Technical Note

Optimization of Subscapularis Tendon Repair in Stemless Shoulder Arthroplasty Using a Resorbable Pressure-Dissipating Onlay Suture Disk Implant

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Abstract: Successful subscapularis repair in stemless shoulder arthroplasty is crucial to reduce complications and improve postoperative function. As stemless shoulder arthroplasty continues to grow in popularity, several subscapularis tendon repair techniques are being developed, with a current trend toward knotless devices and double-row anchor-based constructs. In this article, we present our technique for repair of a subscapularis tendon peel using a suture-capture construct that aids in compression of the tendon onto its footprint and then gradually releases the tension as the capture resorbs and tendon healing occurs. The suture-capture tissue repair technology uses a disk or button that pushes down a larger area of tissue onto the bone, eliminating gap formation between the bone and tendon; as the button's material degrades, compressive, shearing, and tensile forces are transferred to the tendon tissue to achieve complete remodeling of the repair.

Stemless shoulder arthroplasty (SSA) has proved reproducible and safe in patients with glenohumeral arthritis and an intact rotator cuff. The recent literature suggests that the mid- and long-term results with these implants are favorable; nonetheless, there are still some concerns about subscapularis tendon management.[1-3]

The main techniques for mobilizing the tendon in SSA include tenotomy, peel, or lesser tuberosity osteotomy. Regardless of the technique, surgeons must repair the tendon using strong constructs that lead to complete healing.[4] Failure of repair after shoulder arthroplasty can lead to major complications such as impaired postoperative function, anterior instability, loosening of components, and postoperative pain.[5,6]

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The peel technique has been reported to yield a successful healing rate of 83%.[7] Several repair methods have been described, most of which involve double-row anchor-based nonabsorbable suture constructs.[7] The use of these implants can sometimes result in increased stress shielding of the tissue due to a higher Young modulus, leading to inadequate tendon healing or bone loss, which is why resorbable implants are gaining popularity for tissue repair in the field of orthopaedics.[8,9]

This article presents a description of our subscapularis peel repair technique using an implant comprising a beaded suture and a disk made of resorbable polymer (ZipE; ZipTek Global, Sarasota, FL) (Video 1). The implant technology aids in compression of a larger area of tissue down to the bone, improving contact forces and increasing the chances of complete healing. Its resorbable nature allows for load transference from the implant to the tendon as healing takes place, minimizing the stress shielding effect and promoting tissue remodeling.[10]

Surgical Technique

Anatomic Landmarks

For arthroplasty cases, the beach-chair position and deltopectoral approach are the mainstay in our practice (Fig 1). Although the deltopectoral approach is

Fig 1. Beach-chair position showing the right side of the patient. Prior to surgery, the surgeon must ensure that patient positioning is appropriate. For the beach-chair position, the patient should be placed at a sufficient height on the table to ensure that, when the table is raised, the patient's buttocks sit comfortably at the hinge or break of the table, with the lower back fully situated on the bed. The table is raised to 60° to 65°, and 2 pillows or folded surgical towels are placed underneath the patient's legs, making sure the knees and hips are in a resting position. Next, the head of the patient is secured using the specific headset with a foam mask; care is taken to secure the head in adequate alignment with the neck. Once the patient is in the desired position, safety straps are applied and the nonoperative limb is placed in an arm holder.

relatively straightforward, there are some anatomic landmarks the surgeon must identify prior to surgery. To ease orientation, the anterior and posterior borders of the acromion, clavicle, acromioclavicular joint, and scapular spine are identified and marked (Fig 2). The coracoid process is easily palpated in the anterior aspect of the shoulder directly in line with the acromioclavicular joint; this will be outlined and serve as the starting point of our incision. We track and mark the superior border of the pectoralis major tendon in the axilla at 40° of abduction, as well as the deltoid muscle insertion at the lateral aspect of the shoulder. The distance between the pectoralis major tendon and the deltoid insertion is divided into thirds: medial, middle, and lateral. The incision is marked from the coracoid process to a point located between the medial and middle thirds of this division at the level of the deltoid "V." The incision is carried out and deepened with sharp dissection until the superficial fascia is visualized; then, the deltopectoral groove is dissected, and the cephalic vein is identified and protected. Blunt dissection is carried out in the subdeltoid space, and a self-retaining retractor is placed between the conjoint tendon and the deltoid muscle. At this point, the bicipital groove and biceps tendon must be identified.

