Technical Note

Blended Suture-bridge Technique for Arthroscopic Rotator Cuff Repair

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Abstract: Techniques in rotator cuff repair are constantly evolving, with the main goal of a biologic, stable, and tension-free construct. Significant controversy exists between various methods, and there is no gold standard surgical protocol. We demonstrate an alternative arthroscopic rotator cuff repair technique with 2 key components. First, we performed a transosseous equivalent, suture bridge technique with a combination of triple-loaded medial anchors and knotless lateral anchors. Second, we incorporated 2-strand and 3-strand suture shuttling through the torn rotator cuff and selective medial knot-tying. A total of 6 passes through the tendon are made, comprising 1-2-3-3-2-1 strands each pass. This minimizes the number of passes through the tendon and the overall number of medial knots. Our technique retains the known biomechanical advantages akin to a double-row repair, including less gap formation and wider footprint coverage. In addition, using fewer medial knots with efficient suture passing may result to decreased cuff strangulation and favorable biologic environment for tendon healing. We theorize that this technique may yield lower retear rates while maintaining immediate stability, translating to improved clinical results.

The main objective of any rotator cuff repair surgery is to yield a biologic, stable, and tension-free construct. Open surgery has been used in the past, but with the development of better arthroscopic techniques, arthroscopic rotator cuff repair has become the gold standard.[1] Controversy exists regarding which arthroscopic repair technique is optimal for tendon—bone healing and better outcomes. Cuff repair techniques range from single-row, classic double-row, transosseous equivalent (TOE), and anchorless.[2] Although recent studies are equivocal as to which technique is superior, arthroscopic TOE repair may be clinically superior due to anatomic footprint restoration with improved tendon—bone contact area.[3]

Knotted medial-row TOE is proven to be biomechanically superior, with increased contact area and less gap formation[4,5] at the expense of increased strain at the level of the knots.[5,6] Furthermore, the need for knot-tying has been questioned due to risk of potential vascular compromise, leading to increased risk of medial-row failure.[7] These controversies led to the development of knotless suture anchors to reduce tendon strangulation and maintain tendon perfusion.[8]

With the advantages and disadvantages of each technique in mind, we developed a technique comprising knotted and knotless suture bridge configuration. The medial-row sutures are passed through the tendon in groups to lessen injury and selective knot-tying decreases risk for tissue strangulation. We hypothesized that this technique would yield lower retear rates while maintaining immediate postrepair stability, wide contact area, and less gap formation, which may translate to improved clinical results.

Surgical Technique (With Video Illustration)

The patient is positioned reclined 70° on a beach chair after induction. Skin landmarks are identified and 4 portals are marked as seen in Figure 1. We commonly use 4 arthroscopic portals to approach most rotator cuff tears. The involved upper extremity is kept free, and a draped Mayo table is used as support.

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Routine diagnostic arthroscopy is performed from the posterior viewing portal to assess intra-articular pathologies. An evaluation of the articular side of the supraspinatus, infraspinatus, and subscapularis tendon insertion is performed. The camera is then redirected to the subacromial space, where bursectomy with acromioplasty is done. After adequate visualization is achieved, attention is shifted to the personality and extent of the rotator cuff tear.

As seen in Figure 2, a full-thickness tear of the supraspinatus is identified from the lateral portal. The footprint at the greater tuberosity is abraded using an arthroscopic shaver until a cortico-cancellous bed is seen. Microfracture is performed using a straight chondral pick, creating a crimson duvet effect. Two triple-loaded suture anchors (HEALICOIL PK; Smith & Nephew, London, UK and Y-Knot RC; CONMED, Utica, NY) are used for the medial row, each anchor positioned lateral to the articular margin and adjacent to the anterior and posterior edge of the tear, respectively (Fig 3).

