Technical Note

Double Row—Equivalent PASTA Repair Technique

John T. Heffernan, M.D., Victor J. Wu, M.S., Mary K. Mulcahey, M.D., Michael J. O'Brien, M.D., and Felix H. Savoie III, M.D.

Abstract: Articular surface partial rotator cuff tendon tears are a common source of shoulder pain and dysfunction, and there is no consensus regarding the optimal arthroscopic treatment. Commonly accepted techniques, such as transtendinous repair or tear takedown with primary repair, may violate healthy tendon tissue and increase the suture anchor density. In this note, we describe an outside-in double row—equivalent technique for repair of partial articular-sided rotator cuff tears. A medial row of inverted horizontal mattress stitches is placed percutaneously using spinal needles to shuttle partially absorbable braided sutures into the joint. The technique may incorporate a soft tissue biceps tenodesis into the rotator cuff with a second, oblique medial row mattress stitch. Suture limbs are retrieved and tied in the subacromial space and then secured to a lateral anchor. The result is a side-to-side double row—equivalent rotator cuff repair, anatomically reproducing the footprint of the rotator cuff without removing healthy tissue. We believe this is an efficient and reproducible technique that preserves intact bursal tissue, limits implant costs, and produces reliable healing in partial articular-sided tears of the rotator cuff.

Partial rotator cuff tendon tears are a common source of shoulder pain and dysfunction that were first described by Codman in 1934.[1] Advances in shoulder arthroscopy over the last 3 decades and improvements in imaging have highlighted the prevalence of partial tears. Popular classification schemes by Ellman[2] and Milstein and Snyder[3] describe tears by location, size, and tissue quality. Despite the increasing awareness and arthroscopic treatment of partial rotator cuff tears, no consensus has emerged in the literature of an optimal technique for arthroscopic repair.[4-7] Multiple fixation methods have been described with the goal of restoring the rotator cuff to its greater tuberosity footprint to promote healing. Commonly accepted arthroscopic techniques include transtendinous repair or tear takedown with primary repair, both of which result in a violation of healthy bursal tissue or may create tendon length or layer mismatch.

We present our technique of an outside-in, oblique side-to-side double row—equivalent repair of partial articular-sided rotator cuff tears. Using spinal needles to percutaneously shuttle nonabsorbable braided sutures into the joint, a medial row of inverted horizontal mattress stitches is placed medial to the tear. The technique may incorporate a soft tissue biceps tenodesis into the rotator cuff with a second, oblique medial row mattress stitch. Suture limbs are retrieved and tied in the subacromial space and then fixed to a lateral anchor.

Conceptually this is a double row—equivalent repair as the horizontal mattress stitch replaces a traditional medial anchor repair. When incorporating a biceps tenodesis, the pierced transverse humeral ligament acts as the medial anchor. The lateral anchor captures the medial sutures and secures the cuff to its anatomic footprint in the manner of a traditional double row repair. This repair closes the tendon obliquely, side to side, and places the debrided tendon end in contact with the abraded exposed greater tuberosity of the humeral head.

This is a reproducible and efficient technique, which has the advantages of preserving intact tendon on the bursal side. The repair uses only a horizontal mattress

From the Department of Orthopaedic Surgery, Tulane University School of Medicine, New Orleans, Louisiana, U.S.A.

The authors report the following potential conflicts of interest or sources of funding: M.K.M. is a paid speaker for Arthrex. M.J.O. is a paid consultant for Smith & Nephew, DePuy Mitek, and Stryker. F.H.S. receives support from Smith and Nephew, DuPuy Mitek, Rotation Medical, Exactech, and CONMED. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received January 29, 2019; accepted April 14, 2019.

