Technical Note

A Combined Rip-Stop and Double-Pulley Technique in Arthroscopic Suture-Bridge Repair

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Abstract: Rotator cuff tear is one of the most common upper-extremity pathologies and often requires repair. The pursuit of optimal arthroscopic rotator cuff repair has spurred numerous technical innovations and stitch-pattern refinements. First, the double-pulley construct can increase tendon-bone compression and provide a joint seal. Second, the rip-stop configuration can reduce the possibility of tendon cut-through and improve the biomechanical properties of the fixation. Thus, an alternative method is introduced by incorporating both techniques simultaneously into arthroscopic suture-bridge repair, in which the medial double-pulley construct assumes the function of a rip-stop. This method may improve the biology of tendon healing and reduce the retear rate after rotator cuff repair.

In the quest for perfect arthroscopic rotator cuff repair, surgical techniques and instruments have undergone great advances in the past few decades. Recently, arthroscopic suture-bridge repair with a medial knot construct has become a popular method because it possesses superior biomechanical properties and yields satisfactory clinical results.[1-7] However, retear is still inevitable, and retear is mostly encountered at the musculotendinous junction (type 2 retear).[8,9] Previous studies have reported that tendon cut-through, tendon strangulation, and undue tension at the medial row are contributing factors to type 2 retear.[8,10-12]

Considering the deteriorating clinical outcomes after type 2 retear and technical difficulty of revision surgery, technical modifications are required.[9,13] Rip-stop techniques have been shown to reduce tendon cut-through and improve the resistance of the suture-tendon interface.[1,3,12,14,15] In addition, the medial double-pulley construct can prevent tendon strangulation, improve tension distribution, increase tendon-bone compression, and provide a joint seal.[4,10,16-18] Therefore, we present a surgical method that incorporates both the rip-stop configuration and the double-pulley construct into a suture-bridge repair with medial knot tying in an effort to improve cuff healing and reduce the risk of retear (Video 1).

Surgical Technique

Patient Preparation and Diagnostic Arthroscopy

After the induction of analgesia, the patient is placed in the lateral decubitus position with arm traction. The operative extremity is draped in sterile fashion. The arthroscope is introduced into the glenohumeral joint through a standard posterior portal. Then, an anterior-lateral portal is established through the rotator interval, and all the intra-articular structures are explored. Biceps tenotomy or repair of a Lafosse type 1 or 2 subscapularis tear is performed at this point. Thereafter, the arthroscope is switched to the subacromial space through the standard posterior portal, followed by the establishment of a lateral subacromial portal and a posterior-lateral portal. On completion of the subacromial bursectomy and acromioplasty, the cuff margin is debrided to identify the tear configuration. As shown in Video 1, a large and retracted tear involving the supraspinatus and infraspinatus tendon is observed (Fig 1A). The torn rotator cuff tendon can be reduced to cover its anatomic footprint after an anterior interval slide (Fig 1B).

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Received June 7, 2024; accepted July 25, 2024.

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2212-6287/24929
https://doi.org/10.1016/j.eats.2024.103247

