Technical Note

All—Extra-articular Repair of Anterosuperior Rotator Cuff Tears

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Abstract: Anterosuperior rotator cuff tears involve the subscapularis tendon, supraspinatus tendon, and rotator interval. The long head of the biceps is usually affected and unstable in these complex lesions. Arthroscopic repair of anterosuperior rotator cuff tears often consists of 2 different procedures. Whereas the subscapularis tendon is reconstructed under intra-articular visualization, the supraspinatus tendon is reconstructed under extra-articular visualization. The rotator interval is often sacrificed to improve visualization and instrumentation. The presented technique uses an all—extra-articular approach, which helps to reconstruct these complex rotator cuff lesions in their whole extent without switching from the inside to the outside of the shoulder joint. The preservation of the rotator interval leads to a more stable and anatomic reconstruction.

Anterosuperior rotator cuff tears (ASRCTs) involve the subscapularis tendon (SSC), supraspinatus tendon (SSP), and rotator interval (RI).[1] These complex lesions lead to impaired shoulder function combined with severe rest and night pain. Because the RI is usually involved in these tear types, the long head of the biceps (LHB) may become unstable.[2] Instability of the LHB consecutively leads to pain because of inflammation and partial or complete tears.[3]

Arthroscopic repair of ASRCTs achieves pain reduction and improved shoulder function.[4] Besides the reinsertion of the SSC into the minor tubercle (MiT) and the SSP into the major tubercle (MaT), a biceps tenotomy or tenodesis is advisable to prevent persisting pain and instability of the LHB due to injuries to the pulley system.[5]

For arthroscopic management of ASRCTs, 2 different approaches are commonly used. The SSC is treated under intra-articular visualization using single-row suture anchor refixation to the MiT. For this technique, parts of the RI need to be resected to achieve a sufficient view over the tendon and suture-passing devices. In contrast, the SSP is repaired under extra-articular visualization using single- or double-row refixation to the MaT.

The classic technique with extra-articular repair of the SSP after intra-articular repair of the SSC is related to certain disadvantages:

- Switching to the subacromial bursa after repairing the SSC may be related to swelling, bleeding, and poor visualization.
- Resection of the RI leads to a separation of the SSC and SSP that makes anatomic repair more difficult.
- Preparation and visualization of the SSC footprint on the MiT are demanding, especially if a conventional 30° arthroscope is used.

The presented all—extra-articular technique avoids these disadvantages because ASRCTs are treated as 1 large cuff tear and not as 2 different tears. Thus the RI can be preserved, and the footprint of the MiT and MaT may be exposed to the necessary extent. This facilitates a more stable and more anatomic reconstruction. Furthermore, there is no need to switch the arthroscope from the intra-articular to the extra-articular space during cuff repair. This circumstance is time-saving and allows optimal exposure during the repair.

Surgical Technique

Patient Positioning and Anesthesia

The patient is placed in the beach-chair position on a standard surgical table. The affected arm is supported in

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an arm holder (Trimano; Arthrex, Naples, FL) in neutral forward flexion and rotation. The operation is conducted with the patient under general anesthesia and an additional interscalene brachial plexus block. The systolic blood pressure is kept below a maximum of 100 mm Hg to prevent poor exposure due to bleeding.

Intra-articular Assessment and Management of Biceps Tendon

The arthroscope is introduced through a standard posterior portal, and the joint is assessed systematically. After the ASRCT is confirmed, an anterolateral portal is created by an outside-in technique using a spinal needle and scalpel. An arthroscopic grasper is inserted to assess the extent and retraction of the tear, the mobility of the affected tendons, and the stability of the LHB (Video 1). The LHB needs to be treated by tenotomy or tenodesis to protect the repair and to prevent persisting pain. In patients aged 65 years and older with low demands, a tenotomy is carried out right at the attachment on the superior labrum.

