Technical Note

Modified Double-Row Suture Bridge Technique With Double-Row Biceps Tenodesis for Massive Rotator Cuff Tear

Joseph Maalouly, M.D., Dany Aouad, M.D., Antonios Tawk, M.D., and Georges El Rassi, M.D.

Abstract: This article aims to describe a modification of the arthroscopic suture bridge technique for repair of a massive (>3 cm) rotator cuff tear. The method uses 2 medial anchors and 2 lateral anchors for rotator cuff repair, as well as double-row biceps tenodesis. This operative modification may impart better tendon healing and fewer rupture complications than the traditional double-row repair techniques.

Rotator cuff repair using arthroscopic techniques was developed initially to reduce the high morbidity associated with open surgery. The recent literature has indicated that it is possible to obtain effective treatment for rotator cuff tears smaller than 1 cm using single-row (SR) repair.[1] In contrast, for defects between 1 and 3 cm, there is no clear agreement on what double-row (DR) modification is superior to the other, and any SR, DR, knotted transosseous-equivalent (TOE), or knotless TOE technique can be chosen depending on the preference of the surgeon and expectations of the patient.[1] For tears larger than 3 cm, the literature agrees that the modified DR TOE technique can yield better outcomes both functionally and in terms of repair integrity.[1] This study aims to describe a technique that uses medial-row anchors and knotless lateral-row anchors, with an evaluation of its clinical outcomes.

From St Georges University Medical Center, Lebanon, Beirut.

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received December 22, 2019; accepted February 17, 2020.

Address correspondence to Georges El Rassi, M.D., St Georges University Medical Center, Achrafieh, St Georges Street, Lebanon, Beirut. E-mail: georgeelrassi@hotmail.com

2212-6287/191568
https://doi.org/10.1016/j.eats.2020.02.013

Surgical Technique

All operations are performed with the patient in the beach-chair position, under general and regional anesthesia, with weighted traction. First, the posterior soft spot formed by the interval between the infraspinatus and teres minor muscle, located approximately 2 cm below and 2 fingerbreadths medial to the posterolateral corner of the acromion, is palpated (Fig 1). Second, starting with an incision over the posterior soft spot, the standard posterior portal is entered with an introducer, and the joint was inspected with a 30° scope to identify the rotator cuff tendon tear and any other intra-articular lesions (Fig 2). Third, an anterior portal is made after a trial with a spinal needle under direct vision lateral to the coracoid process (Fig 3). Fourth, the biceps tendon is observed to be inflamed (Fig 4), and the decision to perform tenodesis is made, beginning by tagging the biceps tendon with FiberTape (Arthrex), followed by tenotomy. Fifth, in the subacromial space, a standard lateral viewing portal and anterolateral working portal are created 3 cm distal to the anterolateral corner of the acromion, where extensive bursectomy is performed to reveal the biceps tendon and rotator cuff tendon.

Sixth, the full-thickness tendon tear is identified and debrided before the repair begins. Then, the footprint is prepared using a shaver; the bone is abraded gently to preserve osseous integrity and minimize the possibility of suture anchor pullout. An elevator is used to release any bursal-sided adhesions, mobilize the rotator cuff, and obtain a tension-free repair. Seventh, a spinal needle is used to localize placement for an anchor portal, which is typically placed just off the lateral