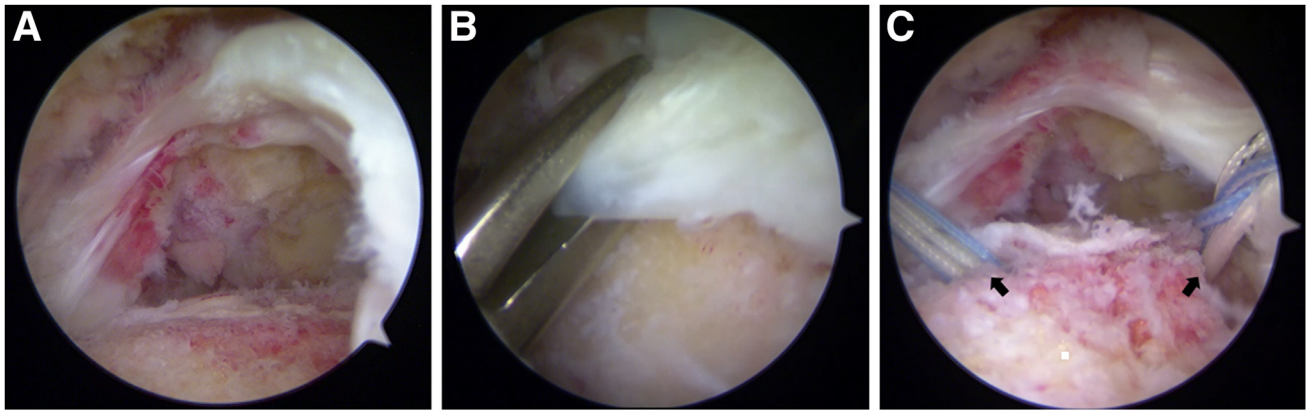

Fig 1. Left shoulder in lateral decubitus position (viewing from posterolateral portal). (A) A relatively large and medialized rotator cuff tear can be seen. (B) The torn rotator cuff tendon can be reduced to cover most of the footprint with a suture retriever. (C) Two triple-loaded medial-row suture anchors (arrows) are placed in the greater tuberosity.

Medial Suture Anchor Placement

After bony bed preparation, 2 triple-loaded suture anchors (5.5-mm BioComposite Corkscrew FT suture anchors; Arthrex, Naples, FL) are inserted at the articular margin of the greater tuberosity. The anterior anchor is placed in the anteromedial aspect of the footprint adjacent to the biceps groove through the anterolateral channel. The posterior anchor is placed 1.5 to 2 cm posterior to the anterior anchor through the posterolateral channel (Fig 1C).

Suture Management

As shown in Video 1, with viewing from the posterolateral portal, 2 white suture limbs and 1 blue suture limb from the anterior anchor are passed through the anterior part of the supraspinatus approximately 2 to 3 mm lateral to the musculotendinous junction with the use of a suture hook (Spectrum I Suture Hook; ConMed, Utica, NY) (Fig 2). Similarly, 2 blue suture limbs and 1 white limb from the posterior anchor are passed through the posterior part of the supraspinatus with a tissue penetrator (Penetrator Suture Retriever; Arthrex). One white suture limb from the anterior anchor and one blue suture limb from the posterior anchor are pulled out of the lateral cannula and tied outside with a static surgeon's knot. The suture limbs are cut above the knot, and the knot is delivered into the subacromial space and seated onto the rotator cuff by pulling on the opposite ends of the sutures that exit through percutaneous portals used for anchor placement. Consequently, the horizontal blue strand from the posterior anchor rests on the supraspinatus tendon (Fig 3). Then, the opposite ends of the blue suture from the anterior anchor and the white suture from the posterior anchor are shuttled through the supraspinatus tendon just medial to the previous horizontal blue strand with a suture hook (Fig 4). We place the horizontal blue strand on the cuff first and then shuttle the sutures medial to it in an attempt to avoid any mismatch between these sutures, which can otherwise cause significant tendon strangulation at the end. Two black-and-white suture limbs from the anterior anchor are retrieved through the anterior corner of the torn supraspinatus tendon, and 2 black-and-white suture limbs from the posterior anchor are retrieved through the torn infraspinatus tendon. After all the suture limbs are allocated evenly in the rotator cuff tendon, the untied end of the white suture from the anterior anchor and the untied end of the blue suture from the posterior anchor are retrieved into the cannula in the lateral portal and tied with a static knot to accomplish a double-mattress stitch compressing the tendon down to the bony bed of the greater tuberosity. The suture limbs from the knot are then cut (Fig 5).

Lateral Knotless Suture Anchor Placement

Finally, all suture limbs in the rotator cuff tendon are pulled out of the lateral cannula and threaded through the eyelet of the lateral anchor (4.75-mm PEEK [polyether ether ketone] SwiveLock anchor; Arthrex). A pilot hole is opened by a punch on the centerline of the rotator cuff tear on the lateral cortex of the greater tuberosity. After all the sutures are properly tensioned, the lateral-row anchor is inserted (Fig 6).