Subpectoral Biceps Tenodesis

If patients are younger than 65 years, a subsequent subpectoral tenodesis is performed using a 3-cm transversal incision at the inferior border of the pectoralis major tendon. After subcutaneous preparation and incision of the fascia, the tendon is identified and pulled through the incision using an Overholt clamp. The tendon is cut 2 cm proximal to the musculotendinous junction and prepared with a No. 2 FiberLoop (Arthrex). After identification of the humerus directly distal to the pectoralis insertion, a 7-mm monocortical bone socket is drilled. The tendon of the LHB is then fixed to the proximal humerus using a 6.25-mm BioComposite SwiveLock Anchor (Arthrex).

Intra-articular Release

If the tear is retracted, an intra-articular release needs to be carried out to achieve a sufficient tear reduction. For this procedure, the arthroscope remains in the posterior portal, and the SSC and SSP are released by cutting adhesions to the labrum and glenoid using an Apollo radiofrequency probe (Arthrex). After the adhesions are cut, mobility is checked again. Further mobility can be gained during the extra-articular release.

Extra-articular Visualization and Release

Extra-articular arthroscopy begins with the arthroscope in the posterior portal. The subacromial and subdeltoid bursa is resected with a shaver introduced through the anterolateral portal. A subacromial decompression is performed using a burr to gain space for the consecutive cuff repair. Inferior osteophytes of the acromioclavicular joint are removed as well. After the subacromial space is increased, a posterolateral portal is created and the arthroscope is switched into it.

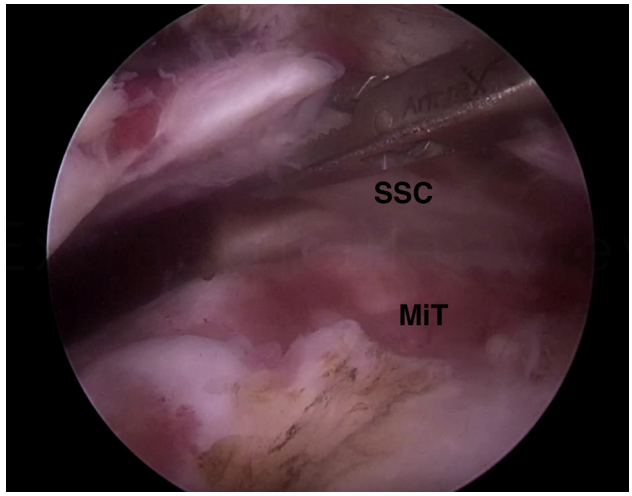

Fig 1. Extra-articular view of anterosuperior rotator cuff tear. A right shoulder is shown with the patient sitting in the beach-chair position. After the intra- and extra-articular release, the mobility of the subscapularis tendon (SSC) and its relation to the minor tubercle (MiT) are assessed with a grasper, which is introduced through an anterolateral portal. The arthroscope is positioned in a standard posterior portal.

Further adhesions of the SSC and SSP are released with the radiofrequency probe introduced through the anterolateral portal. In the case of a retracted SSC, further extra-articular release should be performed with the arthroscope in the anterolateral portal and the radiofrequency probe in an anterior portal located slightly superior and lateral to the coracoid tip. For the extended SSC release, the axillary nerve needs to be identified in the space between the conjoint tendons and the SSC to prevent any injury. After the extra-articular release has been performed, the tendon's mobility is assessed with a grasper (Fig 1).

SSC Reconstruction

The arthroscope is positioned in the posterolateral portal. The bicipital groove is identified (Fig 2). Medial to this, the SSC footprint at the MiT is debrided with a shaver and prepared with a burr. According to the tear size, 1 or 2 anchor holes are created with a punch inserted through the anterior portal. A bioresorbable double-loaded suture anchor (Bio-Corkscrew; Arthrex) is turned into the bone socket. To create a modified Mason-Allen stitch, the first suture of the anchor is passed through the SSC as a mattress stitch using an Expressew suture passer (DePuy Synthes, Warsaw, IN) through the anterolateral portal and a suture retriever through the anterior portal. The other suture is passed through the tendon as a single stitch more medially (Fig 3). The sutures are tied with 7 half-hitches with a knot pusher beginning with the mattress suture and ending with the single stitch. Once the sutures are tied (Fig 4), the stability of the SSC repair is checked under internal and external rotation. Because the RI is still

