Technical Note

Arthroscopic Double-Pulley Suture-Bridge Repair of Supraspinatus Tendon Tear

Peiguan Huang, M.Med., and Xiaojun Tang, M.D.

Abstract: At present, the suture bridge is a widely used surgical pattern in the treatment of supraspinatus tendon tear, but the shortcomings of a suture bridge, including expensive lateral-row anchor and increased type 2 retear rate, is obvious. The double-pulley suture-bridge described in this Technical Note uses a double-loaded suture anchor (medial-row anchor) as lateral-row anchor instead of traditional lateral-row anchor, combined with double-pulley technology forming suture-bridge in treatment of supraspinatus tendon tears. The surgical technique is described in pearls, pitfalls, advantages, and disadvantages.

There are several known repair patterns in the treatment of supraspinatus tendon tears, including single-row, double-row, and suture bridge. The suture-bridge technique is universally accepted by surgeons due to contact pressure over the reattached cuff, further footprint percentage, enhanced repair strength, and greater failure load.[1-3] Numerous good clinical outcomes following suture-bridge repair also have been documented.[4,5]

Nonetheless, the suture-bridge technique possesses certain limitations, including expensive lateral-row anchor and increased type 2 retear rate following overtensioning and knotted suture on the medial-row. Arrigoni et al.[6] initially recorded a double-pulley technique that applied the eyelets of 2 anchors as pulleys forming suture-bridge. Predictably, the double-pulley technique can achieve more possibilities for suture-bridge pattern in arthroscopic surgery.

From the Second Affiliated Hospital, Department of Joint Surgery, Hengyang Medical School, University of South China, Hengyang, Hunan, China.

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 July 1, 2023; accepted August 26, 2023.

Address correspondence to Peiguan Huang, M.Med., The Second Affiliated Hospital, Department of Joint Surgery, Hengyang Medical School, University of South China, Hengyang, Hunan, 421000, China. E-mail: 714489037@qq.com

2212-6287/23930
https://doi.org/10.1016/j.eats.2023.08.015

Therefore, we describe the arthroscopic technique of double-pulley suture-bridge (DPSB) using a double-loaded suture anchor (medial-row anchor) as a lateral-row anchor instead of a traditional lateral-row anchor, combined with double-pulley technology forming a suture-bridge. In the treatment of supraspinatus tendon tears, the DPSB technique can not only achieve a suture-bridge but also lower type 2 retear rates and reduce surgical cost.

Surgical Technique (With Video Illustrations)

Preparation

All patients are operated on under general anesthesia, in the lateral decubitus position; the joint space is gently opened by upper-limb traction with 4 kg of weight; a 30° scope is applied. The surgical technique is described in Table 1 (pearls, pitfalls) and Table 2 (advantages, disadvantages). This research has been approved by ethical department in our hospital, and all patients provided informed consent.

Diagnosis and Evaluation

The posterior portal is executed for the joint examination and the ruptured tendon is estimated. Either tenotomy or tenodesis is accomplished for biceps tendon tears or SLAP lesions. Bursectomy is routinely performed. Acromioplasty is performed in curve or hook-type acromion. The cuff margin is debrided back to satisfying-quality tissue. The evaluation of tear width, tear shape, and tendon movability is performed (Video 1). A crescent-shaped supraspinatus tendon tear

Table 1. Surgical Pearls and Pitfalls

Anchor implantation considerations
(1) The lateral-row anchor is implanted in the aspect of greater tuberosity where the ruptured tendon can be anatomically reduced, rather than the lateral border of greater tuberosity.
(2) Suture strand may be locked due to the too-deep anchor implantation.
Suture procedure considerations
(1) The knotted suture strands from medial- and lateral-row anchors must be different colors.
(2) The knots linking suture strands of medial- and lateral-row anchors cannot slide.
(3) Once the suture is suddenly locked during sliding, the knot can be created with a knot pusher in the subacromial space.
(4) Before the second knot is tied in the subacromial space, it is required to make certain the desired quantity tension of the first blue—white suture-bridge to remove any slack of tendon.

with tear width less than 2 cm is the optimal surgical indication for DPSB repair.