Discussion

The suture-bridge repair technique, using either a medial knotted or knotless construct, has been widely accepted for the treatment of rotator cuff tears. Despite similar clinical outcomes, biomechanical studies have shown that the medial knot-tying procedure resulted in increased load to failure, decreased gap formation, and improved footprint coverage.[1-4,7,9] Clinical studies have revealed that retear after suture-bridge repair with medial knot tying predominantly occurred at the musculotendinous junction (type 2 retear).[8,9,19] Tension overload at the medial row, tendon strangulation, and tendon cut-through are identified as the primary

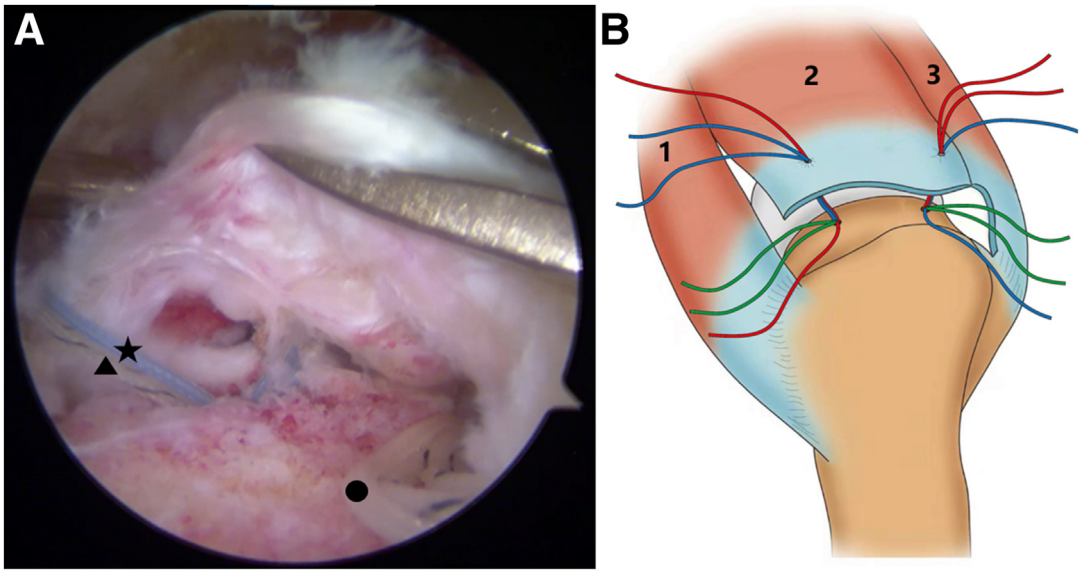

Fig 2. Left shoulder in lateral decubitus position. (A) Viewing from the posterolateral portal, 2 white suture limbs and 1 blue suture limb from the anterior anchor are passed through the anterior part of the supraspinatus approximately 2 to 3 mm lateral to the musculotendinous junction. Similarly, 2 blue suture limbs and 1 white suture limb from the posterior anchor are passed through the posterior part of the supraspinatus. The circle indicates a white suture limb; triangle, black-and-white suture limb; and asterisk, blue suture limb. (B) Suture management. (1, subscapularis; 2, supraspinatus; 3, infraspinatus.)

