Subscapularis Tendon Repair Options

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Abstract: The subscapularis tendon is an important anatomic structure of the shoulder joint and is necessary for an unimpaired shoulder function. Subscapularis tendon lesions frequently need treatment to preserve shoulder function. This article provides an overview of the current treatment of subscapularis tears and details the specific techniques.

Key Words: rotator cuff tear, subscapularis tendon tear, subscapularis tendon repair

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Subscapularis tendon lesions are less common than posterosuperior rotator cuff tears and are often related to preceding trauma with hyperextension or external rotation of the abducted arm.[1] However, recent studies suggest that anatomic conditions like a narrowed coracohumeral interval (coracoid impingement) might influence the pathology of subscapularis tendon tears.[2–5] The incidence of subscapularis tendon involvement in all rotator cuff tears reaches up to 33.8% in the current literature,[6] whereas isolated lesions are considerably less frequent with 5.8%.[6] Several studies have reported the importance of the subscapularis for preservation of a normal shoulder function, strength,[7,8] and stability.[9,10] Therefore, in most young and active individuals surgical treatment is recommended for repairable subscapularis tears.[6,11,12]

CLASSIFICATION

In 2003 Fox and Romeo[13] reported a classification for subscapularis tendon tears, where type 1 describes a partial thickness tear, type 2 a complete lesion of the upper 25%, type 3 a complete lesion of the upper 50%, and type 4 a complete rupture of the subscapularis tendon. In 2007 Lafosse et al[14] modified and expanded this classification. He added the preoperative computed tomography/magnetic resonance imaging (MRI) results regarding humeral head position and fatty degeneration according to Goutallier et al.[15] The 2 classifications are shown in Table 1.

SURGICAL TREATMENT

Before considering the surgical options for subscapularis tendon repair, the correct surgical indication is mandatory. A thorough history, clinical examination, and adequate imaging studies enable the correct diagnosis of a subscapularis tendon lesion. The authors recommend performing an x-ray shoulder series (anteroposterior view, y-view, axial view) to evaluate the articular surfaces, to exclude bony lesions after acute trauma or tendon calcifications and to assess the joint congruity. Typically an MRI is also performed to assess the subscapularis tendon and muscle quality and to evaluate the long head of the biceps tendon and the biceps pulley reflection.[16] Although surgical treatment is clearly indicated in acute subscapularis tears, yielding good and reproducible results,[1,14,17] chronic tears deserve closer attention. The retraction of the subscapularis tendon and the atrophy and fatty infiltration of the subscapularis muscle in chronic tears makes repair more difficult and results in worse clinical outcomes and higher rerupture rates.[1,17–19] Therefore the muscle quality should be evaluated before surgical treatment. Flury et al[19] reported advanced fatty degeneration, stage 3 and 4 according to Goutallier et al[15] (Lafosse et al,[14] type 4 and 5), to be associated with an increased rerupture rate. Hence repair of the subscapularis tendon is not recommended in patients with advanced fatty degeneration. In these cases a substitution with a pectoralis major muscle transfer should be considered.[20,21] However, the results of this procedure while reasonable are not always great.[8,21,22] To avoid long-term complications and to achieve the best possible result early surgical treatment of subscapularis tears is preferred.

SUBSCAPULARIS TENDON REPAIR OPTIONS

Arthroscopic Subscapularis Repair

Arthroscopic shoulder surgery has become highly advanced in recent years. It enables the skilled surgeon to better visualize and address coexisting pathologies, including labral tears and posterosuperior rotator cuff tears. However, arthroscopic subscapularis repair can be challenging even for experienced surgeons. In complex tears, the subscapularis footprint at the lesser tuberosity appears bare and the tendon is usually retracted medially, scarred against the coracoid process and the glenoid neck. The required mobilization of the tendon can be hard to achieve and has to be performed very carefully to preserve important neurovascular structures. Therefore a detailed knowledge of the arthroscopic anatomy about the coracoid is mandatory to minimize the relative risk of injury.[23] Identification of the subscapularis tendon stump can also be challenging and particular attention has to be paid to the insertion zone in order not to miss any so called "hidden" lesions.[24–26] In 2003 Lo and Burkhart[25] defined the "comma sign," formed by a portion of the superior glenohumeral ligament/coracohumeral ligament complex, which has torn off the humerus and extends to the superolateral corner of the subscapularis tendon. In some cases this pathoanatomic marker of the torn subscapularis tendon edge can be helpful to identify the subscapularis stump. Furthermore, the anterior compartment of the shoulder is an extremely tight space, and it may become even tighter as the shoulder swells during arthroscopy.[27]