Suture Anchor Insertion

A burr is used to decorticate for a bleeding footprint. A double-loaded 5.0-mm suture anchor (TWINFIX; Smith & Nephew, Andover, MA, USA) with no. 2 nonabsorbable polyester strands (blue and white), as medial-row anchor, is implanted in the articular border of greater tuberosity. A identical double-loaded 5.0-mm suture anchor (TWINFIX) with no. 2 nonabsorbable polyester strands (blue and white), as lateral-row anchor, is implanted in the aspect of greater tuberosity where the ruptured tendon can be anatomically reduced (Video 2 and Fig 1). All 4 strands from medial-row anchor are passed through medial cuff alternating between blue and white, with 10-mm line distance and 3-mm lateral to musculotendinous junction (Video 3 and Fig 2).

Suture-Relay Procedure

One blue suture strand from medial-row anchor, which had been passed through the cuff, and one white strand from lateral-row anchor, are retrieved through the lateral portal. Extracorporeally, the 2 strands are firmly tied with a static knot over an instrument (Video 4); the knot must be confirmed not to slide. Due to the knot, the irrelevant blue strand from medial-row anchor and white strand from lateral-row anchor are linked into a continuous and intact blue—white suture.

According to the theory of double-pulley technology, the eyelets of medial- and lateral-row anchors are used as 2 pulleys to slide the suture. Then, the blue—white suture along with knot is stepwise delivered into the subacromial space by pulling on the opposite strands of the 2 sutures that exit through percutaneous portals and seated onto supraspinatus tendon (Video 5); the suture strands are cut above the knot. This artificial blue—white suture is actually regarded as the first set of "blue—white suture-bridge" between medial- and lateral-row anchors. The opposite strands of blue and white suture strands need to be pulled with desired quantity tension to ensure supraspinatus tendon can be powerfully compressed against the footprint.

The opposite blue and white suture strands are retrieved through the lateral portal, a static knot is firmly tied with the Sixth Finger Knot Pusher (Smith & Nephew) in the subacromial space (Video 6); the suture strands are also cut above the knot (Video 7). Through the aforementioned operation, the second blue—white suture-bridge, consisting of the opposite blue strand from medial-row and white strand from lateral-row, is created and also powerfully compress supraspinatus tendon against the footprint. Special attention is required to make certain the desired quantity tension of the first set of blue—white suture-bridge to remove any slack of tendon in the whole procedure. Since then, the first group of DPSB repair with 2 sets of blue—white suture-bridges had been obtained.

The white suture strand from medial-row anchor and blue suture strand from lateral-row anchor will be regarded as the second group of DPSB repair, and the procedure will be the same as the first group.

Reattachment Confirmation

With the completion of DPSB repair, 4 of sets blue—white suture-bridges sit on the supraspinatus tendon between medial- and lateral-row anchors and powerfully compress the tendon against the footprint (Video 8 and Figs 3 and 4). The scope is placed in the joint and the reattached tendon is examined eventually.

Table 2. Advantages and Disadvantages

Advantages
(1) Double-loaded suture anchor is used as a lateral-row anchor.
(2) The surgical effect of a suture-bridge is obtained.
(3) Lower surgical cost.
(4) Suitable tendon tension on the medial-row.
(5) Knotless suture-bridge.
Disadvantages
(1) Limited coverage area on the footprint.
(2) Overmuch knots in the subacromial space.
(3) Risk of suture anchor being pulled out.
(4) Ultimate pressurization effect cannot be achieved.
(5) Low error-tolerant surgery.