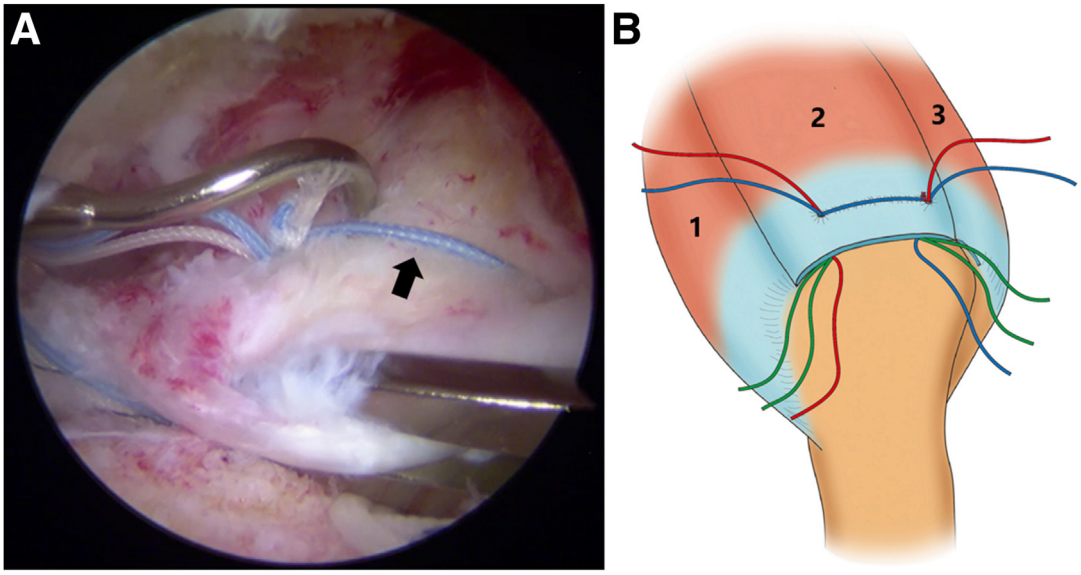

Fig 3. Left shoulder in lateral decubitus position. (A) Viewing from the posterolateral portal, 1 white suture limb from the anterior anchor and 1 blue suture limb from the posterior anchor are pulled outside and tied with a static surgeon's knot. The knot is delivered into the subacromial space by pulling the opposite ends of the sutures. The horizontal blue strand (arrow) consequently rests on the supraspinatus. (B) First pulley. (1, subscapularis; 2, supraspinatus; 3, infraspinatus.)

factors contributing to type 2 retear.[8,10-12] Because revision surgery of type 2 retear is technically challenging for shoulder surgeons, we have integrated the double-pulley construct and the rip-stop configuration into an arthroscopic suture-bridge repair with a medial knot construct to reduce the possibility of type 2 retear and improve the biological process of cuff healing.[13]

With the use of a medial knot-tying technique, tension overload at the medial row and tendon strangulation are responsible for decreased intratendinous blood flow and relatively quick necrosis of the cuff tendon.[8,20,21] However, our medial broad-based parallel double-pulley system compresses the tendon on the footprint in a linear fashion, which can prevent the potential strangulation effect and provide a joint