We used straight (FIRSTPASS MINI; Smith & Nephew) and angled (Spectrum Suture Hook; CONMED) devices for suture passing. Beginning at the posterior aspect of the torn cuff and proceeding anteriorly in a crescent-shaped pattern, the first pass is made on the posterior supraspinatus using one (blue-striped DuraBraid #2; Smith & Nephew) suture. The second pass is placed anterior to the first, using a shuttle suture (ETHIBOND #2; Ethicon, Inc., Somerville, NJ) to pass 2 sutures (one blue-striped DuraBraid #2 and one black-striped DuraBraid #2). At the apex of the tear, the third and fourth passes are performed with a shuttle suture to pass 3 sutures (1 black-striped DuraBraid #2 and 2 plain DuraBraid #2). On the anterior aspect of the tear, the fifth pass was performed in the same manner as the second pass to shuttle 2 sutures (1 black-striped DuraBraid #2 and 1 blue-striped DuraBraid #2). Finally, the sixth pass was performed in the same manner as the first, shuttling one suture (blue-striped DuraBraid #2). The distance between the 6 passes should be not less than 7 mm (Fig 4). The medial row is composed of knotted and knotless sutures. Peripheral, striped sutures are tied, whereas the central plain sutures are untied (Fig 5). For the first 3 passes, the posterior limb is used as the post while the anterior limb is used as the post in tying the striped sutures on the last 3 passes.

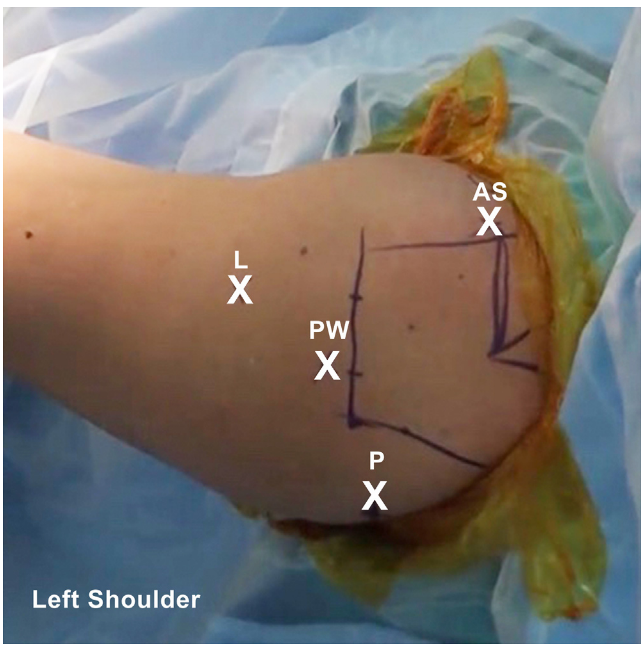

Fig 1. External view of the left shoulder illustrating the portals used with the patient in beach chair position as viewed from cephalad. Precise placement of these portals ensures adequate visualization and proper orientation during shoulder arthroscopy. (AS, anterosuperior; L, lateral; P, posterior; PW, portal of Wilmington.)

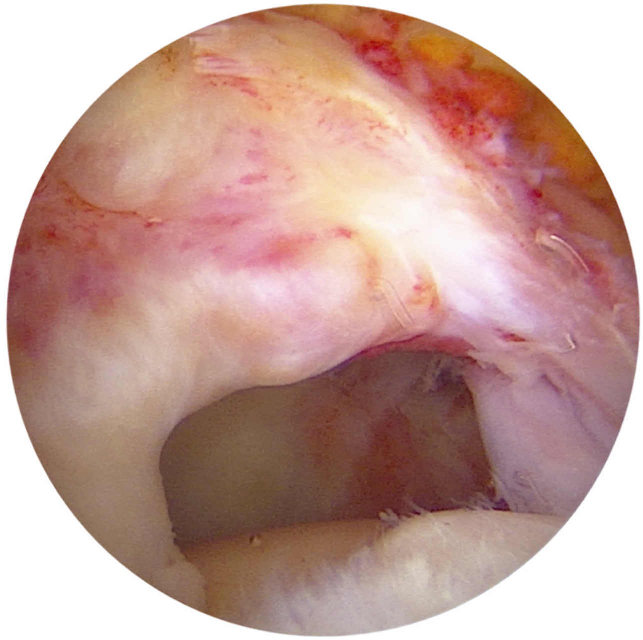

Fig 2. Tear of the left supraspinatus from its insertion seen from the lateral portal using a 30° arthroscope. We use the blended suture-bridge technique in repairing small to medium sized tears that do not need apex reduction or margin convergence.