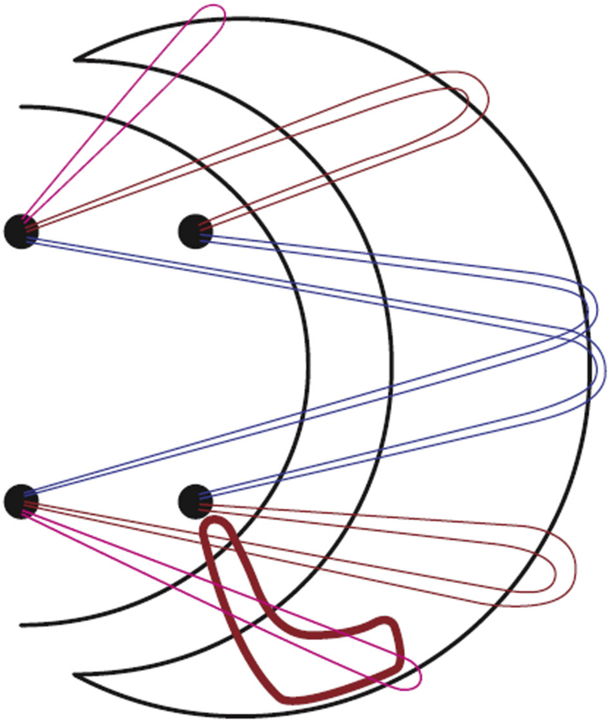

Fig 1. Modified double-row suture bridge technique with double-row biceps tenodesis for massive rotator cuff tear using 2 medial triple-loaded suture anchors and 2 lateral double-loaded suture anchors.

margin of the acromion (Fig 5). An awl is used to create sockets for the suture anchors, which are placed at an angle of 45° relative to the plane of the tuberosity. If the anterior-to-posterior distance of the torn tendon is greater than 1.5 cm, 2 medial anchors are inserted. The medial row is the most important factor determining the stability of the DR technique, so this technique is chosen to decrease the tensile stress by performing a modified technique.

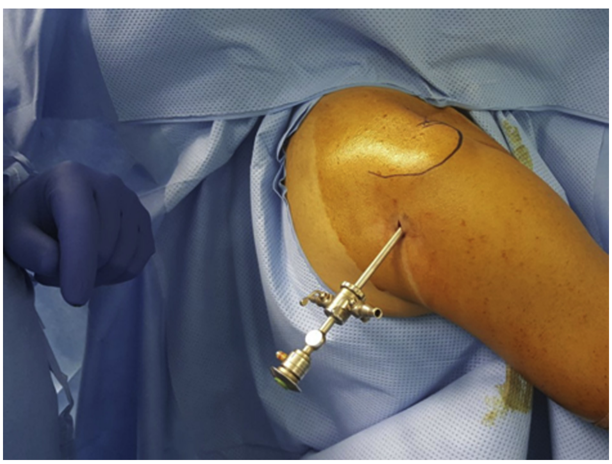

Fig 2. An introducer is inserted into the glenohumeral joint by aiming toward the coracoid process through the soft spot.

Fig 3. A spinal needle is introduced lateral to the coracoid process through the rotator interval under direct vision.

Eighth, starting with the placement of 2 medial triple-loaded suture anchors, which are tested for pullout strength, the biceps tendon is placed under the rotator cuff tear medially (Fig 6). The tip of the awl is used to make several microfractures across the footprint to stimulate a healing response.

Ninth, the arthroscope is positioned back in the posterior portal. Beginning anteriorly, sutures are retrieved individually and passed in a horizontal mattress fashion using a suture-passing device across the entire breadth of the tear (Fig 7). After each pass, sutures are retrieved through the anterior portal. To secure the anterior and posterior edges of the tear, a cinch stitch (FiberSnare; Arthrex) is used. The mattress sutures are tied starting posteriorly.

Tenth, the remaining tape from the most anterior medial anchor is used; one of the sutures proximally is used for proximal biceps tenodesis with a Mason-Allen stitch and later passed in an oblique fashion and tied in such a fashion. The biceps is tested and found to be stable in the biceps groove proximally. Furthermore, one proximal and medial anchor suture is placed for better application of the tendon over the bone-tendon interface. In addition, one suture from the distal anchor is used for prevention of anterior dog ears, and another one is used distal posteriorly for prevention of posterior dog ears (Fig 8).