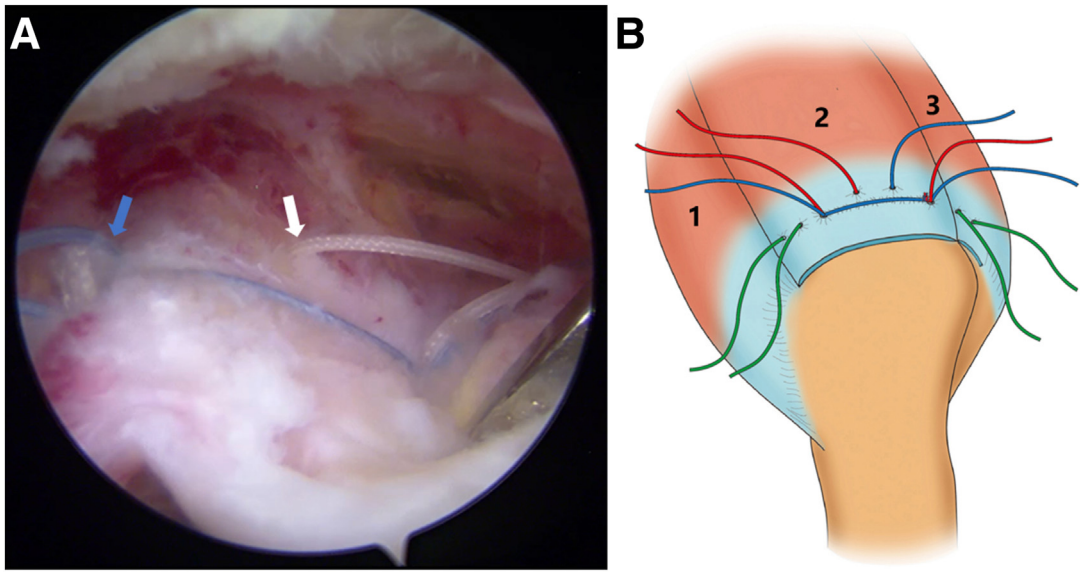

Fig 4. Left shoulder in lateral decubitus position. (A) Viewing from the posterolateral portal, the opposite ends of the blue suture (blue arrow) from the anterior anchor and the white suture (white arrow) from the posterior anchor are shuttled through the supraspinatus tendon just medial to the horizontal blue strand. (B) Suture management. (1, subscapularis; 2, supraspinatus; 3, infraspinatus.)

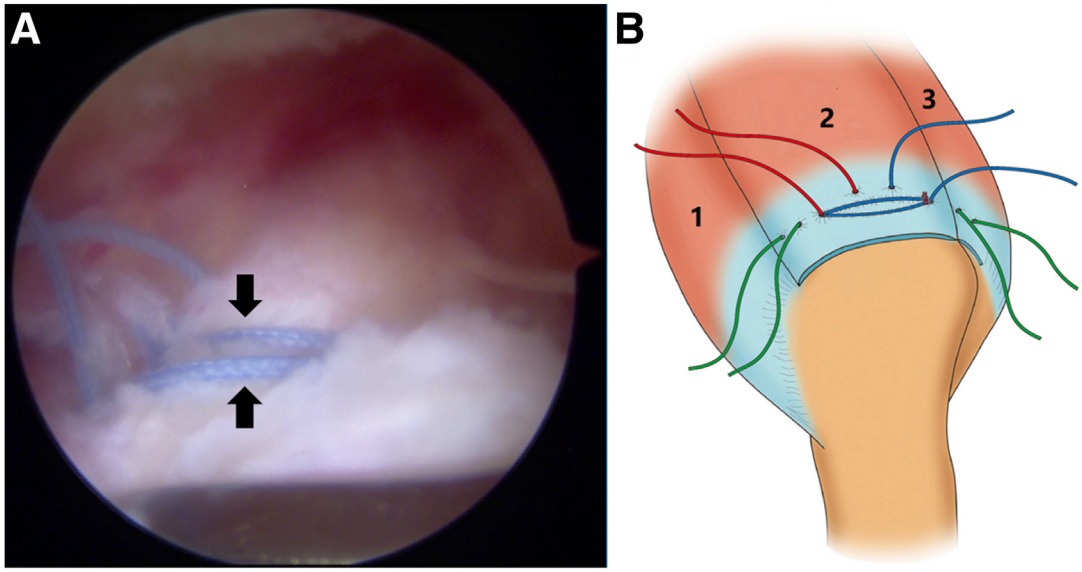

Fig 5. Left shoulder in lateral decubitus position. (A) Viewing from the posterolateral portal, the untied end of the white suture from the anterior anchor and the untied end of the blue suture from the posterior anchor are tied with a static knot to accomplish a double-mattress stitch (arrows). (B) Double-pulley construction. (1, subscapularis; 2, supraspinatus; 3, infraspinatus).

seal.[4,10,18] Moreover, the tension at the suture-tendon interface is equally distributed and shared by the double-pulley construct.[4,16,18]

The rip-stop configuration was introduced to reduce possible tendon cut-through. The Mason-Allen stitch and its variations were mostly used to function as a rip-stop in suture-bridge repair and showed superior biomechanical properties and a higher healing rate.[1-3,12,14] Problems associated with the Mason-Allen stitch and its variations are loss of loop security, intricacy of arthroscopic procedures, and potential tendon injury owing to numerous suture passages especially when facing larger tears.[3,12,14] The surgical method we present, implementing the medial double-pulley construct to act as a rip-stop, is technically easy to perform with minimal suture passage and increases the pressurized tendon-bone contact area.[16]