Address correspondence to Felix H. Savoie III, M.D., Department of Orthopedic Surgery, Tulane University School of Medicine, 1430 Tulane Ave, New Orleans, LA 70112, U.S.A. E-mail: fsavoie@tulane.edu

2212-6287/19121

https://doi.org/10.1016/j.eats.2019.04.006

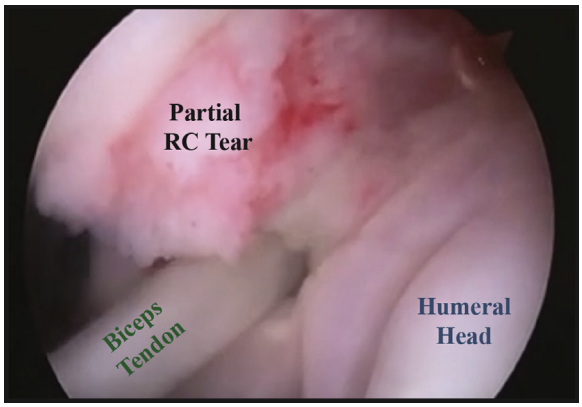

Fig 1. Intra-articular image of partial rotator cuff (RC) tear of a right shoulder. Arthroscopic image from a posterior viewing portal demonstrating a partial articular-sided supraspinatus tendon avulsion.

stitch of nonabsorbable suture passed percutaneously with a spinal needle and a single lateral anchor, thereby limiting anchor density and helping to control costs. A step-by-step demonstration of the procedure can be seen in Video 1.

Surgical Technique

Preoperative Planning

A thorough history and physical examination is paramount to an accurate diagnosis. The Whipple test with a retracted scapula can distinguish partial tears of the supraspinatus tendon from full-thickness tears or tendonosis by correcting scapular dyskinesias and eliminating subacromial impingement as an etiology.[8,9] Radiographs or magnetic resonance imaging can aid in the identification of related pathology and tear size.

Portals and Initial Assessment

The procedure may be performed in either the lateral decubitus (author's preference) or beach chair position. A standard posterior viewing portal is established for systematic evaluation of the glenohumeral joint (GHJ) and tear (Fig 1). An anterior portal is established with an outside-in technique to introduce a 5-mm plastic cannula just superior to the subscapularis tendon.

Rotator Cuff Repair

Step 1: Tear and Rotator Cuff Preparation

A shaver is introduced through the anterior portal and brought superior to the biceps tendon to the rotator cuff tear. The tear is debrided to evaluate the depth and classify the tear, as well as to promote a healing response. Debridement proceeds until healthy rotator cuff tissue is identified (Fig 2). If no healthy tissue is encountered, a full-thickness debridement and rotator cuff repair is performed. It is crucial to continue the debridement until all pathologic tissue is removed.

The shaver is then repositioned inferior to the biceps tendon and used to lightly debride and abrade the exposed greater tuberosity footprint. Great care is taken to avoid damaging the articular cartilage. A Steadman microfracture awl is then used to trephinate the debrided surface of the humeral head. Together, these steps serve to promote a tendon-to-bone healing response.

Step 2: Passage of Medial Row Sutures

With the arthroscope in the posterior portal, an 18-gauge spinal needle is passed through the skin and into the GHJ, 2 to 3 cm posterior and 2 cm lateral to the anterolateral corner of the acromion. The needle is angled 30° above the surface of the arm and in line with the humerus to recreate the normal relationship of the rotator cuff layers (Fig 3). Under direct visualization from inside the GHJ, the needle is advanced through healthy supraspinatus tendon, medial and posterior to the partial thickness tear. A no 1. polydiaxanone (PDS) absorbable monofilament suture (Ethicon, Somerville, NJ) is placed into the needle and directed into the joint. Using an arthroscopic grasper, the PDS suture is removed from the anterior portal. A no. 2 braided, nonabsorbable suture (Orthocord; Depuy Mitek, Raynham, MA) is secured to the PDS outside of the body with a simple loop and shuttled back through the rotator cuff tear (Fig 4).