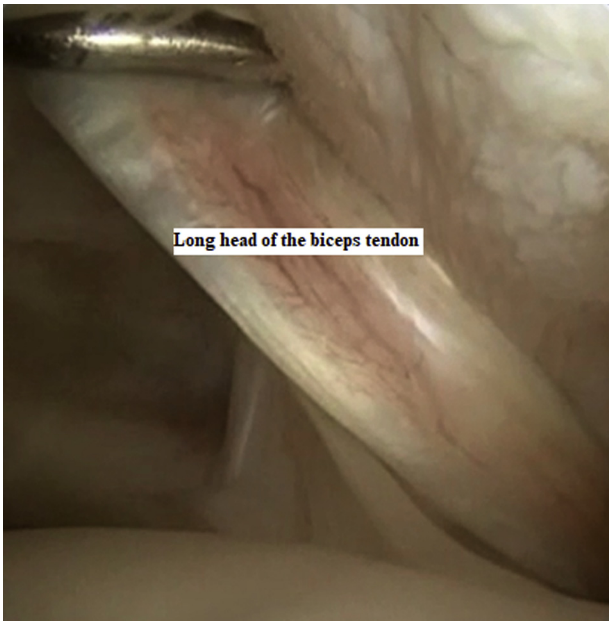

Fig 4. Intra-articular diagnostic arthroscopy showing inflammation of long head of biceps tendon.

Eleventh, the bone is exposed just lateral to the greater tuberosity using coblation (Arthrex) to prepare for lateral-row anchor placement. Usually, 3 lateral-row anchors are used. An awl is used to create the socket for the anchor, which is placed just lateral to the footprint in the greater tuberosity. Alternating sutures are retrieved from the lateral portal and passed through the eyelet of the lateral-row anchor. Distally within the groove, if the biceps is still loose, a second suture from the distal row is taken and fixes the biceps in place, thus achieving a DR technique (Fig 9). The anchor (SwiveLock; Arthrex) is placed into the socket; however, prior to fully seating the anchor, the sutures are tensioned and bridged over the bursal surface of the rotator cuff.

Once the anchor is fully seated, the sutures are cut flush with the anchor. This procedure is repeated for the second lateral-row anchor. The additional eyelet sutures preloaded on the lateral-row anchor are passed for additional fixation (Video 1). Closure is performed in the standard fashion with No. 3-0 nylon sutures, and dressing is placed, followed by placement of a shoulder immobilizer.

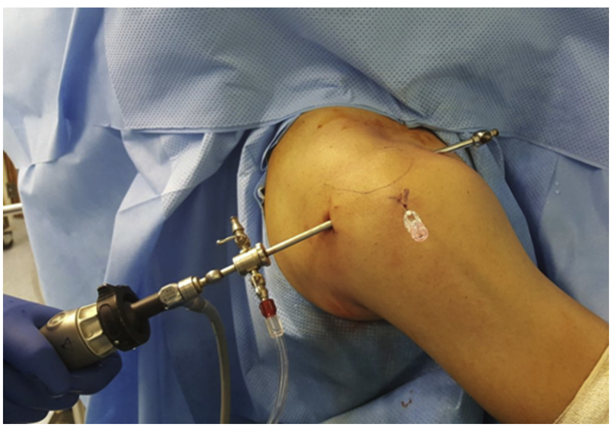

Fig 5. A spinal needle is introduced 1 to 2 cm distal to the lateral acromial edge as a guide to create the lateral portal.

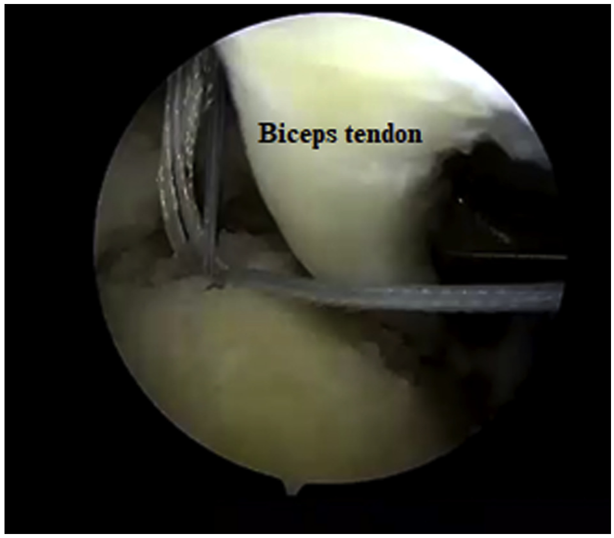

Fig 6. The biceps tendon is placed under the rotator cuff tear medially.