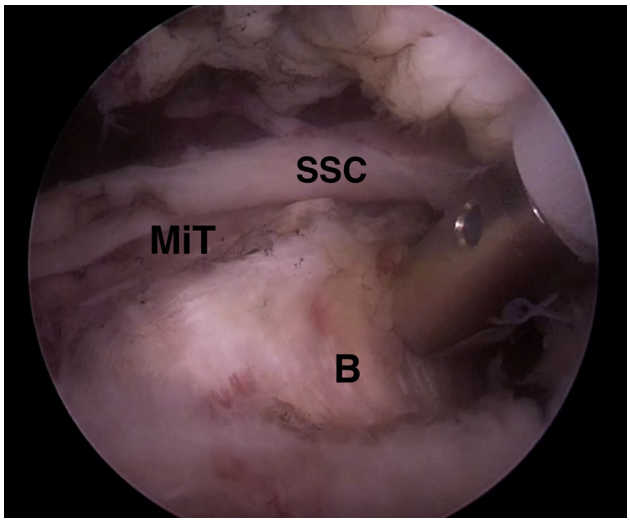

Fig 2. Relation of bicipital groove (B), minor tubercle (MiT), and subscapularis tendon (SSC). A right shoulder is shown with the patient sitting in the beach-chair position. The bicipital groove (B) is identified posterior and lateral to the MiT and SSC. The radiofrequency probe is introduced through an anterolateral portal. The arthroscope is positioned in a posterolateral portal.

intact, the SSP is already reduced at this part of the procedure.

SSP Reconstruction

For the last step of the cuff repair, the arthroscope remains in the posterolateral portal. The footprint at the MaT is debrided and prepared to a bleeding surface with a burr through the anterolateral portal. For the anatomic reinsertion of the SSP, a knotless suture bridge technique with suture tapes (SpeedBridge; Arthrex) is used. The first anchor (Bio-SwiveLock Anchor; Arthrex) is loaded with a nonresorbable suture tape (FiberTape; Arthrex) and inserted anteromedially (posterior to the bicipital groove and immediately lateral to the humeral cartilage, Fig 5). Because the free ends of the tapes are linked to each other, only 1 suture passage through the anterior portion of the SSP is performed with the Expressew suture passer. The sutures are consecutively retrieved through the anterior

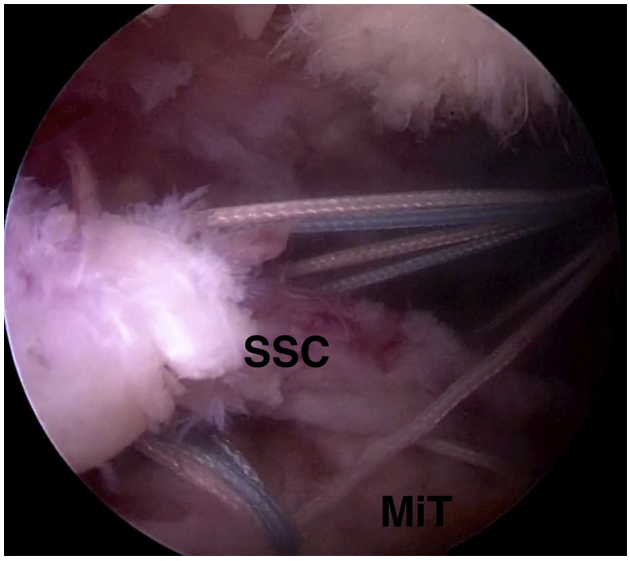

Fig 3. Suture passage during single-row reconstruction of subscapularis tendon (SSC). A right shoulder is shown with the patient sitting in the beach-chair position. The sutures are passed through the SSC by a modified Mason-Allen technique. The anchors are located in the minor tubercle (MiT). The arthroscope is positioned in a posterolateral portal.