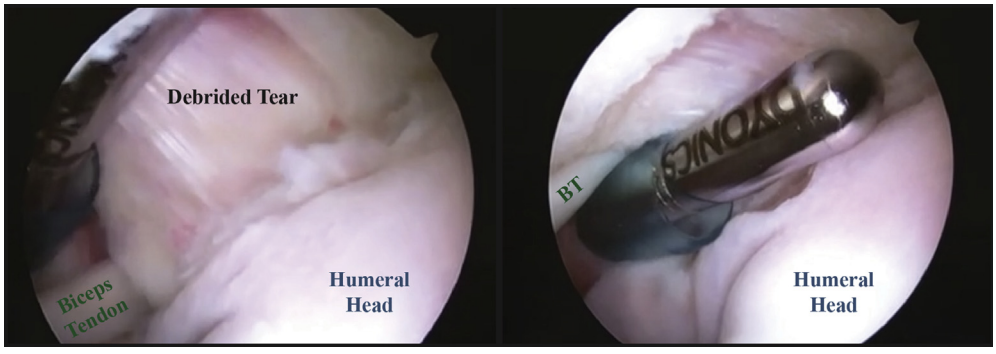

Fig 2. Preparation of rotator cuff tear and greater tuberosity footprint in a right shoulder. Arthroscopic images from a posterior viewing portal demonstrating debridement of a partial supraspinatus tear (left) and abrasion of the greater tuberosity (right). Note the position of the shaver relative to the biceps tendon (BT).

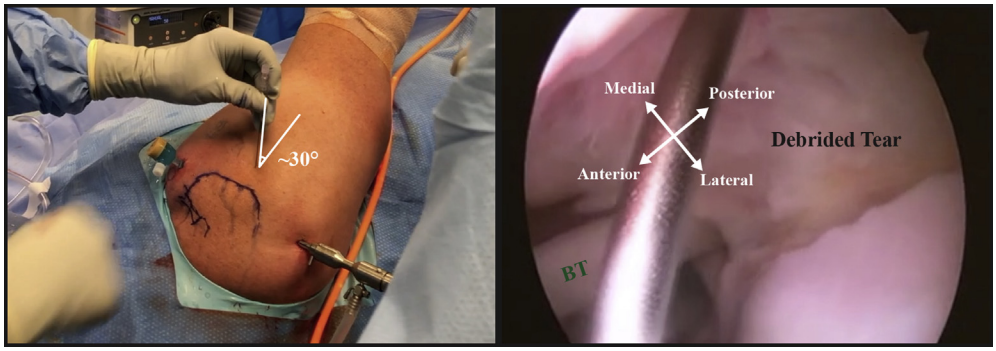

Fig 3. Oblique entry of spinal needle allowing for medial placement of nonabsorbable sutures. Operative photo of a right shoulder (left) demonstrating spinal needle entry at 30° relative to the skin surface. This ensures that a stitch can be passed medial to the tear as shown in the intra-articular image of a right shoulder from a posterior viewing portal (right).

The spinal needle is then moved 1 to 2 cm posterior and 2 cm distal to the anterolateral corner of the acromion and advanced into the GHJ with the needle now directed to enter the joint medial and anterior to the edge of the partial tear, usually through the anterior supraspinatus cable. A no. 1 PDS suture is passed through the needle and withdrawn through the anterior portal. The free end of the first no. 2 braided, nonabsorbable suture is passed through the loop of the no. 1 PDS outside of the body and shuttle into the joint through the skin. This creates an inverted horizontal mattress stitch medial to and transversely spanning the width of the tear with the 2 free ends outside the body (Fig 5). If biceps tendon pathology is present, a second (different colored) nonabsorbable suture is shuttled simultaneously with the second end of the first no. 2 suture via the PDS shuttle for a biceps tenodesis stitch.

If a stitch for a biceps tenodesis was used, the 2 free ends of the different colored suture will be exiting the body anterior to the rotator cuff and through the anterior portal, respectively. A spinal needle is now placed 3 cm distal to the anterior corner of the acromion and directed toward the humerus so that the needle captures the mid to distal aspect of the