The advantages of our surgical technique include increased compression at the tendon-bone interface, reduced possibility of tendon cut-through, decreased

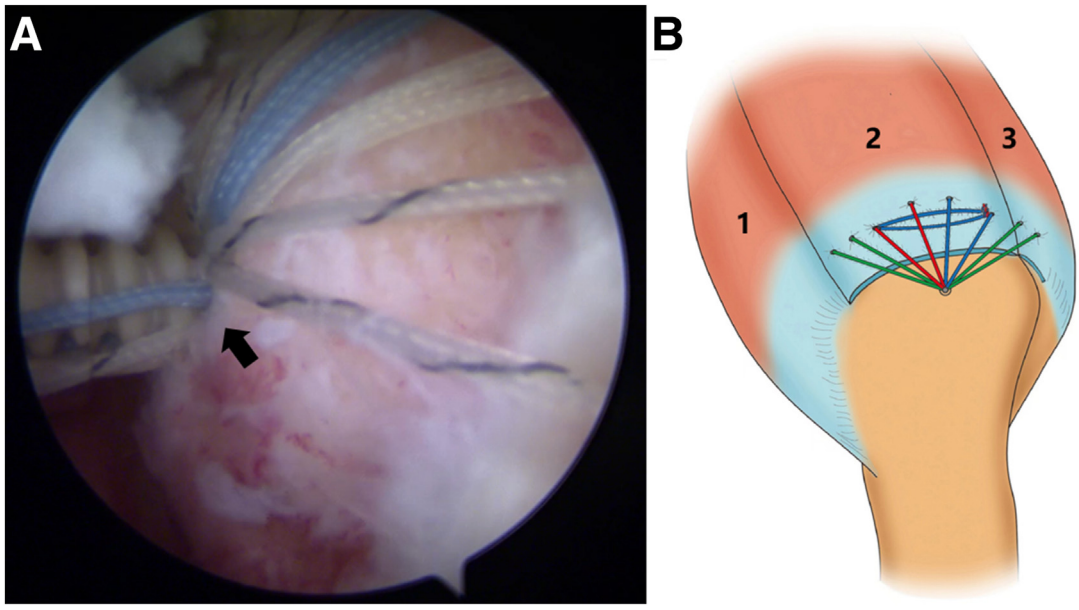

Fig 6. Left shoulder in lateral decubitus position. (A) Viewing from the posterolateral portal, all suture strands from the medial anchor are fixed in the lateral row by the knotless suture anchor (arrow). (B) Lateral-row fixation. (1, subscapularis; 2, supraspinatus; 3, infraspinatus.)

Table 1. Advantages and Disadvantages of Combined Rip-Stop and Double-Pulley Technique in Arthroscopic Suture-Bridge Repair

Advantages
The double-pulley construct increases compression at the tendon-bone interface and provides a joint seal.
The double-pulley construct eliminates tendon strangulation and improves tension distribution.
The rip-stop configuration reduces the possibility of tendon cut-through.
The technique is technically easy to perform and requires minimal suture passage.
Disadvantages
Biomechanical data are unavailable.
Our technique is unsuitable for extremely retracted and immobile cuff tears for which double-row repairs are unfeasible

risk of tendon strangulation, equal distribution of tension along the medial row, and an effective joint seal. There are several limitations of our method. First, no biomechanical data are available. Second, our technique is not recommended for extremely retracted and immobile rotator cuff tears for which double-row repairs are unfeasible (Table 1).

In conclusion, the combined rip-stop and double-pulley technique in arthroscopic suture-bridge repair can not only solve the clinical problem of retear but also improve the biology of tendon healing, which may represent a promising alternative in arthroscopic rotator cuff repair.

Disclosures

Both authors (J.X., Y.Z.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Special thanks are given to Yu Hui for help with the schematic illustrations.

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