Technical Note

Arthroscopic Suture-Bridge Repair of the Subscapularis Tendon—"Inside and Outside the Box" With Preservation of the Comma Sign

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Abstract: The subscapularis muscle and its tendon are of major importance in the kinematics of the glenohumeral joint. Therefore, a diligent repair of subscapularis tears is essential. We describe our reliable standardized arthroscopic suture bridge technique to repair subscapularis tears under intra- and extraarticular visualization and with preservation of the "comma sign." This technique provides excellent exposure of the subscapularis tendon, allows its complete release in the subcoracoid space and ensures a safe and stable repair.

The subscapularis muscle is the largest muscle of the rotator cuff and originates from the anterior scapular surface. Its insertion on the humeral side consists of a larger superior tendinous part (about 2/3) and a smaller inferior muscular part (about 1/3). The humeral footprint is "comma shaped," with a broad proximal and narrow distal part, its tendinous portion measures 26 × 16 mm.[1]

Isolated subscapularis tendon tears are rare. However, 35% of patients with rotator cuff pathology show concomitant lesions of the subscapularis tendon.[2] The restoration of the broad proximal footprint is important because the superior band of the subscapularis bears the largest percentage of total load of the muscle.[3] Accurate reconstruction also aims at preventing osteoarthritis of the glenohumeral joint.[4] In our experience and in conformity with Lo and Burkhart, most tears occur in the superior tendinous part of the subscapularis.[5] The inferior muscular part, in contrast, is intact in most cases.[6]

Because of its functional importance as the anterior part of the vertical force couple, surgeons have focused on reliable procedures to repair the subscapularis tendon. Single-row (SR)[6] and double-row (DR)[7] techniques have been described in the literature. For both techniques, it has been shown that patients improve in function, strength, range of motion, and pain, with slightly superior results for DR repairs with regards to retear rates.[8] Wellmann et al.[9] were able to demonstrate that the DR technique provides more primary stability from a biomechanical point of view. Hackl et al.[10] recently supported this finding. They demonstrated that the SB repair with stabilization of the "comma sign" enhances the primary stability and thereby reduces micromotion at the tendon–bone interface, which might be important for tendon healing.[10]

Burkhart first introduced the term "comma sign," meaning a sling of tissue that contains fibers of the superior glenohumeral and coracohumeral ligament and that is attached to the superolateral border of the subscapularis.[5] In case of retracted subscapularis tears, the "comma" is a useful guide for subscapularis mobilization. Furthermore, it is attached to the anterior rotator cable of the supraspinatus. Consequently, subscapularis repair with an intact "comma" simultaneously facilitates supraspinatus repair.[11,12]

The purpose of this Technical Note is to describe a reproducible, standardized, and all-arthroscopic SB technique for subscapularis tendon repair. The advantages of this technique are the excellent exposure

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of the subscapularis tendon and its footprint by visualization from "inside and outside the box," i.e., with intra- and extra-articular view. Moreover, preservation of the "comma sign" facilitates the mobilization of the subscapularis tendon and enhances its repair and is helpful for the concomitant repair of the supraspinatus tendon.

Surgical Technique (With Video Illustration)

Surgery is performed with the patient in a beach-chair position under general anesthesia with an additional interscalene block. For the subscapularis tendon repair, we routinely use a 30° scope and 7 portals: the posterior, anterosuperior, anteroinferior, suprabicipital, infrabicipital, posterolateral, and lateral portal. After marking osseous landmarks on the skin, we proceed with the diagnostic arthroscopy using the standard posterior portal. The anterosuperior and suprabicipital portals are established after localization with a spinal needle by an outside-in technique. Primarily, biceps tenodesis or tenotomy is performed as indicated on patient-based criteria and surgeon's preference.

Identification of the "Comma Sign" and Release of the Subscapularis Tendon Viewing From "Inside the Box"

Then, from "inside the box," i.e., with intra-articular view, we carefully inspect the subscapularis tendon and look for the "comma sign," which can be retracted to the glenoid level in certain instances. Once identified, a PDS traction suture is placed around the "comma sign" using the 45° curved Linvatec spectrum device (Conmed, Largo, FL) through a percutaneous infrabicipital stab incision (Fig 1 A and B). A 270° release of the subscapularis tendon is performed under continuous traction until the subscapularis tendon can be easily reduced to its footprint. To do so, we release the capsule, the middle glenohumeral ligament, and the coracohumeral ligament using a radiofrequency device through the suprabicipital portal. The interval tissue is then released anterior to the tendon until the coracoid tip and the lateral border of the conjoint tendons are identified. Subsequently, debriding the interval tissue lateral to the coracoid process and releasing the inferior part of the coracoacromial ligament through the anterosuperior portal establish an anterosuperior "window." Now, a soft-cannula (PassPort Button 40 × 8 mm; Arthrex, Naples, FL) is placed in the anterosuperior portal for later suture management.