Subscapularis Peel

Once the bicipital groove and biceps tendon are pinpointed, a suprapectoral biceps tenodesis is performed with No. 1 Vicryl suture (Ethicon, Somerville, NJ). The superior and inferior borders of the subscapularis tendon are then identified, and the tendon peel begins

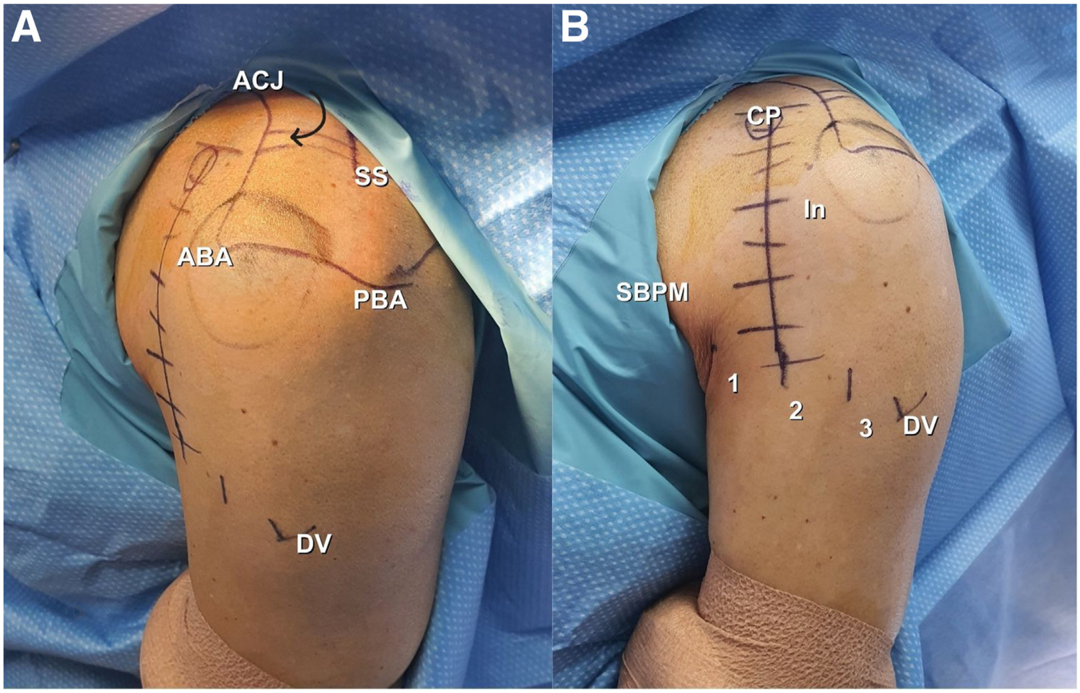

Fig 2. Deltopectoral approach landmarks, left shoulder. (A) To ease orientation, landmarks are outlined on the skin: anterior border of acromion (ABA), posterior border of acromion (PBA), acromioclavicular joint (ACJ), scapular spine (SS), coracoid process (CP), superior border of pectoralis major (SBPM), and deltoid V (DV). (B) To plan the incision (In), the distance from the DV to the SBPM is divided into thirds (1, 2, and 3) and the approach is marked from the CP to a point located between the medial (1) and middle (2) thirds of this division.

at the medial aspect of the bicipital groove, elevating the whole tendon in 1 layer directly from the lesser tuberosity (Fig 3A). As the tendon is being peeled off the bone, progressive external rotation is applied to the shoulder to keep tension in the dissection plane (Fig 3B). With the tendon completely elevated, the humeral head will dislocate; at this point, arthroplasty steps are carried out according to the preoperative plan.