Two knotless suture anchors (FOOTPRINT ULTRA PK; Smith & Nephew; and PopLok; CONMED) are used for the lateral row (Fig 6). The anterior lateral-row anchor is placed on the anterior border of the greater tuberosity, within or posterolateral to the bicipital groove. The posterior lateral-row anchor is placed near the infraspinatus insertion on the lateral aspect of the greater tuberosity. The technique is described in a diagrammatic and arthroscopic video demonstration together with this article (Video 1).

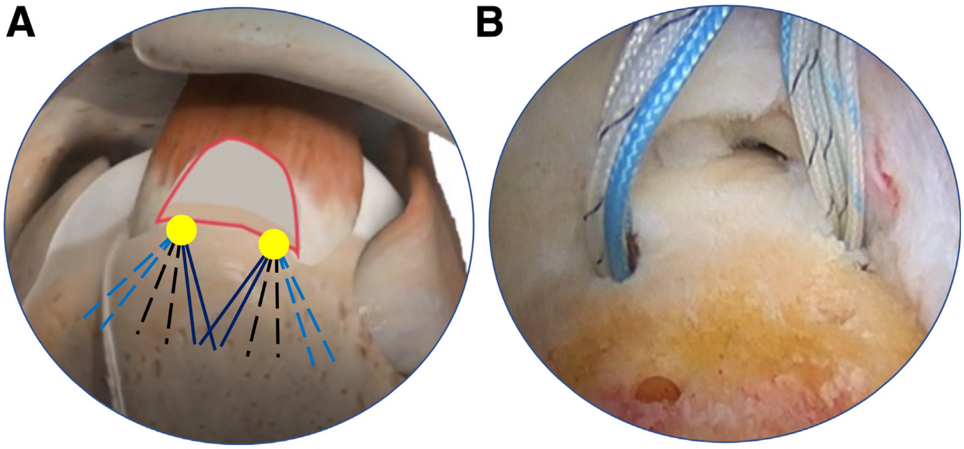

Fig 3. (A) Illustration of the 2 triple-loaded medial-row anchor placement adjacent to the supraspinatus tear. (B) Gross picture of the 2 triple-loaded medial-row anchors placed adjacent to the anterior and posterior edge of the tear as seen in a left shoulder from the portal of Wilmington. Proper placement of the medial row anchors ensures a wider area of compression over the torn cuff and minimizes risk of over-tensioned sutures.

Discussion

The science of tendon repair and healing in the shoulder is complex. Healing between inhomogeneous tissues is a slower process compared with that between similar tissues, and recreating the anatomy of tendon-to-bone insertion is challenging.[9] Retear rates for arthroscopic rotator cuff repair vary from 39% to 94%, affected by patient age, severity of tear, and type of repair technique.[2,9] The outcome of rotator cuff repair relies on techniques of surgery that aid the biology of healing. Our technique is a result of modifications that puts the rotator cuff in a favorable environment for healing.

An ideal repair produces maximal restoration of the footprint contact area, with adequate compression of the tendon and minimal motion.[10] This is the focal difference between single-row and double-row repairs.[11,12] Double-row based repairs result to a wider contact area and higher resistance to gap formation.[11] It is also shown to be more resistant to displacement under a cyclic loading test.[13] However, long-term clinical benefit has yet to be established. In addition, holes on the tendon created by suture-passing instruments, overtensioning, and crowding of multiple fixation sites led to increased tendon strangulation, which carries more risk for retear at the medial row with a healed footprint.