Discussion

Cho et al.[7] classified rotator cuff failure pattern into 2 categories: type 1 retear at the tendon—bone interface of the footprint and type 2 retear at the musculotendinous junction with healed footprint. The

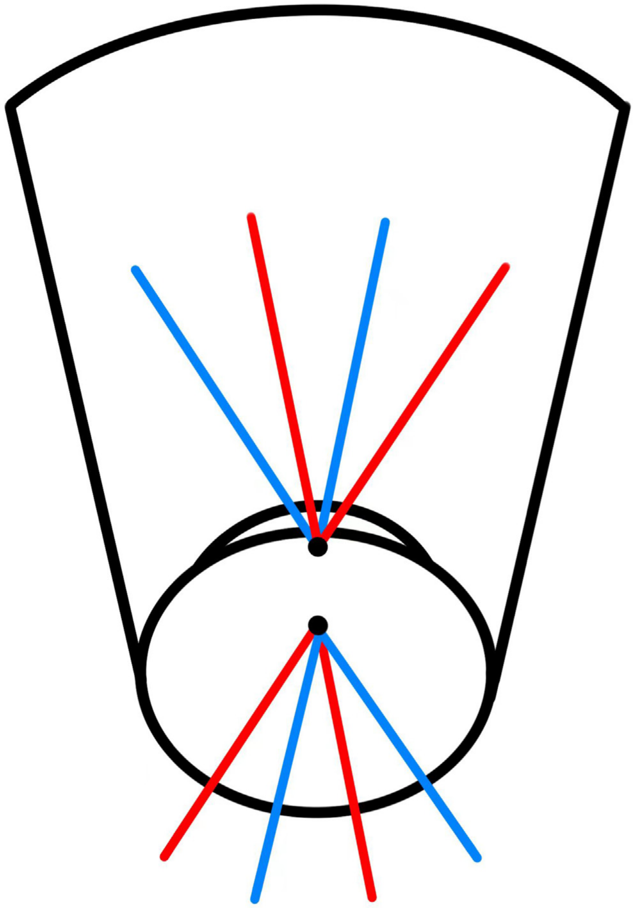

Fig 1. Two identical double-loaded suture anchors with 4 strands (blue and white), as medial- and lateral-row anchor, are implanted in the greater tuberosity.

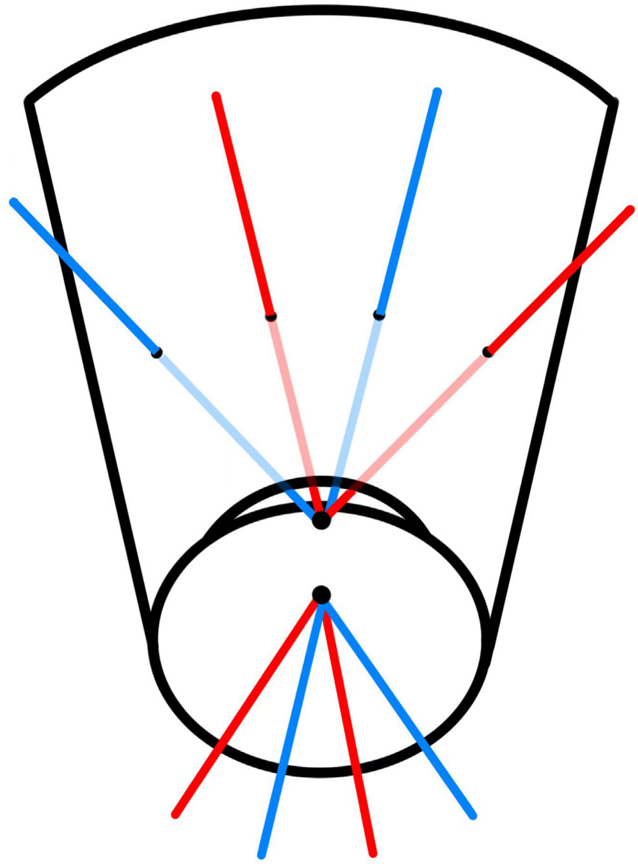

Fig 2. All 4 strands from medial-row anchor are passed through medial cuff alternating between blue and white, with 10-mm line distance and 3 mm lateral to musculotendinous junction.

overtensioning of medial-row has been considered as an important factor of type 2 retear when accepting suture-bridge repair.[8] Sano et al.[9] believed that averting overtensioning of medial-row could lower type 2 retear rate, which should be balanced with the requirement to recover the footprint.