Tunnel Placement

Although the original technique for the use of the aforementioned implant involves a suture anchor,[10] we prefer a modified approach with transosseous fixation. After humeral head resection and before implant fixation, 2 tunnels are drilled from medial to lateral and from lateral to medial using a 2.0-mm drill bit in the proximal and distal ends of the subscapularis footprint

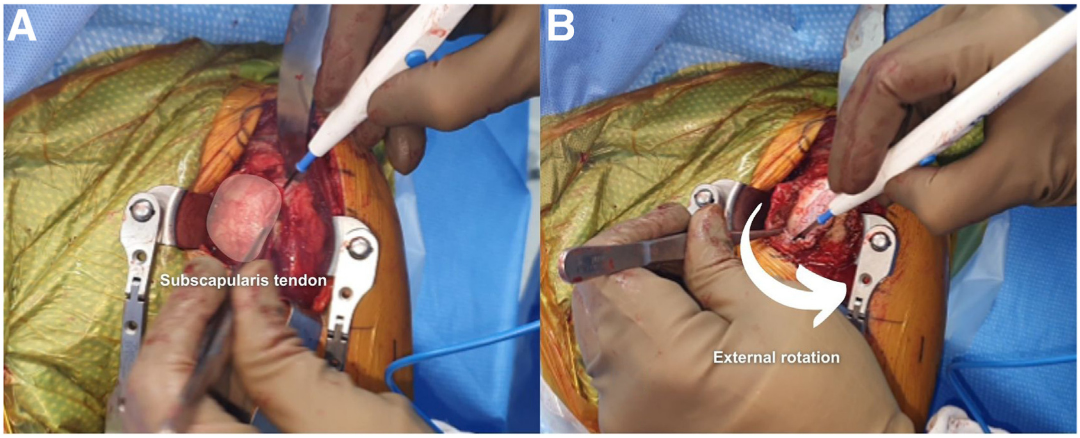

Fig 3. Subscapularis peel, left shoulder. (A) After deep dissection, the superior and inferior borders of the subscapularis tendon are identified. A peel technique is used to elevate the tendon from the lesser tuberosity, starting just medial to the bicipital groove. Care is taken to peel the tendon in 1 plane only. (B) As the tendon peel progresses medially, the shoulder is placed in external rotation to ease dissection and achieve a controlled dislocation of the humeral head.

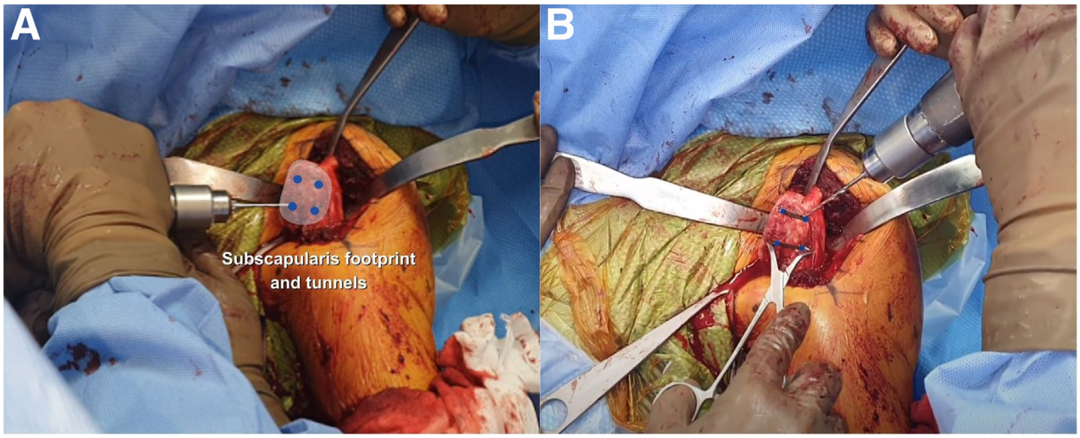

Fig 4. Tunnel placement, left shoulder. (A) Prior to implant fixation, the subscapularis footprint is identified and prepared. Two tunnels are drilled from medial to lateral and from lateral to medial using a 2.0-mm drill bit. Arrow: showing the drilling direction. (B) Completion of the tunnels may be eased using a clamp; care must be taken to ensure sufficient bone purchase to avoid iatrogenic lesser tuberosity fracture.