ARTHROSCOPIC TECHNIQUE

Positioning and Instruments

The procedure can be performed both under general or interscalene block anesthesia. Maintenance of a mean arterial

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TABLE 1. Classification of Subscapularis Tendon Tears According to Fox and Romeo[13] and Lafosse et al[14]

Classification of subscapularis tendon tears according to Fox and Romeo[13]
Type I: partial thickness tear
Type II: complete tear of the upper 25% of the tendon
Type III: complete tear of the upper 50% of the tendon
Type IV: complete rupture of the tendon
Classification of subscapularis tendon tears according to Lafosse et al[14]
Type I: partial lesion of superior one third of the tendon
Type II: complete lesion of superior one third of the tendon
Type III: complete lesion of superior two third of the tendon
Type IV: complete lesion of the tendon but centered humeral head and fatty degeneration classified less than or equal to Goutallier et al[15] stage III
Type V: complete lesion of tendon but eccentric humeral head and fatty degeneration classified more than or equal to Goutallier et al[15] stage III

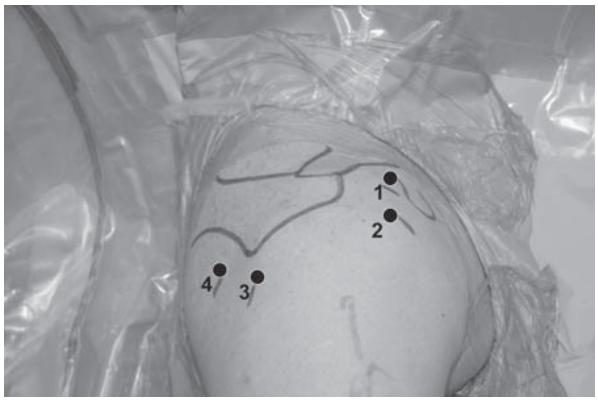

FIGURE 1. Right shoulder of patient in beach-chair position, marked bony landmarks and incisions. Anterior (1), anerolateral (2), posterolateral (3), and posterior (4) portals are shown.

pressure of 70 to 90 mm Hg or a systolic pressure near 100 mm Hg allows maximal visualization and minimizes bleeding. Epinephrine in the arthroscopic solution can also help to control bleeding and to maximize visualization.

A thorough examination of both shoulders under anesthesia is performed on every patient, the examination under anesthesia can provide additional information about concomitant pathologies like restricted range of motion, instability, or hyperlaxity, which might not be evaluable preoperatively due to the patients' complaints. More important, it will show whether there is asymmetry of external roation. A large, complete subscapularis tear usually results in an increased external rotation on the affected side. Moreover stability of the shoulder can also be assessed, as some subscapularis tears are also associated with anterior instability. We prefer the beach-chair position for arthroscopic subscapularis repair, which frees up the medial border of the scapula so that the upper extremity can easily be moved and rotated at necessary angles to better visualize the subscapularis and its insertion. Moreover, the beach-chair position allows an easy conversion to an open procedure if necessary. To position the arm appropriately during different parts of the surgery, the use of a mechanical arm holder is recommended, which allows the surgeon to apply traction to the arm and open the subacromial space or coracohumeral interval to improve visualization again. The procedure can also be performed rather routinely in the lateral decubitus position.

The basic instruments required for arthroscopic subscapularis repair include a 30-degree arthroscope, a motorized shaver, a radiofrequency tissue ablation device, a suture passing and retrieval instrument, a single-hole knot pusher, a suture-cutting device, and graspers. In addition, a 70-degree arthroscope can be helpful. For better fluid management an arthroscopic pump is recommended, as this allows the surgeon to adjust the pressure as needed in any situation. To avoid early swelling of the shoulder the initial pump pressure is set low at 35 to 40 mm Hg.

Surgical Landmarks, Incisions, and Portals

At the beginning of every case we mark the bone landmarks on the skin. Thereby the acromion, clavicle, acromioclavicular joint, scapular spine, coracoid process, and coracoacromial ligament can easily be identified (Fig. 1).