Because of this, knotless repairs have gained popularity. Multiple laboratory studies showed no significant difference in contact pressures between untied and tied medial row.[14,15] However, we have observed increased gap formation on the articular side in knotless medial-row constructs, which is an unfavorable condition in tendon repairs. Gapping at the repair site also allows synovial fluid leakage to the footprint, which was previously proposed to be an unfavorable environment for

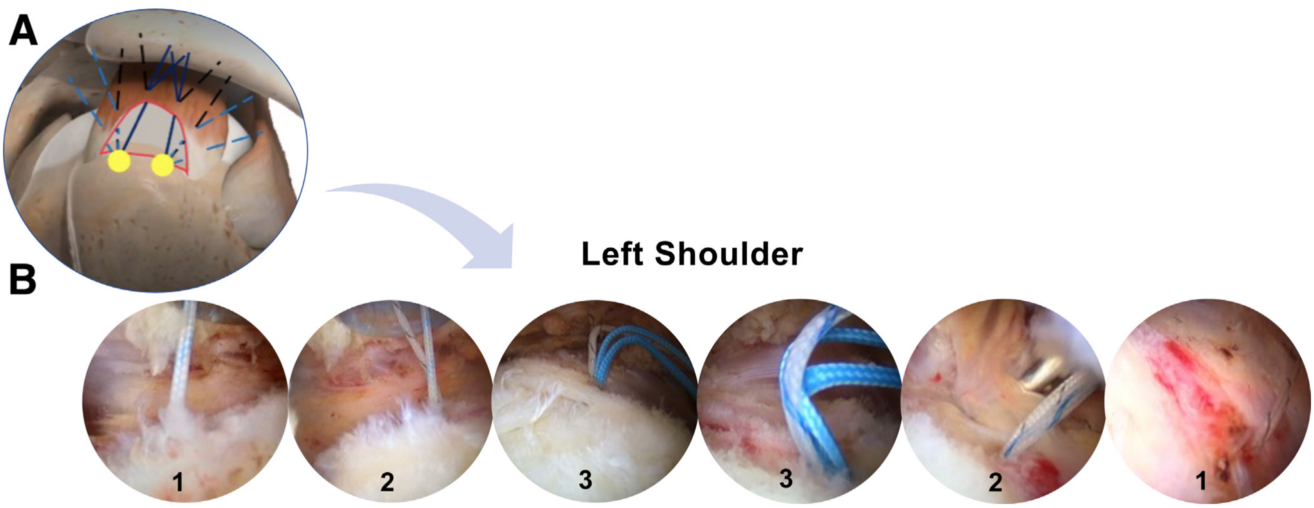

Fig 4. (A) Illustration of the 123-321 suture configuration after suture shuttling through the torn rotator cuff tendon. (B) Arthroscopic view in a left shoulder of the corresponding sutures passed into the tendon in groups of 1,2,3,3,2,1. Each group of sutures are shuttled in exact sequence so that the peripheral sutures may be tied with ease and the central sutures are left untied.