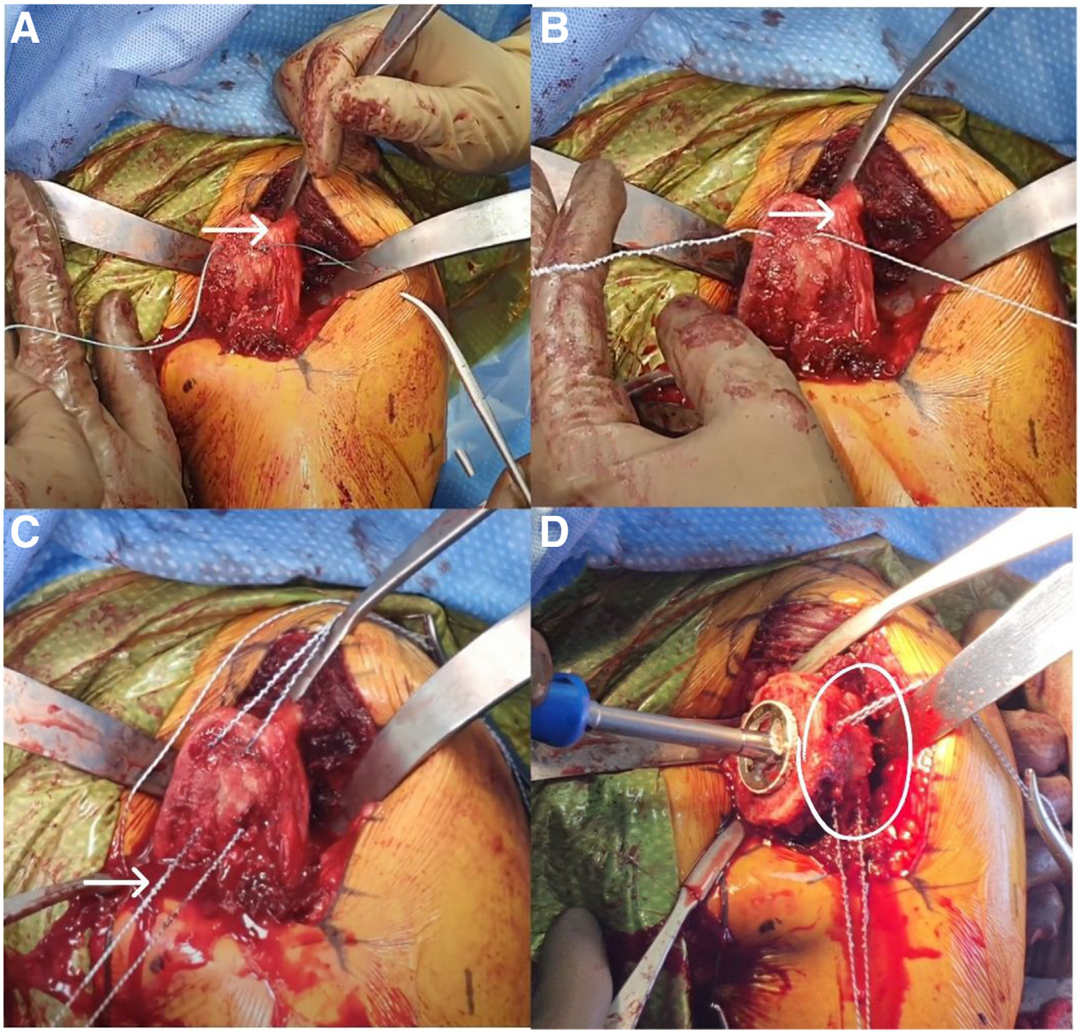

Fig 5. Suture passing, left shoulder. (A, B) Once the tunnels are in place, a shuttling suture is used to pass the beaded suture through the tunnels either from lateral to medial or from medial to lateral. Arrow in A and B: showing medial to lateral suture pass. (C) The process is repeated with the remaining tunnel, leaving 2 strands of the beaded suture in each tunnel; at this point, it is important to even out the sutures, making sure the same number of beads is available on each side of the tunnels. Arrow: noting the beaded suture evened out. (D) The sutures are left in place while arthroplasty steps are carried out. Oval: footprint is completed with sutures left in place.

