Arthroscopic Double-Row Repair of Posterosuperior Rotator Cuff Tears: Suture Bridge Technique Reinforced With Modified Mason—Allen and Simple Sutures

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Abstract: Rotator cuff (RC) tears represent one of the most common causes of pain and dysfunction of the shoulder. Numerous RC repair techniques have been reported. In this Technical Note, we introduce an arthroscopic double-row repair technique that combines a suture bridge construct with modified Mason—Allen and simple suture fixation to optimize load-sharing and compression of the RC to the footprint. The described technique is ideal for crescent-shaped and large reparable U-shaped posterosuperior RC tears.

Rotator cuff (RC) tears are among the most common shoulder pathology in adults.[1] When indicated, arthroscopic RC repair can reduce shoulder pain and improve function. The transosseous-equivalent technique (suture bridge [S-B]) popularized by Park et al.[2] has become the reference standard surgical technique for posterosuperior RC tears.[3] This technique uses the suture limbs from the medial mattress sutures to bridge and compress the repaired tendon from medial-to-lateral on the RC footprint. Although the clinical results of this method have been good, some disadvantages exist. Gerber et al.[4] demonstrated the biomechanical superiority of the Mason—Allen suture compared with conventional techniques. Furthermore, cases of retear at the level of the medial mattress sutures may occur due to the potential ischemic character of these sutures on the repaired tissue.[5,6]

In this article, we describe an arthroscopic RC repair technique that combines the S-B technique, 2 modified Mason—Allen, and 2 lateral-based simple sutures. The goal of this technique is to reduce the risk of retear by decreasing tension on the 2 medial mattress sutures and by increasing the total number of sutures and suture limbs.

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Surgical Technique (With Video Illustration)

Patient Positioning

The patient is placed in the beach-chair position with 3 kg (for women) to 4 kg (for men) of constant traction applied to the upper limb to position the arm in neutral rotation and 30° to 40° of forward flexion.

Diagnostic Arthroscopy

A diagnostic arthroscopy is performed using a 4-mm arthroscope with 30° angulation placed within the standard posterior viewing portal. Under direct visualization, an accessory working anterosuperolateral (ASL) portal is created using an "outside-in technique" (i.e., with a spinal needle), just posterior to the bicipital groove and horizontal to the RC footprint. The footprint is prepared with a burr or hand rasp (in cases of soft bone) to stimulate bone bleeding and enhance tendon healing. Using a spinal needle off the anterolateral border of the acromion, the position of the first anchor is confirmed (4.5-mm triple-loaded resorbable Genesys suture anchor, ConMed, Largo, FL) just posterior to the bicipital groove at the junction of the articular cartilage and RC footprint. Using 1 of the 3 sutures, a biceps tenodesis is performed using the double lasso loop technique.[7] Surgeon discretion is used to determine the need to perform a biceps tenodesis and is not required for the RC repair technique outlined below. If a biceps tenodesis is not performed, double-loaded suture anchors can be used within the medial row.

The arthroscope is then placed into the subacromial space using the same posterior portal skin incision. Under direct visualization and using outside-in technique, a lateral portal is established in the centered position of the RC tear and a subacromial bursectomy is performed. Next, the subdeltoid bursa is excised adjacent to the lateral aspect of the greater tuberosity and the deep fascia of the lateral and anterior deltoid muscle is released to increase the working space (i.e., "panorama view").[8] The arthroscope in then placed in the lateral portal for viewing to complete the bursectomy and fascial release. The scapular spine, anterior band of the supraspinatus tendon, and musculotendinous junction of the supraspinatus and infraspinatus muscles are visualized while controlling hemostasis.

RC Repair Technique

Next, a tendon grasper is used to assess tear pattern, tendon mobility and the ideal position of the posterior-medial (P-M) anchor. The described technique is ideal for crescent and large reparable U-shaped posterosuperior RC tears. If required, an anterior interval slide can be performed, releasing the coracohumeral ligament, to improve mobility of the RC to the footprint. Using a spinal needle for localization, the P-M anchor (4.5-mm double-loaded resorbable Genesys suture anchor; ConMed) is inserted.