Diagnostic arthroscopy is performed through a standard posterior portal. For better visualization of the subscapularis tendon, respectively the lesser tuberosity, the field of view can be adjusted as required by abduction or internal/external rotation. For all our subscapularis tendon repairs an anterior and an accessory anterolateral portal are created. The anterior portal is generally placed just lateral to the coracoid and below the coracoacromial ligament. It allows access to the lesser tuberosity in an angle of approximately 45 degrees and is especially used for anchor placement and suture management. Next, the anterolateral portal is established just anterior and slightly medial to the anterolateral tip of the acromion. This portal enables proper preparation of the lesser tuberosity, appropriate mobilization of the subscapularis, and easy suture passage, as it approaches the tendon fairly parallel. We recommend placing a cannula into this portal; the authors use a 5.0-mm ribbed clear cannula (Arthrex, Naples, FL). A smaller cannula provides more working room in the rotator interval. Alternatively, an 8.25-mm cannula can be used. The key to proper portal placement is first verifying the intra-articular position and the expected work angles with a spinal needle. Furthermore, it is important not to place the 2 anterior portals too close to each other.

Surgical Procedure Step by Step

Biceps Tendon

In most instances, when there is a tear of subscapularis tendon, the biceps pulley is also been disrupted and the long head biceps tendon itself is subluxated medially (pulley lesion group 3 according to Habermeyer et al[28]).[16] Therefore a thorough examination of the biceps tendon and its pulley system is mandatory. When there is a tear in the long head biceps tendon and/or its pulley system, tenodesis or tenotomy is indicated to avoid the risk of persistent pain and subscapularis repair failure. The authors prefer immediate tenotomy of the biceps tendon at the supraglenoid tubercle, leaving the labrum intact. This is done before repair of the subscapularis tendon, and subsequently the long head of the biceps tendon is tenodesed with miniopen subpectoral biceps tenodesis, once the subscapularis repair is completed. Tenotomy of the long head of the biceps tendon (LHB) improves visualization and helps with the working area in the anterior compartment of the shoulder. Furthermore, the subpectoral tenodesis eliminates any possibility of recurrent biceps subluxation or persistent pain due to loss of biceps excursion (biceps entrapment) or other pathologies within the biceps groove. It reliably relieves pain and improves function.[29] It also eliminates any type of sawing

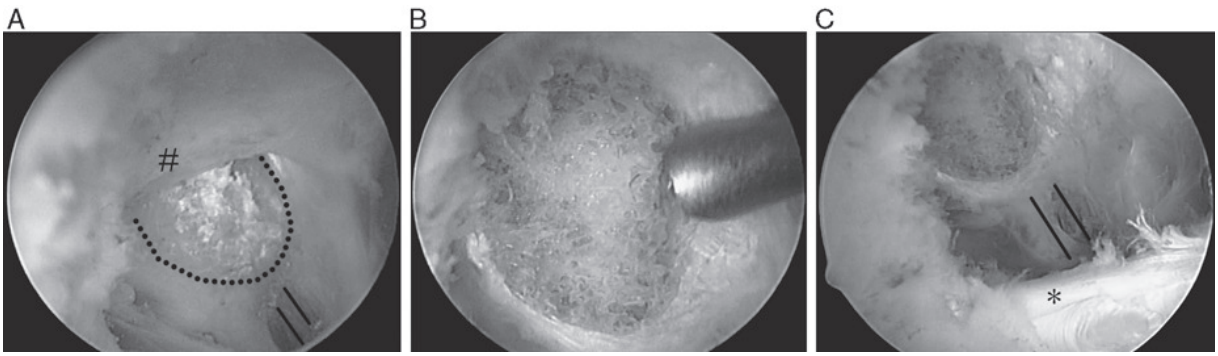

FIGURE 2. Coracoplasty in the right shoulder of the patient in modified beach-chair position, viewing from posterior (same applies to Figs. 3–5). A, Open joint capsule (#) and prepared coracoid process (dotted black line) before coracoplasty. B, Resection of the posterolateral aspect of the coracoid tip with a 4-mm burr. C, completed coracoplasty. The partial subscapularis tear is marked with (*), the black lines indicate the course of the conjoined tendons.

mechanism of injury to the subscapularis tendon, as we have shown in the laboratory.[30]