Rehabilitation

The first stage of rehabilitation begins with the application of an arm sling for immobilization. The first phase of the rehabilitation protocol, including passive range of motion of the shoulder and the elbow without any active range of motion, starts at 7 to 10 days postoperatively and lasts up to 4 weeks. This phase aims to reduce pain and inflammation while gradually restoring passive range of motion. In the second phase (from week 4 to week 6), progressive active-assisted range of motion is initiated around the shoulder, beginning with anterior elevation of the shoulder, followed by gentle abduction and external rotation of the shoulder, as well as active elbow flexion and extension and forearm supination and pronation without resistance. This aims to achieve gradual restoration of active range of motion. The last phase consists of initiating light-resistance exercises, progressing as tolerated until reaching normal strength and endurance.

Discussion

Compared with the more traditional SR approach, the DR method was initially developed to promote better biomechanical properties and to assist structural healing by closely approximating the original footprint in an effort to promote better clinical outcomes. Biomechanical properties such as mechanical stability, initial fixation strength, and gap formation

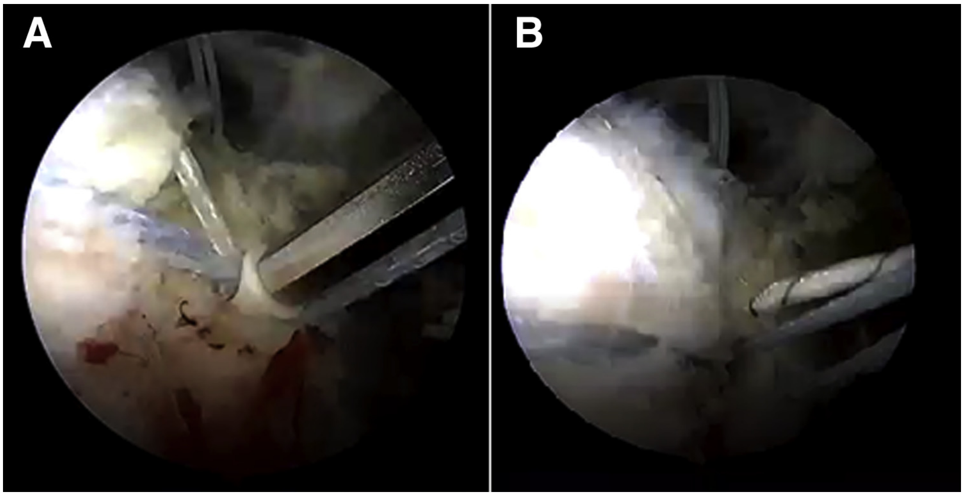

Fig 7. (A) Sutures are retrieved individually and passed in a horizontal mattress fashion (B) using a suture-passing device across the entire breadth of the tear.

are essential to promote better healing and a durable repair.[1] In fact, most of the literature agrees that the DR approach is biomechanically superior to the SR method. A systematic review of meta-analyses carried out by Mascarenhas et al.,[2] including only studies with the highest level of evidence, showed that the DR approach is superior to the SR approach in providing structural healing, although the debate remains when considering the cost-effectiveness, increased operative time, and material cost of the DR technique.

Biomechanical studies have also been carried on the TOE technique, with its knotted and knotless approaches showing promising results especially in preventing synovial fluid leakage in the repair,[1] an important feature of the construct in creating an adequate microenvironment for healing. However, there are conflicting results in the literature when comparing the knotted approach and knotless approach, which was created initially to alleviate the medial insufficiency created by the medial-row knots, with some studies finding the approaches similar and others stressing the importance of the medial set of rows in imparting a superior biomechanical construct.[1] In a systematic review performed by Mall et al.,[3] tying of the medial set of rows showed improved biomechanical features in 4 of the 5 studies included, whereas 1 study alone found no difference in contact pressure, gap formation, and mean failure load compared with the traditional suture bridge technique.[4] In addition, although there are some studies pointing to appreciable functional outcomes with the knotted and knotless TOE techniques, the literature is lacking studies comparing these variations with the more conventional double-row technique functional outcomes. In fact, Mall et al. stated that although tying the medial set of rows imparted superior biomechanical features, more studies are needed to support enhanced healing rates of the medially knotted TOE compared with the knotless variation.