Through a canula set-up in the ASL portal, sutures are passed from posterior-to-anterior through the RC, alternating suture limbs first from the P-M anchor and then the anterior-medial (A-M) anchor (in Mason−Allen configuration) (Fig 1 A and B, Video 1). In a consecutive fashion, the first limb of the first suture is passed at the posterior margin of the torn infraspinatus tendon. Just anterior to this limb, the first limb of the second suture is passed medial to the first suture, and then the second limb of the first suture is passed in-line with the first passed suture to complete the horizontal mattress suture from the P-M anchor. The same technique is used to shuttle sutures from the A-M anchor through the supraspinatus tendon. Thereby, we obtain a similar medial row suture bridge technique that uses a modified Mason−Allen configuration.

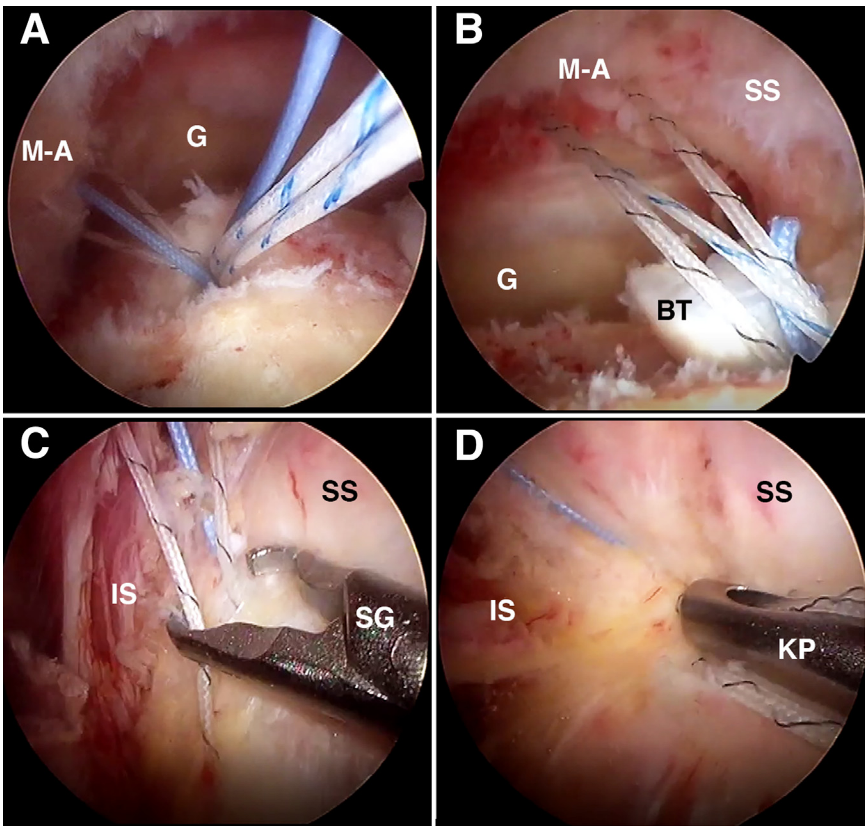

Fig 1. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the beach-chair position reveals a large full-thickness, crescent-shaped tear of the supraspinatus (SS) and infraspinatus (IS) tendons. (A) Sutures from the posterior-medial anchor are passed from posterior-to-anterior in a modified Mason−Allen (M-A) configuration. (B) Sutures from the anterior-medial anchor are then passed in a similar fashion. Note, the long head biceps tendon (BT) has been tenodesed. (C and D) The 2 horizontal mattress sutures are then tied. (G, glenoid; KP, knot pusher; SG, suture grasper.)

Following suture shuttling, the 2 horizontal mattress sutures are tied, while the second suture limbs previously shuttled medial to the horizontal mattress remain untied (Fig 1 C and D, Video 1).

Next, using a suture grasper, one suture limb from each of the 2 previously tied medial mattress sutures and the "free" deep limb (i.e., the limb of the second suture not passed through the RC) are shuttled through the cannula of the ASL portal. A 4.5-mm knotless suture anchor (all-PEEK PopLok; ConMed) is used to capture the 3 previously shuttled suture limbs and inserted laterally just posterior to the bicipital groove and in-line with the anterior margin of the RC tear (Fig 2A).[9] Care is taken to ensure that suture limbs are not cut after securing the lateral row anchor and reducing the RC to the footprint. The process is repeated for placement of the second lateral row anchor, which is inserted within the posterolateral aspect of the greater tuberosity, in-line with the P-M anchor (Fig 2B), completing the suture bridge portion of the procedure (Fig 3, Video 1).