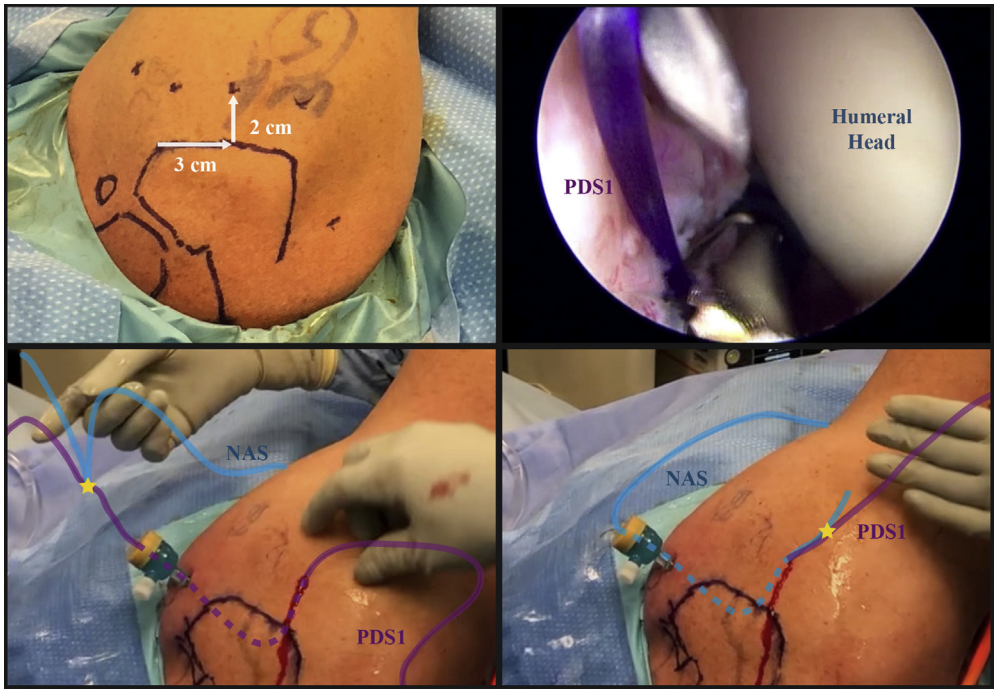

Fig 4. Operative photos and arthroscopic image of a right shoulder demonstrating intra-articular passage of nonabsorbable suture using a polydiaxanone (PDS) guide. Spinal needle placement 3 cm posterior and 2 cm lateral to the anterior edge of the acromion (top left). An absorbable PDS suture is passed through the spinal needle intra-articularly and pulled through the anterior portal (top right). A simple loop is used to attach a nonabsorbable suture to the PDS (bottom left) and pulled through so that the nonabsorbable suture is now in the joint and exiting posterior to the tear (bottom right). The yellow star indicates a simple loop. NAS, nonabsorbable suture; PDS1, first PDS suture for posterior limb.