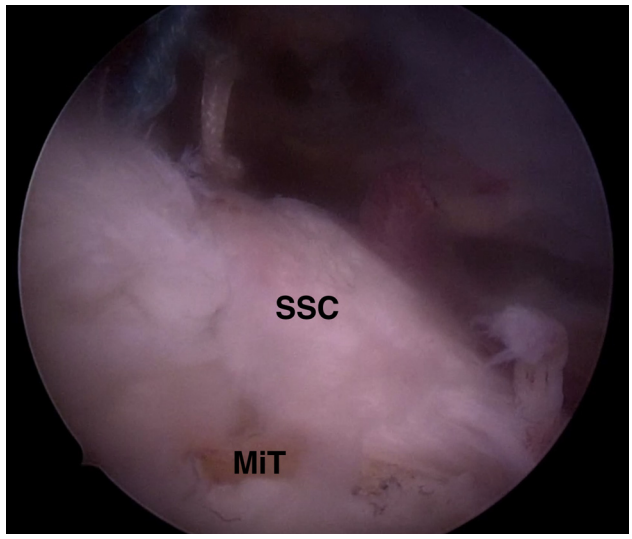

Fig 4. Completed reconstruction of subscapularis tendon (SSC). A right shoulder is shown with the patient sitting in the beach-chair position. After knot tying, the SSC is refixed to its origin at the minor tubercle (MiT). The arthroscope is positioned in a posterolateral portal.

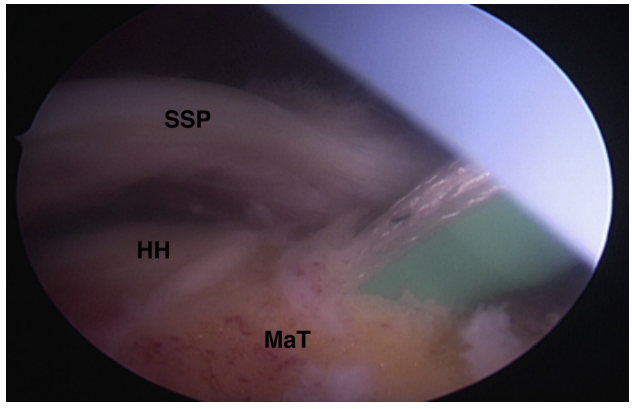

Fig 5. Reconstruction of supraspinatus tendon (SSP). A right shoulder is shown with the patient sitting in the beach-chair position. The first suture bridge anchor for the SSP is inserted anteromedially into the major tubercle (MaT), immediately lateral to the humeral head (HH). The suture anchor is inserted through a flexible cannula located in an anterolateral portal. The arthroscope is positioned in a posterolateral portal.

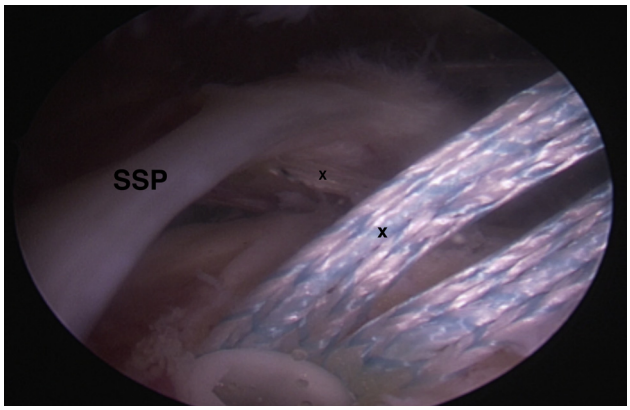

Fig 6. Reconstruction of supraspinatus tendon (SSP). A right shoulder is shown with the patient sitting in the beach-chair position. The second suture bridge anchor for the SSP is inserted posteromedially into the major tubercle. Each medial-row anchor is loaded with a nonresorbable suture tape (X). The suture anchor is inserted through a flexible cannula located in an anterolateral portal. The arthroscope is positioned in a posterolateral portal.

portal, and the sutures are cut proximal to their link and pulled separately to ensure complete passage through the tendon. The second anchor is inserted posteromedially (at the posterior end of the footprint and immediately lateral to the humeral cartilage, Fig 6), and the suture tape is passed through the SSP more posteriorly.