Next, the 2 appropriately paired suture limbs from the P-M (i.e., the first limb of the second suture previously passed through the infraspinatus tendon) and the second "free" deep limb of the same suture which is secured in the posterolateral anchor are tied, completing the Mason—Allen suture configuration posteriorly (Fig 2 C and D, Video 1). The process is repeated to complete the Mason—Allen configuration anteriorly (Fig 4).

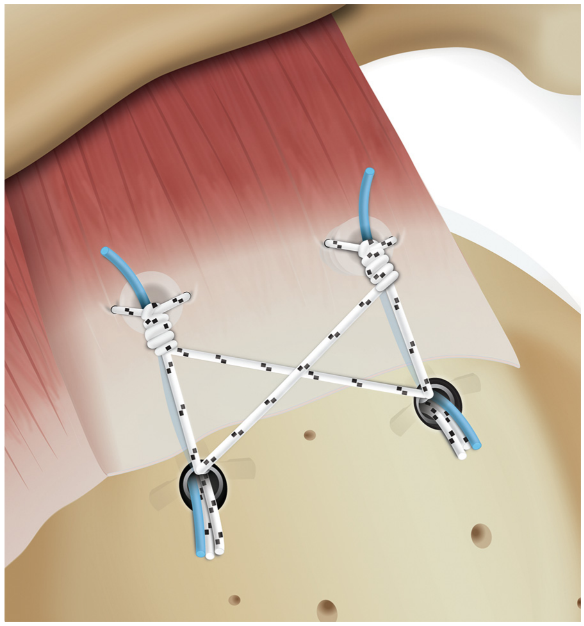

Fig 3. Illustration of a right shoulder (superior view) summarizing the steps required to complete the suture bridge portion of the rotator cuff repair.