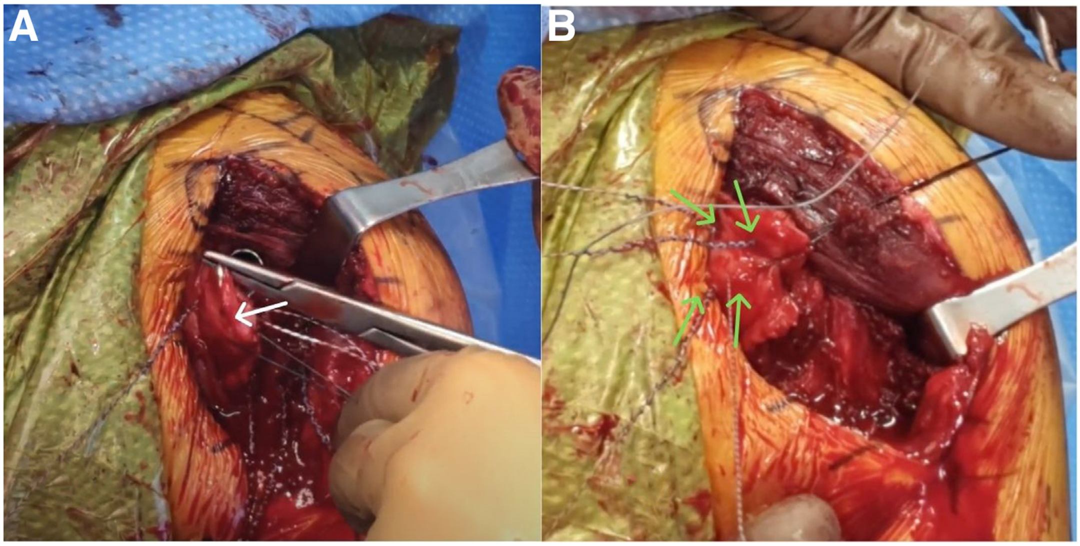

Fig 6. Subscapularis repair, left shoulder. (A) After the prosthetic joint has been reduced, the shoulder is placed in 30° of external rotation, and a traction suture (arrow) is used to facilitate tendon reduction. (B) By use of free needles, all 4 strands of the beaded suture (arrows) are passed through the subscapularis tendon, covering both halves of the footprint.

(Fig 4). Then, a shuttling suture is used to pass the beaded suture through the tunnels until the ends are evened out, and the sutures are left in place while stemless arthroplasty is completed (Fig 5).

Subscapularis Repair

After the stemless humeral component has been implanted, we are ready to repair the subscapularis tendon. To this purpose, the prosthetic joint is reduced, and the shoulder is placed in 30° of external rotation. A traction suture is used to reduce the tendon to its footprint, and by use of free needles, all 4 strands of the beaded suture are passed through the tendon's substance in its proximal and distal halves (Fig 6). Next, the suture capture (button) is loaded with the beaded suture using the nitinol loop provided by the manufacturer. After the button is loaded, it is pushed down to the tendon either manually or with the help of a knot pusher. The process is repeated for the remaining strands, with adjustment of tension when needed. When the appropriate tension is achieved, the sutures are cut, with care taken to leave at least 2 remaining suture beads over the button. The shoulder is then taken through passive internal and external rotation to confirm stability of the construct (Fig 7). Finally, the wound is irrigated copiously, and the deltopectoral approach is closed in layers.

Discussion

Stemless implants for shoulder arthroplasty have gained popularity over the past few years as a treatment option for patients with sufficient bone quality and fully functional rotator cuffs. It offers several advantages, such as bone preservation, decreased operative times and blood loss, as well as a reduced risk of intraoperative periprosthetic fracture and easier explantation and revision.[11]