For the knotless lateral-row fixation, 2 more suture anchors (Bio-SwiveLock) are required. One suture tape from the anterior anchor and one from the posterior anchor are retrieved through the anterolateral portal and pulled through the anchor's eyelet. A hole is tapped into the superolateral aspect of the MaT in line with the anterior medial-row anchor. After the lateral-row anchor has been inserted through the anterolateral portal, the suture tapes are pulled alternately and the anchor is turned into the hole. The remaining 2 suture tapes are then retrieved and fixed into the posterolateral MaT likewise, with the remaining suture anchor in line with the posteromedial anchor. The stability of the SSP suture bridge repair (Fig 7) is checked under internal and external rotation.

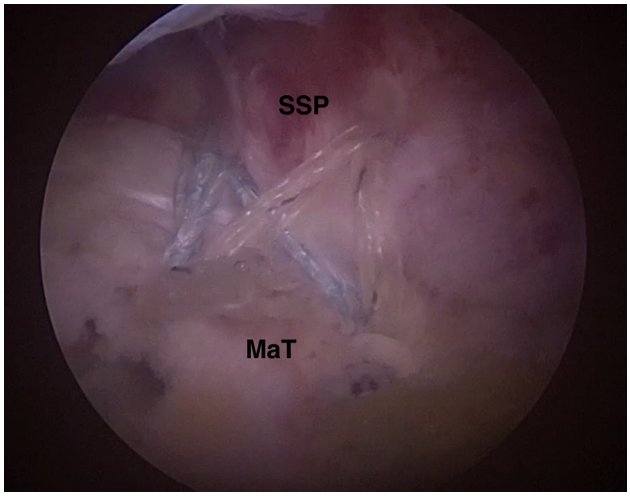

Fig 7. Completed suture bridge repair of supraspinatus tendon (SSP). A right shoulder is shown with the patient sitting in the beach-chair position. After completion of the suture bridge, the SSP is refixed to the major tubercle (MaT). The arthroscope is positioned in an anterolateral portal.

Table 1. Advantages and Disadvantages of All–Extra-articular Repair of Anterosuperior Rotator Cuff Tears

Advantages
Preservation of integrity of rotator interval
Better visualization of minor tubercle and bicipital groove
Extra-articular visualization during whole procedure
Treatment of 1 larger tear and not of 2 different tears
Facilitation of extra-articular release
Disadvantages
No intra-articular visualization during cuff repair
Identification of subscapularis tendon under extra-articular visualization may be demanding

Postoperative Rehabilitation

The affected shoulder is immobilized in an abduction sling for 6 weeks. For the first 3 weeks, no shoulder exercises are permitted. After 3 weeks, the shoulder is mobilized passively until 60° of abduction, 10° of external rotation, and 60° of forward flexion. After the sling has been removed, the patient starts assisted active movements until 90° of abduction and forward flexion. Active range of motion is then improved stepwise until the end of week 12. Full weight bearing is permitted after 6 months. Return to contact sports is possible after 9 months.