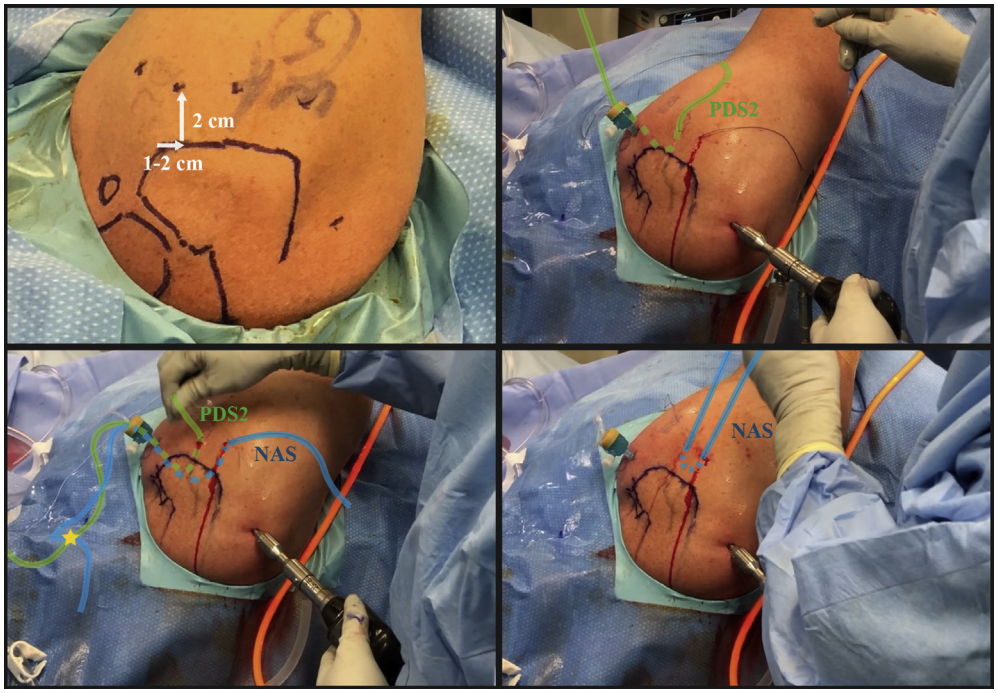

Fig 5. Operative photos of a right shoulder demonstrating completion of reverse mattress stitch for the supraspinatus. A second spinal needle placed 1 to 2 cm posterior and 2 cm lateral to anterior edge of acromion (top left). A second absorbable PDS suture is passed through the spinal needle intra-articularly and pulled through the anterior portal in the same manner as the first (top right). A simple loop attaches the remaining limb of the nonabsorbable suture to the polydiaxanone (PDS; bottom left) and is pulled through so that the nonabsorbable suture now forms a mattress stitch medial to the tear (bottom right). The yellow star indicates a simple loop. NAS, nonabsorbable suture; PDS2, second PDS suture for anterior limb.

transverse humeral ligament and pierces the biceps tendon (Fig 6). A no 1. PDS suture is passed into the joint, brought out through the anterior portal, and used to shuttle the remaining limb of the second no. 2 braided, nonabsorbable suture. This results in a second stitch obliquely spanning the anterior corner of the supraspinatus and capturing the biceps tendon, using the transverse humeral ligament as an anchor to perform the repair and tenodesis simultaneously.

Step 3: Suture Retrieval and Tying

The cannula in the anterior portal is repositioned in the subacromial bursa by using a blunt switching stick to slide laterally onto the subscapularis tendon and into the subacromial bursa. Tension is maintained on the anterior 2 limbs, and each is retrieved out the canula using a blunt crochet hook (Fig 7). The suture limbs are withdrawn from the cannula, and a sliding knot is then tied into the subacromial space while

Fig 6. Incorporation of soft tissue biceps tenodesis in a right shoulder. A second nonabsorbable suture can be passed with the anterior limb of the supraspinatus stitch. This suture can be retrieved with the polydiaxanone simple loop method using a spinal needle placed 3 cm distal from the anterior corner of the acromion (left). This forms an oblique stitch that traps the biceps tendon against the transverse humeral ligament (right).

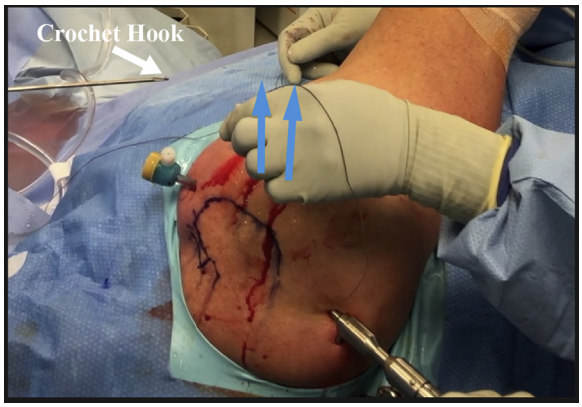

Fig 7. Blind retrieval of suture in a right shoulder. Suture limbs may be retrieved "blindly" in the subacromial space with the arthroscope directed intra-articularly. Note the assistant applying external traction to the suture to elevate the limbs of the bursal surface for easier retrieval.

visualizing side-to-side tear closure intra-articularly. One limb of the suture is cut while the other is saved for the lateral anchor. This repairs the anterior supraspinatus cable and can also tenodese the biceps using the transverse humeral ligament as the anchor. The remaining limb from the more anterior stitch is saved for the lateral anchor (Footprint Ultra PK; Smith and Nephew, Andover, MA). The second suture, if it involves any part of the infraspinatus, is left untied as a Boileau inverted mattress tension band stitch. Both remaining limbs of this posterior horizontal mattress stitch are saved for the lateral anchor whether or not they are tied.