Although the advantages of canal-sparing implants are clear to us, the optimal management of the subscapularis tendon continues to be an area of concern and controversy. Numerous studies have looked to compare the biomechanics and healing rates of tenotomy, lesser tuberosity osteotomy, and peel, with variable results. Even though tenotomy has been widely used in the past, there have been reports of failure necessitating pectoralis major tendon transfer or conversion to reverse shoulder arthroplasty to address residual instability.[12] In 2019, Aibinder et al.[2] sought to investigate the results of all 3 subscapularis management approaches in stemless arthroplasties in a multicenter study and showed no statistically significant differences in clinical subscapularis failure between the groups. It is interesting to note that 2 patients in the peel group underwent revision surgery owing to early subscapularis failure, although no specific information was included regarding the repair method in these patients. In 2021, Werner et al.[7] presented a cadaveric study comparing subscapularis peel with a "backpack" repair versus a double-row knotless repair and reported no significant differences between the 2 techniques, with a slightly higher load to failure for the double-row group.

Subscapularis tendon attenuation, nonunion, or retear may result in persistent pain, weakness, and in some cases, mild to severe anterior instability. Nevertheless, as previously stated in the literature, diagnosis of a ruptured subscapularis tendon after arthroplasty can be quite elusive and requires a high degree of suspicion because physical examination findings may