A study by Wu et al.,[5] describing a modification of the TOE knotless suture bridge (SB) technique, called the “modified suture bridge,” claims to combine the advantages of the knotless technique in the medial row with better biomechanics than knot-tying repairs. The modification was designed to augment the initial weak fixation provided by the knotless approach with a combined decrease in knot irritation and impingement. The modified SB approach uses a single triple-loaded anchor with suture limbs secured to the lateral row without knot tying. The construct uses a rip-stop technique and triple-loaded anchor to improve the biomechanical properties of the traditional knotless design. In addition, the rip-stop technique, compared with a simple or mattress stitch pattern, is superior regarding load-to-failure characteristics and providing resistance to tissue cutout, with better distribution of the medial-to-lateral tensile strength.[5] However, it is important to state that although biomechanical studies are important to gauge the best construct and compare different approaches, they fail to replicate rotator cuff repairs performed in clinical practice and they provide data only on the initial biomechanics, with no insight on the durability of the repair.[1]

Initially created to enhance and facilitate the surgical approach, the SB repair technique has been shown to be an easier, biomechanically promising, more cost-effective approach. In fact, the more conventional DR technique created a phenomenon of anchor overcrowding, and the technique, which relies on point fixation, failed to prevent synovial leaking, falling short in improving clinical outcomes. The SB construct relieves lateral-row tissue strangulation, solves the problem of anchor overcrowding by sliding the second row of fixation laterally to the tuberosity,

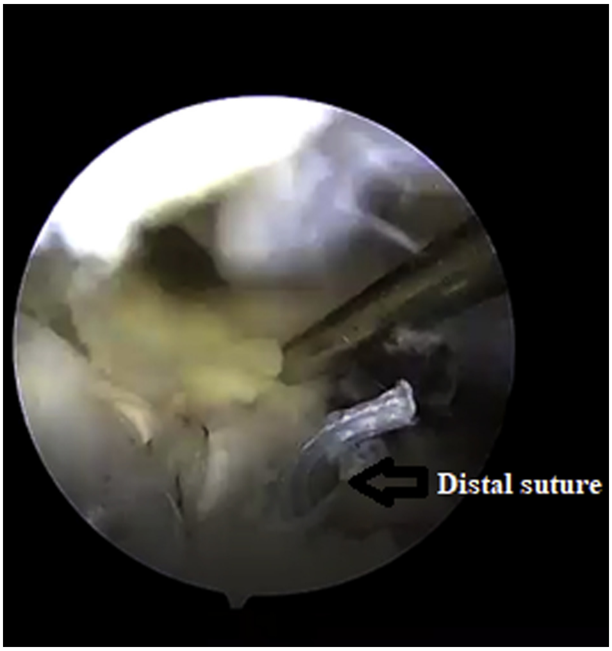

Fig 8. One suture from the distal anchor for prevention of anterior dog ears formation, and another one is used distal posteriorly for prevention of posterior dog ears.

and allows for better compression of the tissue to the anatomic footprint with bridging sutures.[1] However, the knotted technique created an excessive load at the medial row, causing tendon strangulation and, ultimately, medial-row insufficiency.[1] This led to the development of the completely knotless approach. This technique was proved to be technically simpler; allowed an augmented suture tendon—to—surface pressure, which is hypothesized to create a better healing environment; and proved to eliminate the problem of medial insufficiency created by the knotted technique.[6]

In the literature, the results regarding functional effects, structural integrity, and rerupture rates have been studied and compared between the aforementioned methods. Among rotator cuff repair techniques, the DR and SB approaches seem to yield lower rerupture rates for tears of any size compared with the SR method.[7] In contrast, when comparing the long-term functional and clinical benefit, especially for small tears, many studies have failed to find any difference in functional and clinical outcomes between the SR and DR techniques, as shown by multiple scores and multivariate analysis.[7,8-10] Moreover, among the few studies carried out to compare the functional outcomes and repair integrity of rotator cuff tears, several have failed to show any difference between the DR and SB techniques when comparing these methods regarding patient satisfaction and retear rates.[7] In addition, although there are some studies pointing appreciable functional outcome for the knotted and knotless TOE technique with no difference in functional outcome between them.[7] Park et al.,[11] in a study using human cadaveric shoulders, showed that the TOE technique is superior to the DR technique in terms of footprint restoration and strength. However, when the retear rates of the DR and SB techniques were compared, no statistically significant difference was found between the 2 methods.[7,12] It also has been agreed that for a full-thickness rotator cuff tear larger than 3 cm, the DR technique results in better shoulder strength and cuff integrity,[13] whereas in a recently published meta-analysis, the SB technique was superior in terms of the retear rate and University of California, Los Angeles (UCLA) score.[14] In addition, for full-thickness subscapularis tears, there are conflicting results as to which technique is superior, with most studies agreeing that there is no statistically significant difference between the SB and DR techniques in decreasing retear rates.[13] Recently, a modified SB technique has been published that relies on fixing the marginal dog-ear deformity formed medially with suture from the medial-row anchors, thereby decreasing retear rates.[15]