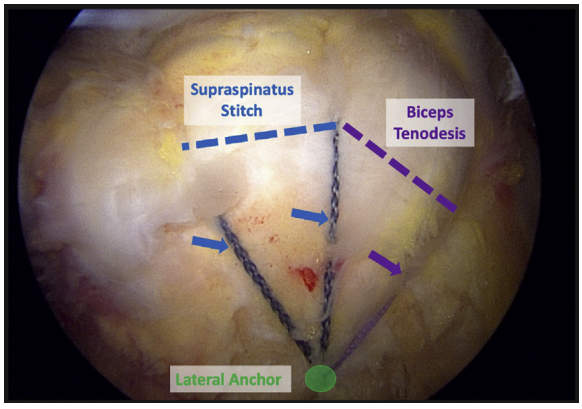

Fig 8. Subacromial image of completed repair of a right shoulder tear from the lateral portal. Sutures passed through the anterior and posterior aspects of the supraspinatus tendon are typically tied unless the posterior extent of the tear exits in the infraspinatus, in which case they are left as an inverted mattress stitch with both limbs into the lateral row anchor as shown here. Blue arrows indicate the suture limbs of the rotator cuff stitch, and the purple arrow indicates the suture limb for biceps tenodesis.

Table 1. Advantages and Limitations of the Technique

Advantages	Limitations
1. Preservation of intact tendon on the bursal side.	1. May provide less secure fixation in high-grade partial tears or with poor tissue quality.
2. Reduced suture anchor density preserves greater tuberosity footprint biology.	2. "Blind tying" of sutures in subacromial space can be challenging.
3. Efficient technique that is able to incorporate biceps tenodesis into repair.	3. Technique requires precise 3-dimensional understanding of shoulder anatomy to avoid tendon layer mismatch.
4. Limited implant costs.	

Step 4: Lateral Row Repair

The arthroscope is withdrawn from the GHJ and redirected into the subacromial space. A lateral working portal is established in line with the anterior border of the acromion and 3 cm distal to the lateral edge. A lateral bursectomy is performed at this stage, taking great care not to shave the remaining limbs of the suture repair. If indicated, additional subacromial pathology may be addressed at this time. A plastic cannula is then inserted through the lateral portal. The remaining suture limbs are retrieved out the cannula and fed through the eyelet of a lateral anchor, and then the anchor is inserted into the lateral aspect of the greater tuberosity to complete the repair (Fig 8). Conceptually this represents a double row—equivalent repair as the horizontal mattress stitch replaces a medial row anchor repair, and the lateral anchor captures the medial construct and secures the cuff to its anatomic footprint. This repair closes the tendon obliquely, side to side, and places the debrided tendon

Table 2. Pearls and Pitfalls of the Technique

Pitfalls	Pearls
Difficulty in "blind" suture retrieval and tying in subacromial space with arthroscope directed intra-articularly.	1. Appreciate the tissue planes. 2. Keep the cannula on the superior rotator cuff when retrieving sutures. 3. Assistant applies external traction to suture to elevate ends off the bursal surface.
Failure of repair due to improper stitch placement.	1. Ensure proper placement of spinal needles relative to acromion. 2. Spinal needles enter obliquely at 30° to arm surface.
Failure of repair due to not recognizing full extent of tear.	1. Abduct and internally and externally rotate humerus for full tear visualization. 2. Completely debride tear without violating articular cartilage with shaver to ensure sufficient high-quality tissue.

end in contact with the abraded exposed greater tuberosity of the humeral head to promote healing.

If the biceps tendon is tenodesed as part of the procedure, the bicipital groove distal to the tenodesis site is released to ensure there is no distal tendon pathology. The coracohumeral ligament may be released from the base of the coracoid to take tension off the repair. Final evaluation of the tear is performed viewing from the lateral portal. If more fixation is desired, the procedure may be duplicated with an additional horizontal mattress stitch across the tear and secured laterally into a second lateral row anchor.