Coracoid Process and Coracohumeral Interval

As mentioned above, subcoracoid impingement, with narrowing of the coracohumeral interval, can certainly be related to subscapularis tendon tears.[2–5] The causality of cause and effect is still unclear but we do recommend routinely evaluating the coracohumeral interval when there is a subscapularis tendon tear. Finally, we recommend performing a coracoplasty when the coracohumeral distance is narrowed on preoperative images (< 8 mm in women and 10 mm in men on axial computed tomography or MRI planes in neutral position), and coracoid impingement can be confirmed intraoperatively by proving contact between the subscapularis/lesser tuberosity and the coracoid process in abduction/flexion and internal rotation. By doing so, one can avoid mechanical compression between the coracoid and subscapularis repair. Furthermore, a subcoracoid decompression creates more space to work, which makes the surgery technically easier for the subsequent subscapularis repair.

We start by creating a window into the rotator interval just above the superior border of the subscapularis, preserving the medial sling of the biceps sheath, the middle glenohumeral ligament, and the superior glenohumeral ligament, to expose the coracoid. This preparation is performed through the anterior portal by use of mechanical shavers and a radiofrequency device. By dissecting on the lateral side of the coracoid, no neurovascular structures will be injured. The anatomic landmarks include the conjoined tendon inferiorly, the coracoacromial ligament laterally and the base of the coracoid medially. When reaching the lateral aspect of the coracoid, the radiofrequency device can be used to remove the soft tissue from the tip and posterior aspect of the coracoid. Next, a 4-mm burr is used through the anterior portal to remove approximately 5 mm of the posterolateral tip of the coracoid (Fig. 2). The goal should be to medialize and anteriorize the coracoid, while preserving the major tendinous attachments, particularly the conjoined tendon, and avoiding excessive resection medially, which could lead to an iatrogenic fracture.

Subscapularis Tendon

Mobilization: First of all, the mobility of the torn subscapularis tendon has to be assessed using a grasper through one of the anterior portals. In cases of acute tears, the subscapularis tendon can be reduced to the lesser tuberosity easily and without great tension. In these cases one can proceed directly to the repair. If however, the tendon is retracted and scarred against the surrounding tissue, a 3-sided release has to be performed to mobilize the tendon. In these cases the key to finding the torn subscapularis tendon is the comma sign, as described by Lo and Burkhart.[25] The comma sign consists of the medial sling of the pulley system (coracohumeral ligament, superior gelenohumeral ligament), which remains attached to the superolateral border of the torn subscapularis tendon and retracts with it. Therefore it can serve as an excellent landmark, when searching for the torn subscapularis tendon.

After the subscapularis tendon is successfully identified, a suture or grasper can be placed at the superior border of the subscapularis tendon to provide traction during the release. The systematic 3-sided release starts anteriorly by dissecting the soft tissue attachments between the subscapularis and the coracoid. The superior release comprises the lysis of adhesions between the lateral arch of the coracoid and the superior border of the subscapularis. To protect the neurovascular structures, we do not typically dissect medial to the base of the coracoid. Finally, the posterior release is performed to break up adhesions between subscapularis and glenoid neck. Frequently the interval between the labrum and the capsule needs to be divided to allow for proper mobilization of the subscapularis tendon. In some cases a more aggressive and complete release of the coracohumeral ligament and the middle glenohumeral ligament is also helpful or necessary.

Repair: The arthroscopic subscapularis repair can be performed from intra-articular or from extra-articular approaches. The intra-articular approach is appropriate for small upper one-third tears that are completely visible from within the joint (Lafosse et al,[14] type 1). For larger more retracted tears, it is usually easier to work extra-articularly, visualizing through the anterolateral portal to see the subscapularis fossa directly. This approach is helpful for larger tears as the lower border of the subscapularis is covered by the inferior gelenohumeral ligament and therefor hard to visualize from within the joint.[31] The axillary nerve can also be properly visualized and protected from this approach.