Completion the Subscapularis Tendon Release Viewing From "Outside the Box"

To complete the 270° release, the subscapularis tendon is visualized from "outside the box," i.e., under extra-articular view. For this purpose, the scope is switched to the suprabicipital portal and is placed anterior to the "comma sign" with the help of a switching stick (Fig 2 A and B). Now the tendon release can be completed under optimal visualization of the subcoracoid space. We avoid preparation medial to the coracoid base to avoid neurovascular complications.

Anchor Placement and Suture Management

After switching back to the posterior portal "inside the box," we then proceed with footprint preparation using an aggressive shaver blade, before placing a triple loaded anchor (TWINFIX Peek; Smith & Nephew, Hertfordshire, United Kingdom, or Y-knot, Conmed, Largo, FL) into the lesser tuberosity using the soft cannula in the anterosuperior portal (Fig 3). A percutaneous low anteroinferior portal is established in an outside-in technique to facilitate suture management (Fig 4). Two suture pairs are shuttled in a horizontal or oblique mattress configuration through the subscapularis tendon with the use of a Cleverhook (Mitek Sports Medicine, DePuy Synthes, Raynham, MA) (Fig 5 A and B). The last suture pair is placed in a vertical simple stitch configuration, whereby the last

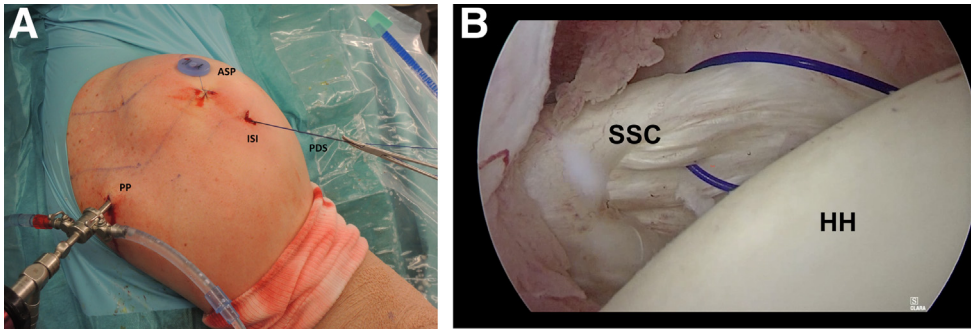

Fig 1. Right shoulder. Visualization of the subscapularis tendon from "inside the box" and placement of a PDS traction suture around the "comma sign" through an infrabicipital stab incision. (**A**) Intraoperative setup with the patient in a beach chair position. (**B**) Arthroscopic view "inside the box" through a standard posterior viewing portal. (ASP, anterosuperior portal; HH, humeral head; ISI, infrabicipital stab incision; PDS, polydioxanone; PP, posterior viewing portal; SSC, subscapularis.)

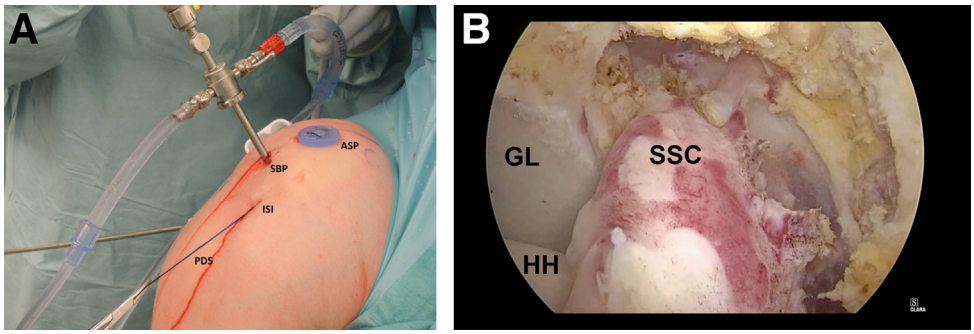

Fig 2. Right shoulder. Visualization of the subscapularis tendon from "outside the box." (**A**) Intraoperative setup with the patient in a beach chair position. The scope is switched to the suprabicipital portal and is placed anterior to the "comma sign." (**B**) Arthroscopic view from "outside the box" through a suprabicipital viewing portal. (ASP, anterosuperior portal; GL, glenoid; HH, humeral head; ISI, infrabicipital stab incision; PDS, polydioxanone; SSC, subscapularis.)

limb is not pierced through the tendon but encloses the superior border of the subscapularis tendon. This results in a rip-stop or Mason–Allen like suture configuration. All knots are tied with a Nicky`s sliding knot through the anterosuperior cannula. Attention is paid to place the free superior limb of the simple stitch medially onto the healthy subscapularis tendon. Two suture pairs are preserved for the later suture bridge configuration, the middle one is cut (Fig 6). As an alternative option, better visualization for knot-tying might be obtained from "outside the box" using the suprabicipital viewing portal in the same manner as mentioned above.