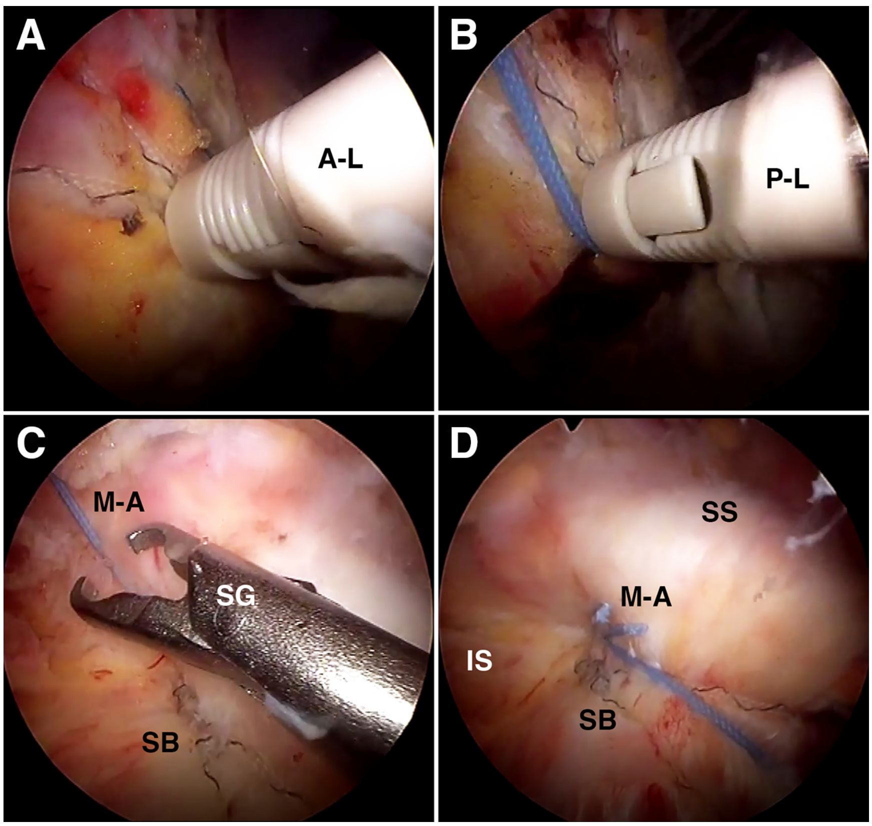

Fig 2. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the beach-chair position. (A) In preparation for placement of the first lateral row anchor, one suture limb from each horizontal mattress suture and the free deep suture limb from the anterior-medial anchor that has not been shuttled through the supraspinatus tendon are loaded into a 4.5-mm knotless all-peek PopLok anchor (A-L, anterolateral anchor). (B) The process is repeated for placement of the second lateral row anchor within the posterolateral aspect of the greater tuberosity, in-line with the posterior-medial (P-M) anchor (P-L, posterolateral anchor). (C and D) The 2 appropriately paired suture limbs from the P-M and P-L anchors are then tied, reinforcing the suture bridge (SB) construct with a modified Mason-Allen suture (M-A); the process is repeated anteriorly. (IS, infraspinatus; SG, suture grasper; SS, supraspinatus.)

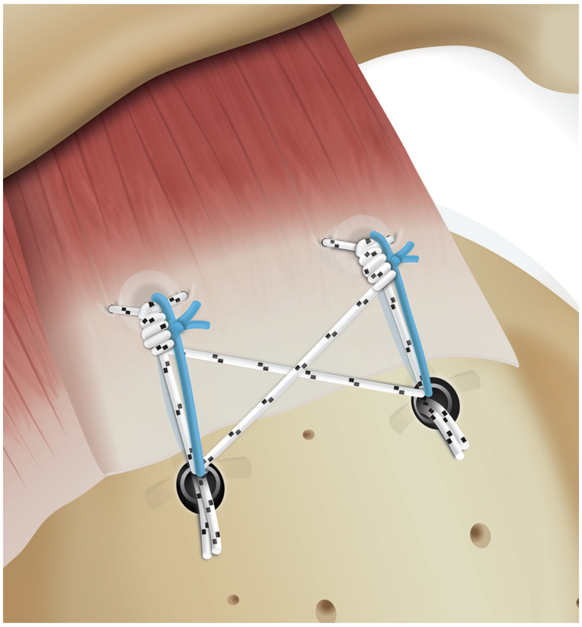

Fig 4. Illustration of a right shoulder (superior view). After completing the suture bridge portion of the rotator cuff repair, the 2 appropriately paired suture limbs from the posteromedial and posterolateral anchors are tied, reinforcing the suture bridge construct with a modified Mason−Allen suture. The process is repeated anteriorly.

The quality of the reduction of the RC tendon to the footprint is controlled in the aforementioned series of steps. If a small gap or dog ear remains anteriorly, the 2 suture limbs captured and remaining within the anterolateral anchor (i.e., from the previously tied horizontal mattress suture) can be used and passed through the anterior free margin of the supraspinatus tendon in a simple fashion (Fig 5 A). The same steps can be followed if a small gap or dog ear remains posteriorly or centrally (i.e., between the 2 medial row anchors) using the 2 suture limbs captured and remaining within the posterolateral anchor (Fig 5 B and Video 1). The final construct is then assessed ensuring anatomic restoration and compression of the RC to the prepared footprint (Fig 5 C and D and Fig 6, Video 1).

Postoperative Rehabilitation

The patient is placed in an abduction sling for 4 weeks, followed by 2 weeks in a regular sling. The patient will start a self-regulated rehabilitation protocol with or without hydrotherapy in the following days after surgery. The patient can expect to return to activities of daily living and driving 3 months after surgery, and full activities between 6 and 12 months postoperatively.