Before the repair can be performed a 5-mm shaver is used to freshen up the edges of the torn subscapularis and a 4-mm burr is inserted to prepare the bone bed on the lesser tuberosity. It is important to create a bleeding base before anchor placement, but decorticating the bone should be avoided. In some cases, even after mobilization, it is not possible to bring the retracted subscapularis back to its insertion. In such cases, to

FIGURE 3. Suture shuttle. Perforation of the subscapularis tendon with an 18-G spinal needle with PDS shuttle suture. The subscapularis tendon is tensioned by an arthroscopic grasper (A and B). Both sutures of the double-loaded anchor are shutteled through the subscapularis tendon (C).

obtain an adequate and tension-free reinsertion, 1 option is to medialize the attachment site up to 5 mm by creating a larger footprint. For a tear involving 50% of the tendon (Lafosse et al,[14] type 2 to 3, Fox and Romeo,[13] type 3) we recommend using 1 double-loaded anchor. In larger tears 2 anchors are used, whereby the inferior anchor is placed first, which allows a proper visualization throughout the complete repair process. In cases in which there is a large complete tear of the subscapularis tendon that extends inferiorly to the muscular insertion, the authors favor a double-row fixation, if there is enough lateral excursion of the subscapularis tendon.

Typically the anchors are placed through the anterior portal at an appropriate angle to the lesser tuberosity, although an additional portal can be utilized to achieve the appropriate angle of insertion. One suture strand of each suture is pulled out of the anterolateral portal through a cannula. There are several perforation instruments like a 30-degree suture lasso or a penetrator (Arthrex) for suture passage through the tendon. An 18-G spinal needle, armed with a #1 PDS suture, is another simple option that can also be used percutanously to penetrate the tensioned subscapularis tendon. Next, the intra-articular part of the PDS suture is pulled out through the anterolateral portal. With a simple eyelet the sutures are connected and the suture strand of the anchor can easily be shuttled through the tendon (Fig. 3). This procedure is repeated with the other suture strand of the anchor. Finally the sutures are tied with the arm in neutral rotation, using standard arthroscopic knot tying, typically through the anterolateral portal and the repair is completed (Fig. 4). Alternatively knotless techniques can also be used and the authors are moving toward that method in most cases.[32]

In larger and more retracted or combined rotator cuff tears that involve both the subscapularis tendon and the supraspinatus and/infraspinatus tendons, we recommend using an extra-articular approach performed from the subacromial and anterior subdeltoid space to repair the subscapularis (Fig. 5). We typically use 3 anterior/anterolateral portals to obtain appropriate visualization and to allow the repair to be performed. Additional portals for supraspinatus or infraspinatus repair can be placed as needed. We recommend performing the subscapularis repair initially when coupled with posterosuperior tears, as this allows an easier and more reliable reconstruction of the posterosuperior rotator cuff.[12] In cases such as this, we prefer to use a double row repair to maximize surface area for healing.[32,33]

OPEN SUBSCAPULARIS REPAIR

Classic open subscapularis repair is favored for larger or more chronic tears and for tears with significant scarring but can be used for all subscapularis tears, as the deltopectoral approach adds very little morbidity. If problems occur during arthroscopic repair the surgeon can switch to the open technique at any time. The open repair is performed with the patient in beach-chair position. A standard deltopectoral approach is performed identifying the deltopectoral interval and dividing the clavipectoral fascia at the lateral aspect of the conjoined tendon. After subcoracoidal and subacromial bursectomy the tendon stump can be visualized. Many times there will be a bursal layer over the torn subscapularis tendon that will obscure its view ("hidden" lesion).[26] Care should be taken to remove this bursal sleeve so that the torn subscapularis tendon, which is deep to this layer, can be visualized. Next, the

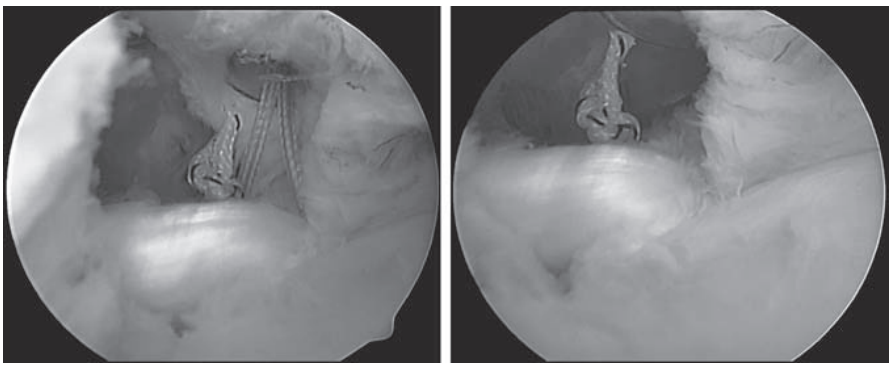

FIGURE 4. Successive tying of the shuttled sutures and completed repair, showing a good reattachment of the subscapularis tendon to the lesser tuberosity.