Subacromial Preparation, Positioning of the Lateral Row Anchor

The subacromial space is now exposed through a standard posterolateral portal. After establishing the lateral portal, subacromial bursectomy and acromioplasty are performed. A soft PassPort Button Cannula 30 × 8-mm is introduced into the lateral portal. The supraspinatus tendon is carefully inspected and repaired if necessary. In the present case (Video 1), an inverted mattress suture addressed an incomplete

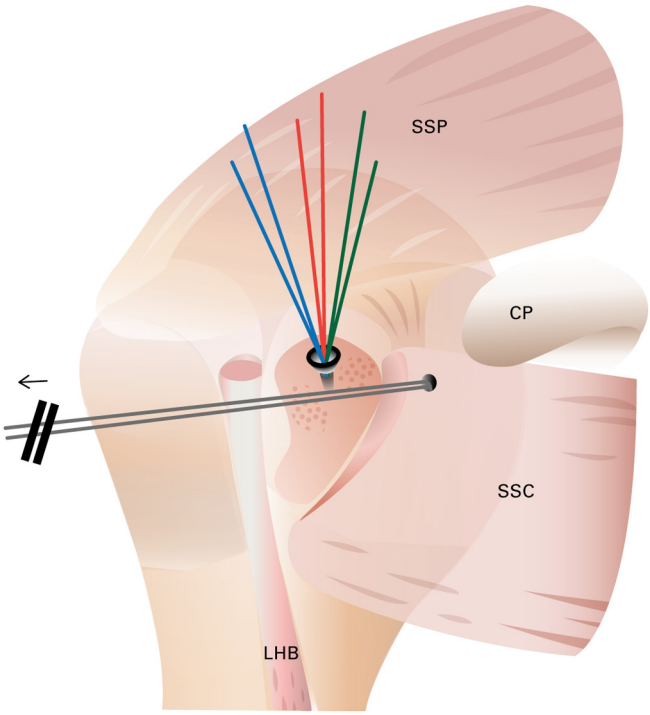

Fig 3. Right shoulder, view from anterolateral. A PDS traction suture (black) is placed around the "comma sign." A triple-loaded anchor is introduced in the lesser tuberosity. (CP, coracoid process; LHB, long head of the biceps; PDS, polydioxanone; SSC, subscapularis; SSP, supraspinatus.)

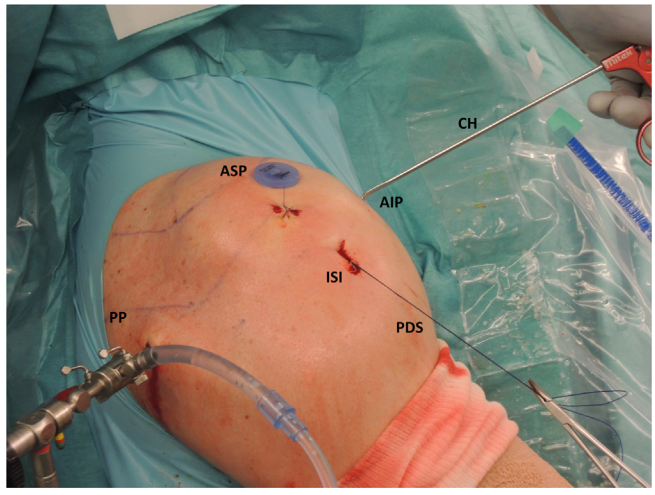

Fig 4. Intraoperative setup, patient in beach chair position, right shoulder. Scope in the posterior portal, viewing "inside the box." To facilitate suture management a percutaneous low anteroinferior portal is established. (AIP, anteroinferior portal; ASP, anterosuperior portal; CH, Cleverhook; ISI, infrabicipital stab incision; PP, posterior viewing portal.)