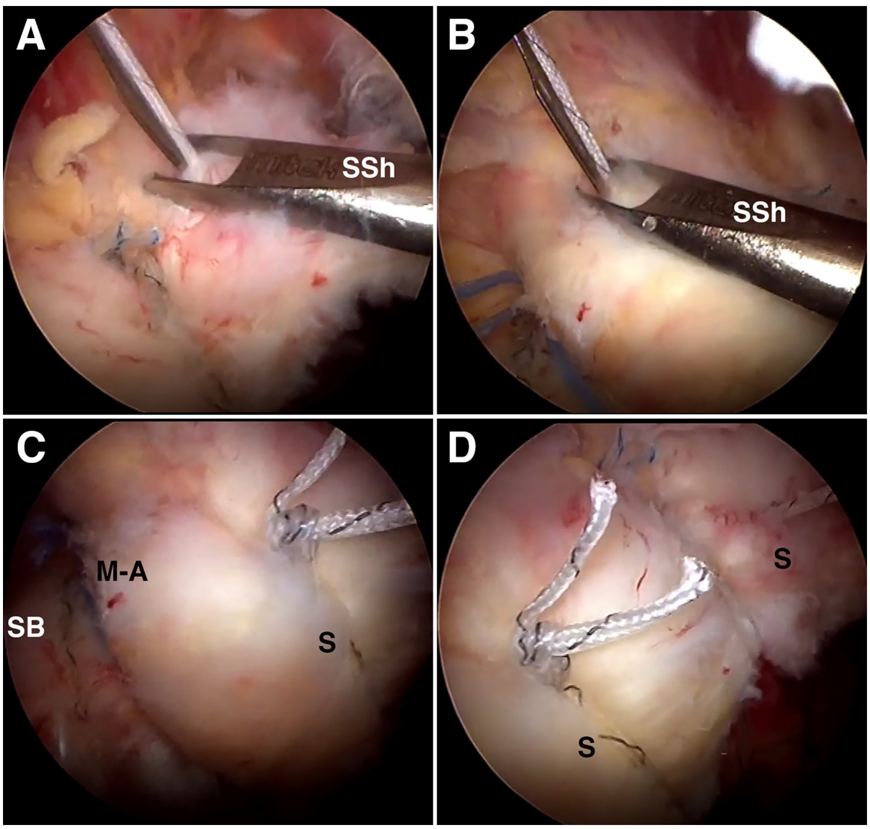

Fig 5. Arthroscopic visualization of the right shoulder (viewing from the lateral subacromial portal) with the patient in the beach chair position. (A) The anterolateral portal serves as the working portal to pass 1 of the 2 suture limbs captured and remaining within the anterolateral anchor through the anterior margin of the supraspinatus tendon in a simple fashion using an antegrade suture shuttle (SSh). (B) One of the 2 suture limbs remaining within the posterolateral anchor is used to address a remaining tendon gap/dog ear within the central aspect of the repaired rotator cuff. (C and D) The passed simple sutures (S) are then tied. (M-A, Mason−Allen; SB, suture bridge.)

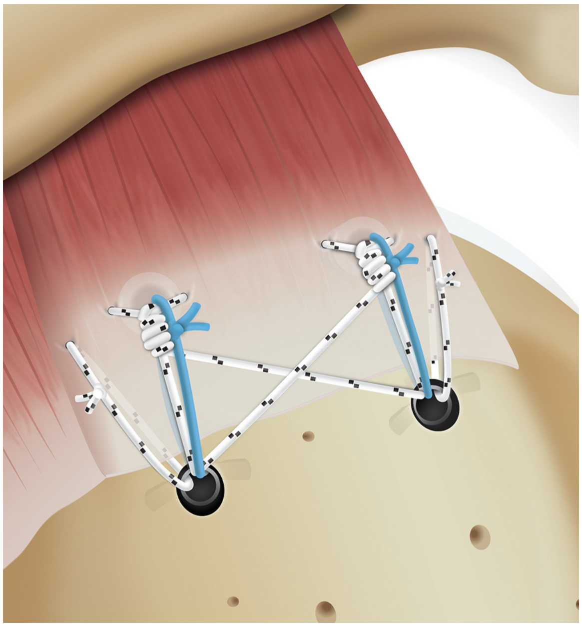

Fig 6. Illustration of a right shoulder (superior view) summarizing the final double-row rotator cuff repair construct. The suture bridge is reinforced with modified Mason–Allen sutures, which is then further secured with simple sutures passed along the free margin of the rotator cuff tendon to compress the tendon to the prepared footprint.

Discussion

In an effort to optimize tendon healing, the surgical treatment of RC tears must achieve 3 criteria: (1) greatest initial fixation strength, (2) minimal gap formation, and (3) largest contact area between the tendon(s) and their footprint(s).[4] Due to better restoration of the footprint, greater initial and failure strength, increased footprint contact pressure, and smaller gap formation, it has been proposed that double-row repairs lead to a better healing environment.[10,11] Although the repair techniques differ with regard to anchor number and suture configuration,[12] all double-row repairs are technically more challenging, require additional anchors and operating room time. However, double-row repairs have been found to be more cost-effective and economically attractive versus single-row repairs for larger RC tears (≥3 cm).[13]