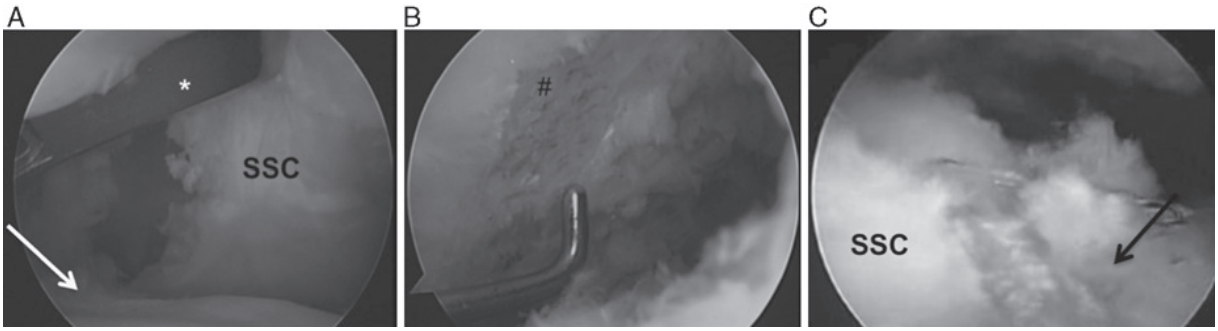

FIGURE 5. Extrarticular subscapularis tendon repair in the left shoulder of the patient in modified beach-chair position, viewing from anterolateral. A, Torn subscapularis tendon reduced by grasper (*). The bare lesser tuberosity is marked by an arrow. B, Performed coracoplasty (#) from extrarticular. C, Completed "double-row" refixation of the subscapularis tendon to the lesser tuberosity (arrow).

edge of the subscapularis tendon is tagged with traction sutures to test mobility. In case of a retracted and scarred tendon, a thorough 270-degree tendon release is necessary to enable a reinsertion to the lesser tuberosity. Care should always be taken to avoid damage to the motor nerves that enter the subscapularis muscle on its anterior surface. The axillary nerve, passing at the inferior border of the subscapularis tendon, also has to be protected and identified before mobilization. Dissection around the coracoid has to be performed carefully to avoid damage to the surrounding neurovascular structures. Before reinsertion of the subscapularis tendon, integrity of the biceps tendon and pulley system should be strictly evaluated. In case of existing LHB or pulley pathologies, a tenodesis is performed fixing the LHB with a suture anchor at the sulcus. The intra-articular part of the tendon is resected. Next, the footprint is prepared, performing a slight decortication of the lesser tuberosity and thus a bleeding bone bed. For large tears, we recommend performing a double-row technique (eg, Speed Bridge, Arthrex) to restore a wide bone-to-tendon contact area on the footprint. Initially the medial row anchors are placed and the sutures (Fibertape, Arthrex) are passed through the tendon medial enough to restore a good footprint. Finally, the lateral row anchors, preloaded with respectively 1 strand of the medial row anchors, are placed and the open subscapularis repair is completed (Fig. 6).

COMPLICATIONS

Possible complications are those seen with arthroscopic shoulder surgery and open rotator cuff repair including infection, nerve damage, stiffness, repair failure, and complications from fluid extravasation.

REHABILITATION

The rehabilitation program is individualized and is not dependent on whether the repair was performed on open or arthroscopic techniques, but is dependent on tear size, quality of the tissues, and the security of the repair. The general rehabilitation protocol is described.

The arm is immobilized in a sling for 6 weeks. In phase 1 (0 to 6 wk) the patient is allowed to come out of the device for passive range-of-motion exercises starting with pendulums and low load passive mid range-of-motion exercises. External rotation is typically restricted to 30 degrees for 6 weeks. In patients with porr tendon quality or a less secure repair, eternal rotation may be restricted to 0 degree for the first 6 weeks. Phase 2 (7 to 12 wk) allows to progress from active-assisted and active range of motion through a full arc of motion. The patient is weaned from the sling after 6 weeks. End-range stretching and joint mobilization techniques can be started. Strengthening exercises start in phase 3 (13 to 16 wk) but only if sufficient glenohumeral and scapulothoracic kinematics have been achieved in phase 2. Persistent range of motion limitations require prolonged passive and active-assisted range-of-motion exercises, stretching, and manual therapy. When sufficient rotator cuff strength is demonstrated patients may proceed to phase 4 (17 to 22 wk). This final step involves strengthening of larger prime mover muscles of the shoulder (pectoralis major, latissimus dorsi, deltoid muscles) and a transition to full activity.

