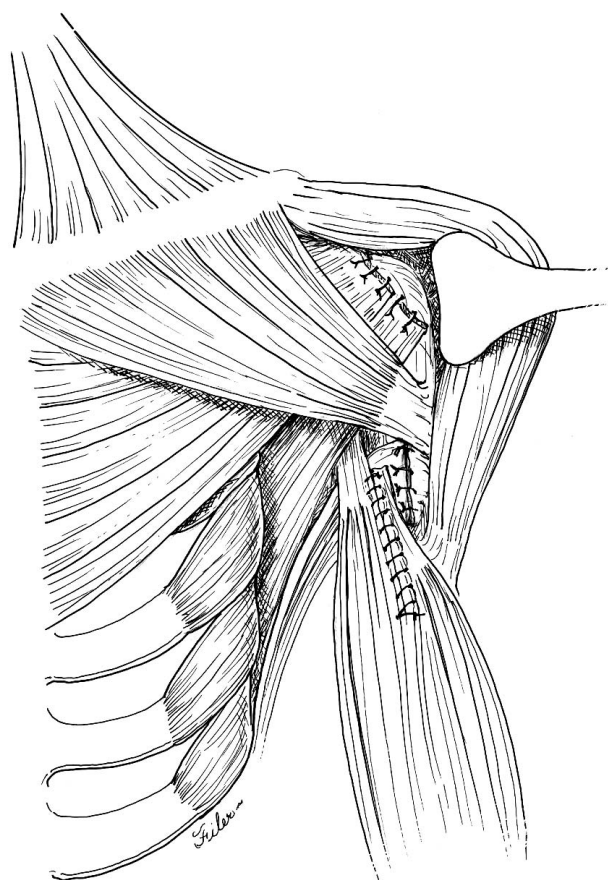
slower than in the cases of a primary rotator cuff repair. Strengthening is started not earlier than the third postoperative month. Return to work or sports is not expected before the sixth month after. As for the latissimus dorsi transfer, completion of rehabilitation requires 12 to 18 months.

## ■ RESULTS AND COMPLICATIONS

Our experience with the STM transfer and the combined SPM–TM transfer is based on the follow-up of 20 patients. All patients had an irreparable subscapularis rupture after previous surgery. A SPM transfer was performed in 11 patients, whereas 9 patients underwent a combined SPM–TM transfer. In all cases the procedure was carried out without complications.

In the SPM group the mean ASES score at an average follow-up of 38 months improved from 42 to 61 points and 9 of 11 patients had significant pain relief. Two patients had persistent pain, which was attributed to a rupture of the transfer and had to be reoperated.

In the combined SPM–TM group, the mean ASES



**FIGURE 12.** Reconstruction of the upper part of the subscapularis with the pectoralis major and the lower part with the teres major.

score increased from 34 to 55 points, and 7 of 9 patients had significant pain relief. One patient had persistent instability 1 year after transfer and underwent fusion as the seventh and last procedure. At the time of surgery the pectoralis major component of the transfer was found to be ruptured.

In both groups functional gains were limited and the subscapularis tests remained positive. A fair comparison with already published reports on pectoralis major transfer for irreparable subscapularis insufficiency is difficult, because all of our patients already had surgery prior to transfer (1–6 procedures) and many of them had not an isolated subscapularis tear, but a anterosuperior tear.

## ■ CONCLUSION

A split pectoralis major muscle transfer is an acceptable salvage option for irreparable subscapularis tendon ruptures. Although limited functional goals may be expected in most cases, the majority of patients obtain a good pain relief, which improves their function below chest level. Addition of the teres major component to the transfer may be beneficial in cases where both the upper and lower portion of the subscapularis muscle is irreparable. Encouraging results in a negative selection of patients justify further investigation. Three-dimensional vector analysis of the pectoralis major transfer and its subtypes is ongoing and may help in optimizing transfer surgery for irreparable subscapularis tears.

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