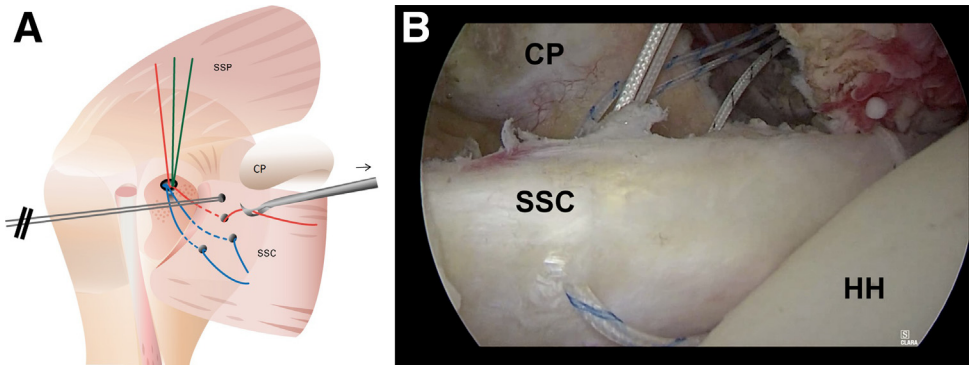

Fig 5. Suture management. (**A**) Illustration of a right shoulder, view from anterolaterally. Two suture pairs are shuttled in a horizontal or oblique mattress configuration (blue and red) through the subscapularis tendon with the help of a Cleverhook. (**B**) Arthroscopic view of the suture management from "inside the box" viewing from the posterior portal, right shoulder.(CP, coracoid process; HH, humeral head; SSC, subscapularis; SSP, supraspinatus.)

undersurface tear of the anterior rotator cable, which was debrided previously. Finally, we identify the position for the lateral row anchor of the suture bridge adjacent to the bicipital groove. After retrieving all the subscapularis and supraspinatus sutures into the lateral cannula, we introduced a 4.5-mm PushLock Anchor (Arthrex) to finalize the SB repair.

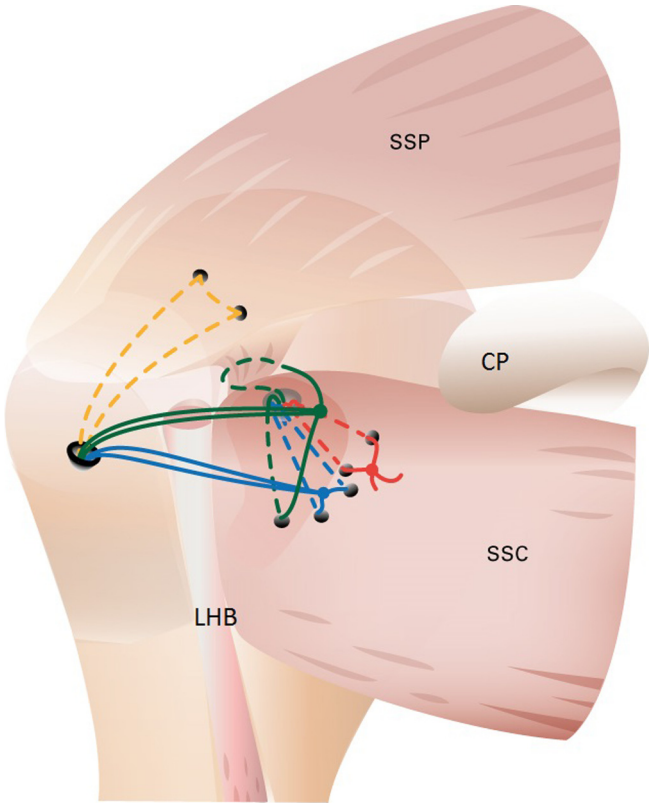

Fig 6. Right shoulder, view from anterolateral. Illustration of the final suture bridge repair of the subscapularis tendon. Two suture pairs are placed in a horizontal or oblique mattress configuration (blue and red); one suture pair is placed in a vertical "simple stitch" (green). Together with the inverted mattress suture of the supraspinatus tendon (yellow) 2 sutures (green and blue) are fixed lateral to the bicipital groove to finalize the suture bridge repair. (CP, coracoid process; LHB, long head of the biceps; SSC, subscapularis; SSP, supraspinatus.)