In the S-B technique described by Park et al.,[2] instead of the 2 rows of fixation as described in conventional double-row repairs, the RC tissue is compressed to the anatomical footprint by the assistance of bridging sutures.[3,14] As a result, the tendon tissue is not penetrated at the lateral row which theoretically decreases tissue strangulation by the suture knots and preserves tendon vascularity.[15] However, it is probable that the medial row suture knots could disrupt tendon vascularity and increase the risk of retear, especially if sutures are knotted at the level of the musculotendinous junction.[5] Conversely, some studies have demonstrated that the S-B technique created greater pressure at the tendon–bone interface and increased failure strength in comparison to conventional double-row repairs.[16,17]

In their meta-analysis, Shi et al.[3] demonstrated that the number of sutures limbs and number of sutures were positively associated with mean ultimate failure load in transosseous sutures and single-row constructs. In the original S-B technique, only 2 medial mattress sutures were performed. In our technique, we propose to pass 8 suture limbs through the RC (vs 4 in the original S-B) and to knot 6 sutures (vs 2 in the original S-B) (Fig 6).

Previous authors have evaluated the contribution of the medial row knots to the biomechanical properties in double-row repairs and have suggested that the medial row knots reduce the failure load by preventing gap formation and absorbing the energy, and therefore preserve the RC footprint.[18-20] One of the goals of our technique is to reduce the tension at the level of the 2 medial mattress sutures by combining 4 simple sutures. By increasing the number of medial sutures, we intend to reduce tissue ischemia at the level of the 2 medial horizontal mattress sutures with subsequent improved distribution of tension which also increases the resistance to failure and reduces the risk of retear and deterioration of clinical results over time.[21]

As demonstrated by Gerber et al.,[4] the resistance to failure of the Mason–Allen suture is greater compared with other suture constructs. We propose to modify the S-B technique by placing a simple suture medial to the horizontal mattress, thereby creating an arthroscopic Mason–Allen configuration and increasing the

Table 1. Advantages and Limitations

Advantages	Limitations
• Better distribution of forces across 6 sutures to decrease potential tissue ischemia at the 2 medial mattress suture knots. • Increasing biomechanical resistance to failure with the use of 2 arthroscopic Masson–Allen sutures. • Reduced tension on the medial row anchors thereby minimizing the risk of anchor failure. • Cost effective: increased number of sutures without an increase in the number of anchors	• Biomechanical data are not available to validate this technique. • Increased use of the lateral row anchors could increase the risk of anchor failure (i.e., pull-out). • Multiplication of sutures could increase surgical time and make the procedure more technically challenging.

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
• Perform a complete anterolateral release of the deep deltoid fascia to increase the subacromial working space. • Use the lateral subacromial portal to obtain a panoramic view of the RC tear. • Identify the anterior border (i.e., anterior band) of the supraspinatus and the musculotendinous junction of the supraspinatus/infraspinatus to ensure proper placement of suture limbs. • Use anterosuperior and posterosuperior accessory portals to ensure proper placement of the medial row anchors. • Successive shuttling of suture limbs from posterior-to-anterior followed by temporary docking of the suture limbs through the posterior portal. • To prevent tissue ischemia and future tendon retear/failure, avoid excessive tension while tying the medial row mattress sutures.	• Failure to perform this release compromises visibility for suture management and placement of lateral row anchors. • There may be a learning curve to realizing the need for and positioning of the lateral portal (i.e., maintaining a good distance with the anterolateral portal). • The rotator cable may be difficult to visualize, especially in chronic retracted RC tears. • The lateral acromion may hinder optimal visualization and positioning of medial row anchors. • Failure to manage sutures can lead to technical errors and additional surgical time. • In cases of chronic retracted tears, it may be difficult to achieve an anatomic reduction of the RC on the footprint. In such cases, a goal of the other four sutures is to improve tendon reduction.

RC, rotator cuff.

biomechanical resistance to failure without complicating the original technique or increasing the anchor number or surgical time. Furthermore, in the classic S-B technique, all biomechanical tension is concentrated on the medial row. With our technique, securing suture limbs in the lateral row anchors permits distribution of tension more homogeneously among all 4 anchors rather than on the two medial row anchors alone which may reduce the risk of anchor failure (Table 1).

The potential limitations and pitfalls of our double-row technique are highlighted in Table 2. Future studies are required to validate the biomechanical principles, clinical outcomes, and economics of this technique.

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