Table 2. Pearls and Pitfalls of All–Extra-articular Repair of Anterosuperior Rotator Cuff Tears

Pearls
In the case of a retracted subscapularis tear, the arthroscope needs to be positioned more anteriorly to visualize the medialized tendon.
The bicipital groove is an easily identified landmark that helps to locate the minor and major tubercles.
The procedure should start with a biceps tenotomy or tenodesis to achieve better orientation.
The subscapularis tendon should be reconstructed first, because this step is more demanding and reduces the supraspinatus tear.
Anterior and lateral acromioplasty may create more space for the consecutive cuff repair.
Pitfalls
Insufficient extra-articular release and bursectomy lead to poor visualization of the anterosuperior rotator cuff.
During the extra-articular release of the anterior shoulder, bleeding may occur if the branches of the thoracoacromial artery are injured.
The inferior extent of the subscapularis tear may be underestimated.
Remnants of the rotator interval may hide the subscapularis tear when it is assessed from the extra-articular side.

Table 3. Risks and Limitations of All–Extra-articular Repair of Anterosuperior Rotator Cuff Tears

Risks
Injury to axillary and subscapular nerves during extra-articular release medial to conjoint tendons
Injury to branches of thoracoacromial artery during anterior extra-articular release
Nonanatomic reconstruction because of misinterpretation of tear type and bone landmarks
Limitations
The rotator interval cannot be preserved in cases of concomitant adhesive capsulitis.
The procedure is not indicated in cases of severely retracted tears or advanced fatty muscle infiltration.
Poor tissue quality may lead to irreparability.

Discussion

For arthroscopic shoulder surgeons, ASRCTs are both demanding and time-consuming, especially when they are large and retracted. The presented technique helps to understand and to repair these tear types as 1 large tear and not as 2 different tears. A summary of advantages and disadvantages of this technique is presented in Table 1. Although the presented technique deals with ASRCTs mainly from the extra-articular side, the surgical procedure needs to start intra-articularly to identify the tear pattern, to assess and treat the LHB, and to perform an intra-articular release.

Treatment of the SSC tear is probably the more demanding part of the surgical procedure. Pearls for arthroscopic SSC surgery such as the comma sign described by Lo and Burkhart[6] in 2003 are helpful to assume the retraction and mobility of the tear. Furthermore, the comma sign, which consists of the coracohumeral and superior glenohumeral ligament, is an important landmark for the right distance between the SSC and SSP and should be preserved. In our opinion, discontinuity of the comma sign leads to a less stable repair of ASRCTs. In contrast to an all–intra-articular approach, the all–extra-articular approach to the SSC does not require resection of the comma sign or other parts of the RI to improve visualization and facilitates preservation of the important structures linking the SSC and SSP.

Although the disruption of the superior margin of the SSC does not lead to inferior postoperative results in ASRCT repairs,[7] preservation of the RI and the comma sign is helpful for anatomic reconstruction of the SSC and SSP and simplifies the repair of these demanding tear types. Preservation of the RI additionally leads to a reduction of the SSP once the SSC is reconstructed, which makes the consecutive SSP repair more comfortable.

The presented technique introduces a single-row repair for the SSC and a double-row repair for the SSP. Pearls and pitfalls are summarized in Table 2. Because double-row repair of the SSC does not yield a superior outcome,[8] we do not use this technique routinely. Furthermore, a double-row repair of both tendons would lead not only to higher costs but also to problems of a narrow space. Because lower retear rates of rotator cuff repair have been described for double-row repair when compared with single-row repair,[9] we generally perform double-row SSP repair.

For the repair of complex ASRCTs, concomitant treatment of the LHB by tenotomy or tenodesis seems inevitable, although Oh et al.[10] showed that preservation of the LHB is related to satisfactory cosmesis and supination strength in rotator cuff repair when compared with tenotomy and tenodesis. This treatment is inevitable because the natural anatomy of the pulley system cannot be restored owing to RI lesions and because the repair of the 2 tendons needs to be protected from an unstable LHB.

Particularly in large and retracted tears, the presented technique is related to potential neurovascular complications during the extra-articular release. In these cases, a repair of the ASRCT should be considered thoroughly not only because of these complications but also because of certain limitations that include tissue quality and fatty muscle infiltration. A summary of risks and limitations is shown in Table 3.

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