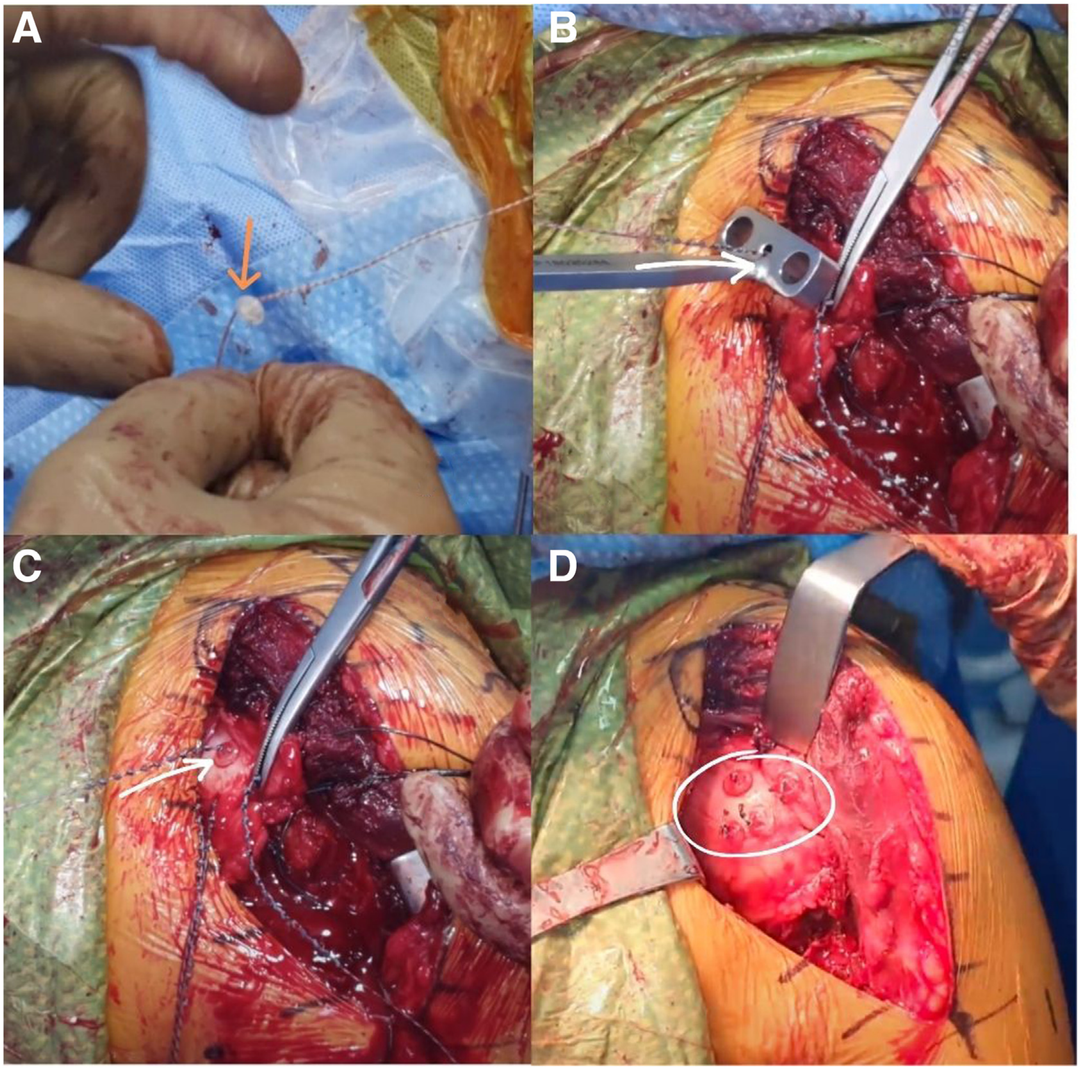

Fig 7. Fixation of repair, left shoulder. (A) To finish the repair, the suture capture (resorbable button) is loaded with suture using the nitinol loop provided by the manufacturer (ZipE) (arrow). (B) Once the button has been loaded, it is pushed down to the tissue (arrow). (C) Tension of the button (arrow) may be adjusted if needed to achieve compression of the tendon to its footprint. (D) The process is repeated with the remaining strands; when the repair is complete, the sutures are cut, leaving at least 2 beads over the button (oval).

not be as reliable as those in patients without arthroplasty, and in the early postoperative phase, some degree of weakness is expected from subscapularis tendon mobilization; in addition, magnetic resonance imaging becomes less effective as a result of metal interference. Patients who have undergone shoulder arthroplasty and present with a history of popping after external rotation, sudden loss of internal rotation, and excessive passive external rotation should undergo a thorough evaluation for subscapularis tendon repair failure and should be treated swiftly. Options for surgical revision include revision tendon repair, pectoralis major transfer, and revision arthroplasty.[6]

Because subscapularis tendon failure can jeopardize the results after SSA, every effort should be made to accomplish a stable construct for the subscapularis repair. This article presents our preferred method for achieving a strong knotless construct that compresses the tendon to its footprint and gradually transfers

Table 1. Pearls to Achieve Correct Subscapularis Tendon Fixation Using Suture Disk Implant

Identification and marking of the lesser tuberosity with electrocautery help in determining the correct entry and exit points of the tunnels.
The surgeon should angle the drill bit by 45° on each side of the tuberosity to ensure good bone purchase.
Connecting the drill holes using a small pointed clamp eases needle passing through the tunnels.
The beaded suture should be evened out symmetrically to avoid difficulties in final fixation.
The surgeon should always leave at least 2 beads over the button to decrease the risk of suture-capture failure.

Table 2. Advantages, Disadvantages, and Risks of Subscapularis Repair With Suture Disk Implant

Advantages
Bone stock preservation is achieved (no anchor is needed).
The contact area of the tendon over the lesser tuberosity is increased.
Button technology allows for knotless fixation.
As the button resorbs, loading is transferred to the tendon-bone junction, enhancing soft-tissue remodeling and healing.
Four different points of compression are obtained with 2 sutures.
Risks
If the tunnels are too shallow, the lesser tuberosity is at risk of fracture.
Care should be taken to avoid confluence of the tunnels.
Disadvantages
Implant cost and lack of availability.

loading to the tendon to encourage tissue remodeling. One of the greatest advantages of this technique is that fixation through transosseous tunnels preserves bone stock in the humeral metaphysis, decreasing the risk of compromising fixation of the humeral component, which may be a downside in anchor-based techniques. The button technology of the construct allows for easy knotless fixation; at the same time, it increases the contact area between the tendon stump and the lesser tuberosity, reducing gap formation with range of motion and enhancing soft-tissue healing. This technique is not without risks, however: Caution should be exercised when drilling the tunnels to achieve sufficient depth and to ensure that the tunnels are not too shallow because this could result in bone failure and fracture of the lesser tuberosity. Pearls to achieve correct fixation are shown in Table 1, and Table 2 describes advantages, disadvantages, and risks of our technique. As with all recently developed technologies, mid- and long-term outcomes should be evaluated to determine the true influence of the aforementioned implant's biomechanical properties on patients.

Disclosures

All authors (M.R.S., J.E.T.R., R.G.G., A.C.M.L., A.F.C.A., D.C.H.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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