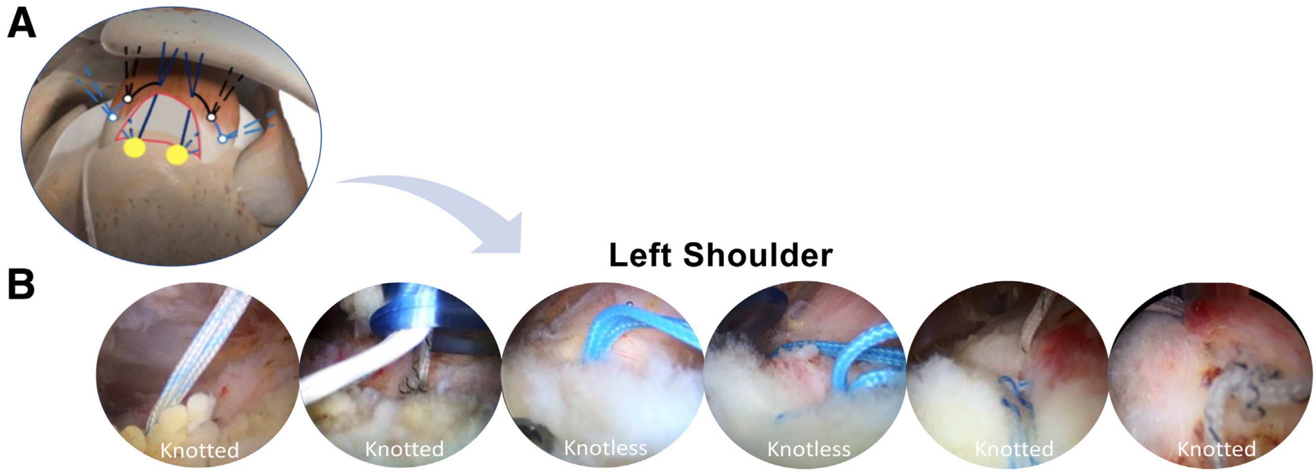

Fig 5. (A) Illustration of the combined medial row knotted and knotless techniques: the peripheral striped sutures are tied while the central plain sutures are left untied. (B) Arthroscopic view in a left shoulder of the combined medial row knotted and knotless techniques which converted the 123-321 configuration to groups of 2 sutures. Correct suture management is very important in this step, as it is crucial to carefully knot paired sutures and keep the correct pair of knotless sutures together.

tendon healing.[9] Takeuchi et al.[13] have proposed lateral-row fixation before medial knot-tying. By securing the lateral-row anchors before tying the medial knots, stress concentration on the medial row is decreased, which led to lower rates of type 2 failures. Knot-tying is crucial to reduce strain and neutralize excessive force at either the medial or lateral row, which is strongly related to decrease in blood flow to the tendon.[6,16] To address excessive stress concentration on the medial row, we perform selective medial row-tying. This minimizes gap formation after repair and excessive stress concentration and tissue