Discussion

Due to improvement of imaging and arthroscopic techniques, we know that subscapularis tears are more common than previously thought.[2] They usually occur in the superior tendinous portion of the subscapularis,[5] whereas the inferior muscular part is usually preserved.[6] According to Lafosse et al.,[13] visualization of tears involving the superior two-thirds is achieved best from "inside the box" using the beach-chair position. Other authors recommend the visualization and repair of subscapularis tears from "outside the box," incorporating the "comma sign" into the repair of anterosuperior rotator cuff tears.[12]

Our technique provides the advantage of visualization of the subscapularis tendon from "inside and outside the box," which provides excellent exposure even for severely retracted subscapularis tears (Table 1). Whether to perform SR or DR repair is still under discussion. Both techniques show good functional results, with a slight advantage for DR repairs.[8] Respecting this issue and due to our SB technique, we achieve good footprint coverage with one triple-loaded anchor in the medial row, which leads to simultaneous reduction of the intact muscular portion. Moreover, incorporating the lateral row of the SB subscapularis repair in the lateral row of the supraspinatus repair saves time and hardware. Preserving the "comma sign" provides the following benefits: (1) latest biomechanical research has proven enhanced primary stability in SB repairs with stabilization of the "comma sign"[10]; (2) it can be used as a guide to localize the subscapularis tendon in case of severe retraction; (3) mobilization and release of the subscapularis tendon becomes easier; and (4),

Table 1. SB Repair of the Subscapularis With Preservation of the Comma Sign: 12 Steps

1. Diagnostic arthroscopy
2. Management of the LHB
3. Identification of the "comma sign" and placement of a PDS traction suture
4. 270° release of the subscapularis tendon from "inside the box":
   - ○ release of the anterior capsule, MGHL, CHL
   - ○ debridement of interval tissue to identify the coracoid tip and conjoint tendon
5. Preparation of the anterosuperior "window" and placement of a soft cannula
6. Visualization of the subscapularis from "outside the box" and completion of the 270° release
7. Switching back to the posterior portal "inside the box" for footprint preparation and placement of a triple loaded anchor
8. Suture management
   - ○ create a percutaneous anteroinferior portal
   - ○ suture shuttling through the subscapularis tendon with the Cleverhook (Mitek) using the percutaneous anteroinferior portal
   - ○ two suture pairs in a horizontal mattress configuration
   - ○ one suture pair in a vertical "simple stitch" configuration
9. Knot-tying
   - ○ visualization from "inside or outside the box" as preferred
   - ○ preserve 2 suture pairs for later suture bridge configuration.
10. Visualization of the subacromial space, acromioplasty if indicated and placement of a soft cannula
11. Careful inspection of the supraspinatus tendon and treatment if indicated
12. Creating the lateral row of the SB configuration
    - ○ placement of a 4.5-mm PushLock anchor (Arthrex) lateral to the bicipital groove
    - ○ optional in case of additional lesion of the supraspinatus: integrate the subscapularis sutures in the supraspinatus repair

CHL, coracohumeral ligament; LHB, long head of the biceps tendon; MGHL, middle glenohumeral ligament; PDS, polydioxanone; SB, suture bridge.

reduction of the "comma" leads to reduction of the supraspinatus tendon due to its connection to the anterior rotator cable.[11]

The described technique has some limitations and risks (Table 2). We only use a 30° scope, which might limit the exposure of the lower portion of the subscapularis in case of extensive tears. In our experience and due to the visualization of the tendon from intra-articular and extra-articular, we achieve an excellent view to the subscapularis tendon. In certain cases, the use of a 60° scope might help to improve visualization.

Due to preservation of the "comma sign," the so-called "hidden lesions" of the subscapularis might be missed.[14] Remobilization of the subscapularis and preparation of the anterior window should be done carefully. As the brachial plexus is located medial to the coracoid process release medial to the base of the coracoid process can cause neurovascular complications and should be avoided.

Table 2. Advantages, Limitations, Risks

Advantages	• SB repair of the subscapularis tendon with broad footprint coverage • Visualization of the tendon and footprint "inside and outside the box" • Preservation of the "comma sign" with: ○ easier mobilization of retracted subscapularis tears ○ enhanced primary stability of the SB repair ○ easier reconstruction of supraspinatus tears • Integration of the lateral row of the subscapularis-SB-repair in the supraspinatus repair: ○ time-saving and less hardware
Limitations	• the 30° scope might be limited in extensive subscapularis tears • "hidden lesions" might be missed
Risks	• risk of neurovascular complications medial to the coracoid process

SB, suture bridge.

In conclusion, our technique provides a reliable and anatomic arthroscopic SB repair of the subscapularis tendon with excellent exposure of the tendon from "inside and outside the box" and good footprint coverage. Preserving the "comma sign" enhances the stability of the SB repair and is useful for subscapularis mobilization and reduction. Furthermore, preserving the "comma sign" is beneficial for later supraspinatus repair.

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