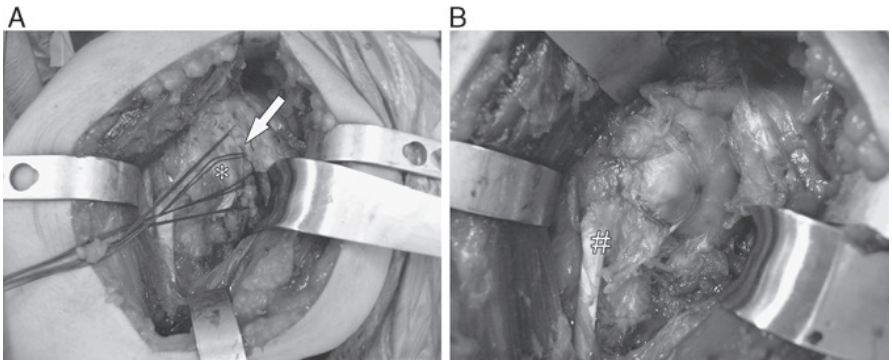

FIGURE 6. Open subscapularis tendon repair of the right shoulder with tenodesis of the long head of the biceps tendon (LHB). A, Subscapularis tendon augmented with traction sutures (arrow); (*) lesser tuberosity. B, Completed suture bridge repair; (#) LHB tenodesis.

DISCUSSION

The subscapularis muscle tendon unit is of great importance for normal shoulder function and untreated tears result in pain, loss of function, weakness, or anterior instability.[7–10] Therefore, to restore the best possible shoulder function, surgical treatment of repairable subscapularis tears is recommended.[6,8,11,12] Both, open[1,17,34,35] and arthroscopic techniques[6,14,27,36–38] are described in literature. With ongoing improvement of arthroscopic techniques and instruments in the past decade, the arthroscopic repair became more and more popular. Clinical studies already showed good and reliable results after arthroscopic subscapularis repair. In 2008 Adams et al[39] reported on 40 patients with arthroscopic subscapularis repair at a mean follow-up of 5 years. They found significant improvements in all outcome scores and a good or excellent result in 80% of the patients. Lafosse et al[14] evaluated 17 consecutive patients with a mean follow-up of 29 months after arthroscopic subscapularis repair. The average relative Constant score improved from 58% to 96%. The authors conclude that arthroscopic subscapularis repair can yield marked improvement of shoulder function, significantly decrease pain, and result in durable structural repair.

Today, open subscapularis repair is mainly recommended for complete and chronic tears with significant retraction of the tendon and extensive scarring against the surrounding tissue. However, open repair can be used for all types of subscapularis tears, as the deltopectoral approach adds very little morbidity and the results in literature are also good and reproducible. In 2005 Edwards et al[34] presented results after isolated open subscapularis repairs in 84 shoulders at a mean follow-up of 45 months. They found a mean Constant score improvement from 55 to 79.5 points and a high satisfaction rate. In a recently published study Bartl et al[17] reported on the open repair of isolated traumatic subscapularis tendon tears in 30 patients. At a mean follow-up of 46 months the Constant score had increased from 51.3 preoperatively to 82.2 points. Twenty-seven patients (90%) rated their result as good or excellent. Ultrasound and MRI revealed a structural intact repair at follow-up in 28 shoulders (93%). They summarized that early open repair of isolated subscapularis tears achieved good functional outcomes with a low rerupture rate.

To summarize, both arthroscopic and open-repair techniques can produce reliable and reproducible results. To date there have been no prospective randomized controlled trials comparing the results after open versus arthroscopic repair of isolated subscapularis tears. The arthroscopic repair of subscapularis tears is demanding and can be very challenging even for experienced surgeons. A comprehensive knowledge of the arthroscopic anatomy of the shoulder and mastering arthroscopic techniques is mandatory in this setting. Although arthroscopic repair techniques are becoming more and more popular, surgeons should also be well acquainted with the open technique, as the open technique uses the deltopectoral approach an intermuscular dissection plane with minimal perioperative morbidity, allowing for excellent visualization and safe access to the torn subscapularis tendon.

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