After a thorough literature review, we think that enough evidence exists to suggest that a DR technique is better than an SR technique in terms of stability and function and that a TOE technique is better than a DR technique in terms of stability and function. The main concern is the failure of repair in patients with massive rotator cuff tears; thus, we modified the TOE technique to further decrease this poor outcome. DR

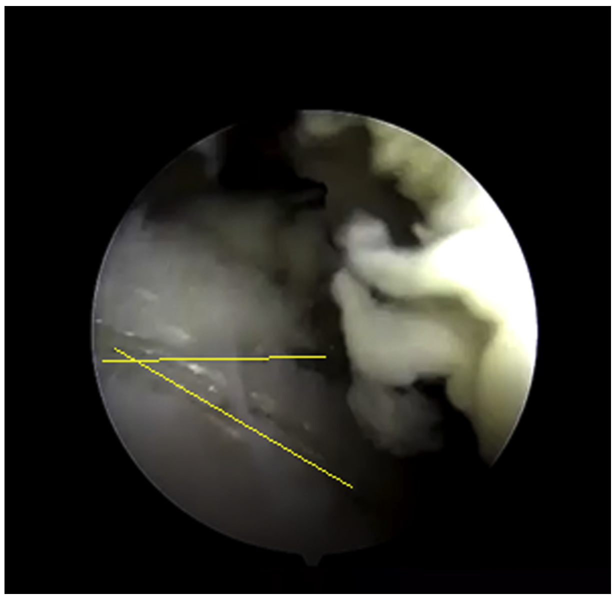

Fig 9. Double-row suture bridge pattern seen on final inspection over rotator cuff tear with biceps tenodesis site.

Table 1. Pearls and Pitfalls of Modified Double-Row Suture Bridge Technique

Pearls	
	Repair integrity respected
	Minimal suture anchor pullout possibility
	Tension free
Pitfalls	
	Not performed for small RCT (<1 cm)
	No active ROM for up to 4 wk postoperatively

RCT, rotator cuff tear; ROM, range of motion.

biceps tenodesis inside the groove allows the achievement of better stability mainly in rotation, as well as better healing of the biceps, so we avoid the anterior shoulder pain that occurs after traditional biceps tenodesis; moreover, preservation of the biceps inside the groove may decrease humeral head ascension. The advantages of the modified DR technique are as follows: better adherence of the rotator cuff over the medial row; lower likelihood of failure because of less tension over the medial row; use of stitches at the most anterior region and most posterior region to decrease dog-ear formation and produce a larger tendon-bone interface; use of a Mason-Allen stitch through the biceps tendon at the most anterior part of the supraspinatus tendon; and use of a Mason-Allen stitch at the most posterior part through the posterior portion of the rotator cuff tear (Tables 1 and 2).

The modification performed in this SB technique led to an improved contact area, firm medial fixation, and decreased tension over the tendon surface while minimizing deformity formation, such as dog-ear and bird-beak deformities. Furthermore, biceps tenodesis is performed using one of the anchor's sutures for fixation. The subject of which technique is best to use remains controversial in the literature, with a preference for the SB or TOE technique for large tears.