Postoperative Protocol

Postoperatively, the shoulder is placed into an abduction sling for 3 weeks. Passive range-of-motion exercises are initiated 1 week after surgery. At 4 to 6 weeks postoperatively, active range of motion is permitted and progressive resistance exercises are performed.

Discussion

Partial tears of the rotator cuff are a common problem, yet no consensus exists on optimal arthroscopic repair techniques. Two commonly used techniques include tear completion or transtendinous repairs.

The percutaneous double row—equivalent repair technique described here is biologically friendly, limits implant costs, and is reproducible and efficient. Table 1 lists a summary of the advantages and disadvantages of this technique. Advantages include an oblique angulation of the spinal needle to prevent layer mismatch, side-to-side suture placement to restore anatomy, and the near harmless passage of suture using only an 18-gauge spinal needle. Healthy tissue is brought into contact with the abraded, microfractured intra-articular part of the greater tuberosity by the oblique orientation of the sutures. The lateral anchor allows for a double row—equivalent repair construct, providing additional compression. Anchor use is limited, thereby reducing costs and implant density on the rotator cuff footprint to preserve room for tendon-to-bone healing. The technique is efficient and reproducible and easily allows incorporation of a soft tissue biceps tenodesis.

Disadvantages of this technique include those common to all rotator cuff repairs including failure, stiffness, and infection. Specific limitations include the concern that this may not be as robust a construct, especially in patients with high-grade partial tears or poor tissue healing potential. Tying the medial horizontal mattress sutures "blindly" in the subacromial space while visualizing articular-sided tear closure from an intra-articular position may be challenging. This may be facilitated by keeping the cannula on the superior rotator cuff when retrieving sutures and by the assistant applying external traction to the suture to elevate the ends off the bursal surface. Likewise, any bursectomy or subacromial work left until after suture passage carries the risk of inadvertent shaving of the nonabsorbable suture. Failure to completely recognize the extent of the tear and percutaneously pass sutures fully medial and posterior to the tear will result in a partial repair. Finally, this technique requires precise understanding of 3-dimensional shoulder anatomy to accurately pass spinal needles and percutaneously shuttle sutures. Inaccurate needle angulation or starting position may result in tendon layer or length mismatch. These limitations are summarized in Table 2, with pearls to avoid these pitfalls.

References

1. Codman EA. *The shoulder: Rupture of the supraspinatus tendon and other lesions in or about the subacromial bursa*. Boston, MA: Thomas Todd, 1934.
2. Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. *Clin Orthop Rel Res* 1990;254:64-74.
3. Milstein ES, Snyder SJ. Arthroscopic management of partial, full-thickness, and complex rotator cuff tears: Indications, techniques, and complications. *Arthroscopy* 2003;19:189-199.
4. Bollier M, Shea K. What surgical technique provides the best outcome for symptomatic partial articular-sided rotator cuff tears? *Iowa Orthop J* 2012;32:164-167.
5. Rossi LA, Atala NA, Bertona A, et al. Long-term outcomes after in situ arthroscopic repair of partial rotator cuff tears. *Arthroscopy* 2019;35:698-702.
6. Rossi LA, Atala N, Bertona A, et al. Return to sports after in situ arthroscopic repair of partial rotator cuff tears. *Arthroscopy* 2019;35:32-37.
7. Jordan RW, Bentick K, Saithna A. Transtendinous repair of partial articular sided supraspinatus tears is associated with higher rates of stiffness and significantly inferior early functional scores than tear completion and repair: A systematic review. *Orthop Traumatol Surg Res* 2018;104:829-837.
8. Strauss EJ, Salata MJ, Kercher J. The arthroscopic management of partial-thickness rotator cuff tears: A systematic review of the literature. *Arthroscopy* 2011;27:568-580.
9. Savoie FH, Field LD, Atchinson S. Anterior superior instability with rotator cuff tearing: SLAC lesion. *Orthop Clin North Am* 2001;32:457-461.