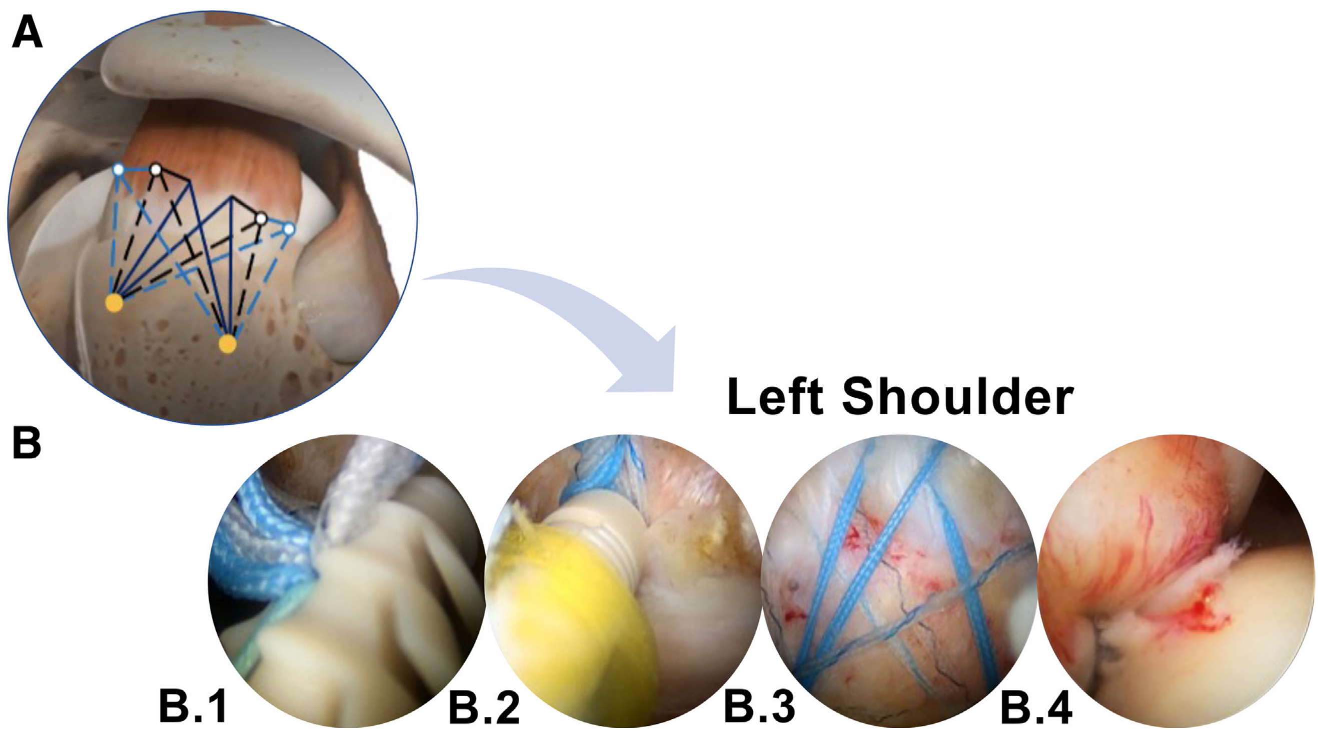

Fig 6. (A) Illustration of the placement of 2 lateral row anchors adjacent to the bicipital groove and the infraspinatus insertion at the lateral border of the greater tuberosity. These 2 areas are reliable areas of adequate bone stock at the proximal humerus and are ideal locations for lateral row anchors. (B.1) Arthroscopic view in a left shoulder of the first lateral-row anchor placed over the lateral border of the greater tuberosity. (B.2) Arthroscopic view of the second lateral-row anchor placed over the bicipital groove. (B.3) Repair viewed in the subacromial space. (B.4) Intra-articular view of the repair showing no gap.

Table 1. Pearls/Pitfalls

Surgical Step	Pearls	Pitfalls
Passing of sutures across the tear site	Crescent-shaped pattern medial to tear site	Avoid passing sutures in a straight line medial to the tear
	Each pass is at least 7 mm apart from another	Placing the sutures too close to each other predisposes to suture cut-out
Suture management	For a triple-loaded suture anchor, the plain-colored sutures are kept untied while the striped-sutures of the same color are knotted	Avoid retrieving similar colored sutures from a different anchor; reposition all the retrieved sutures in a separate portal from the unretrieved sutures
Knot-tying	The posterior limb is used as the post for the first 3 passes, and the anterior limb is used as the post for the last 3 passes.	Interchanging posts during knot-tying will result in uneven knot placement and crowding at fixation sites.

strangulation. Recent biomechanical studies show that knotted medial-row TOE repairs indeed result in lower gap formation and increased protection against cyclic stresses. In addition, both knotless and knotted anchors commonly fail from tearing of suture through the tendon substance. The effect of knotted medial-row anchors does not contribute to this mechanism of failure.[16]

We performed limited passes through the torn rotator cuff by passing more than one suture at the apex of the tear. In combination with strategic positioning of knots, this results to lesser medial-row compression but yields wider distribution of strain between the knotted and knotless sutures. A wider area covered by the suture bridge and an even distribution of compression provides good contact pressure at the repair site, which is proven to be important for healing. The steps we performed in the critical stages of the repair and possible pitfalls are individually outlined in Table 1. Further biomechanical and imaging studies are recommended to determine the relationship of the degree of strain at the medial row and level of vascular insult to the rotator cuff. Table 2 discusses the advantages and disadvantages of this technique. Overall, combined knotless and knotted medial-row sutures with limited tendon passes strike a balance between the various controversies while adhering to basic principles of good repair. However, the use of 2 triple-loaded anchors and multiple suture passes requires careful suture management. To avoid overcrowding of knots at fixation sites, proper post selection should be followed at all times. These very specific points must be followed to yield a stable construct on an environment that favors healing.

Table 2. Advantages/Disadvantages

Advantages	Disadvantages
Peripheral knot-tying allows for decreased gap formation at repair site	Complex suture management due to precise sequence and number of sutures passed
Central knotless sutures minimize tendon strangulation at the medial row	Limited use in high-grade, complex tears with significant retraction; may require additional reduction/repair techniques
Limited passes comprising multiple sutures prevent further injury to the torn tendon	
Final construct leads to wide area of tendon compression over the footprint	

Conclusions and Recommendation

This blended suture bridge technique consisting of limited suture passes through the tendon and strategically placed knotless and knotted medial sutures offer a biologically favorable approach to rotator cuff repair. With specific modifications to technique, we hypothesize that there is lesser risk for tissue and vascular strangulation but adequate immediate repair strength. We recommend this technique for small-to medium-sized tears that do not need apex reduction. We also recommend biomechanical and clinical studies to elaborate on the effects, benefits, and limitations of this technique.

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