Table 2. Advantages and Disadvantages of Modified Double-Row Suture Bridge Technique

Advantages	
	Better mechanical stability
	Reduced gap formation
	Initial fixation strength
	Better structural healing
	More durable repair
	Distribution of tensile strength
	Lower rerupture rates
	Better shoulder strength and cuff integrity for large cuff tears
	Improved stability
	Larger tendon-bone interface
	Better adherence of rotator cuff over medial row
Disadvantages	
	Debatable cost-effectiveness
	Increased operative time
	Increased material cost
	Anchor overcrowding
	Tendon strangulation
	Medial-row insufficiency
	No difference in terms of long-term functional and clinical benefit

References

1. Aydin N, Karaismailoglu B, Gurcan M, Ozsahin MK. Arthroscopic double-row rotator cuff repair: A comprehensive review of the literature. *SICOT J* 2018;4:57.
2. Mascarenhas R, Chalmers PN, Sayegh ET, et al. Is double-row rotator cuff repair clinically superior to single-row rotator cuff repair: A systematic review of overlapping meta-analyses. *Arthroscopy* 2014;30:1156-1165.
3. Mall NA, Lee AS, Chahal J, et al. Transosseous-equivalent rotator cuff repair: A systematic review on the biomechanical importance of tying the medial row. *Arthroscopy* 2013;29:377-386.
4. Busfield BT, Glousman RE, McGarry MH, Tibone JE, Lee TQ. A biomechanical comparison of 2 technical variations of double-row rotator cuff fixation: The importance of medial row knots. *Am J Sports Med* 2008;36:901-906.
5. Wu Z, Zhang C, Zhang P, et al. Biomechanical comparison of modified suture bridge using rip-stop versus traditional suture bridge for rotator cuff repair. *Biomed Res Int* 2016;2016:9872643.
6. Rhee YG, Cho NS, Parke CS. Arthroscopic rotator cuff repair using modified Mason-Allen medial row stitch: Knotless versus knot-tying suture bridge technique. *Am J Sports Med* 2012;40:2440-2447.
7. Hein J, Reilly JM, Chae J, Maerz T, Anderson K. Retear rates after arthroscopic single-row, double-row, and suture bridge rotator cuff repair at a minimum of 1 year of imaging follow-up: A systematic review. *Arthroscopy* 2015;31:2274-2281.
8. Franceschi F, Ruzzini L, Longo UG, et al. Equivalent clinical results of arthroscopic single-row and double-row suture anchor repair for rotator cuff tears: A randomized controlled trial. *Am J Sports Med* 2007;35:1254-1260.
9. Burks RT, Crim J, Brown N, Fink B, Greis PE. A prospective randomized clinical trial comparing arthroscopic single- and double-row rotator cuff repair: Magnetic resonance imaging and early clinical evaluation. *Am J Sports Med* 2009;37:674-682.
10. Grasso A, Milano G, Salvatore M, Falcone G, Deriu L, Fabbriciani C. Single-row versus double-row arthroscopic rotator cuff repair: A prospective randomized clinical study. *Arthroscopy* 2009;25:4-12.
11. Park MC, Tibone JE, ElAttrache NS, Ahmad CS, Jun B, Lee TQ. Part II: Biomechanical assessment for a footprint-restoring transosseous-equivalent rotator cuff repair technique compared with a double-row repair technique. *J Shoulder Elbow Surg* 2007;16:469-476.
12. Kim KC, Shin HD, Lee WY, Han SC. Repair integrity and functional outcome after arthroscopic rotator cuff repair: Double-row versus suture-bridge technique. *Am J Sports Med* 2012;40:294-299.

13. Yoon J-S, Kim S-J, Choi Y-R, Kim S-H, Chun Y-M. Arthroscopic repair of the isolated subscapularis full-thickness tear: Single- versus double-row suture-bridge technique. *Am J Sports Med* 2019;47:1427-1433.
14. Ren Y, Zhang H, Duan Y, Sun Y, Yang T, Tian M. Comparison of arthroscopic suture-bridge technique and double-row technique for treating rotator cuff tears: A PRISMA meta-analysis. *Medicine* 2019;98:e15640.
15. Ryu KJ, Kim BH, Lee Y, Lee YS, Kim JH. Modified suture-bridge technique to prevent a marginal dog-ear deformity improves structural integrity after rotator cuff repair. *Am J Sports Med* 2015;43:597-605.