Despite a high level of scientific evidence advocating the application of a knotted suture-bridge, numerous reports have revealed that the knotted suture-bridge is associated with increased type 2 retear rate.[10,11] Restriction of vascular inflow to the proximal cuff, strangulation of tendon tissue, and overtightening of medial knots, which following knotted suture-bridge repair, can damage the musculotendinous junction and lead to type 2 retear.[12,13] Great attention has been given to the knotless suture-bridge because of less interruption of tendon vascularity, lower stress concentration, and reliable fixation strength.[14,15] Various studies in the literature have documented no significant difference in clinical outcomes following knotless and knotted suture-bridge repair, but type 2 retear rate was lower with knotless repair.[13,16]

With the global economic recession, the burden of medical expenses has become a social problem.[17] Compared with other cuff repair patterns, the suture-bridge procedure has a greater surgical cost.[18] Terhune et al.[19] expressed that the surgical anchor was a variable, surgeon-directed cost. Due to the insufficient cost, surgeons will in fact use fewer lateral-row anchors in the suture-bridge procedure, even change the repair pattern, resulting in unsatisfactory clinical outcomes. If there is a more economical surgical mode of suture-bridge, patients will reap more benefits.

Therefore, we describe arthroscopic technique of DPSB repair, using a double-loaded suture anchor (medial-row anchor) as lateral-row anchor, combined with double-pulley technology to realize suture-bridge repair. This technology can surmount the shortcomings of the traditional suture-bridge; the viewpoints are as follows: First, the DPSB repair puts forward a new idea of suture-bridge technique, resulting in the current suture-bridge is no longer the only choice for surgeons. Second, the DPSB repair can form the irrelevant suture strands from medial- and lateral-row anchors into suture-bridge pattern using a double-pulley technology,

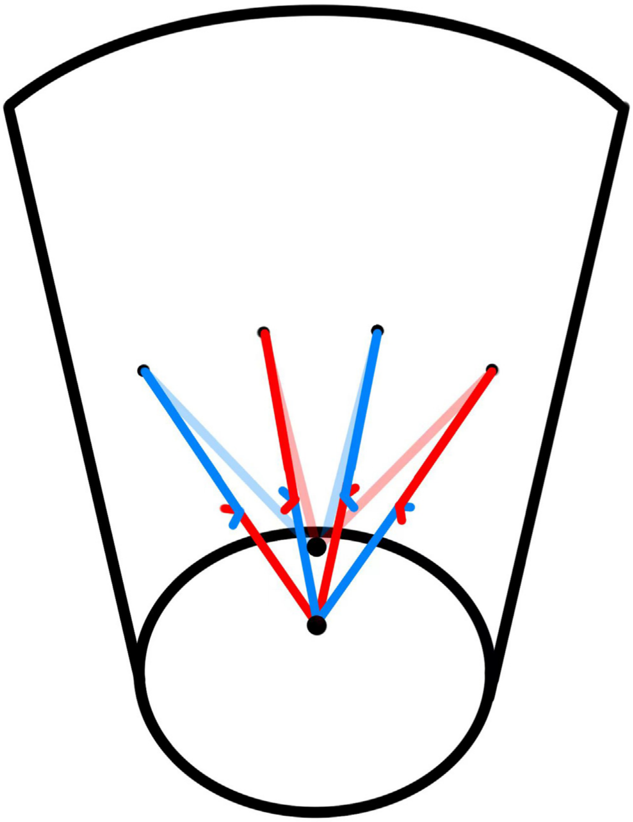

Fig 3. The schematic diagram of the double-pulley suture-bridge repair.

which can not only increase footprint percentage but also compress the supraspinatus tendon against the footprint. Third, the DPSB repair applies inexpensive double-loaded suture anchor as a lateral-row anchor, which will greatly lower surgical cost, especially when more than 2 lateral-row anchors are required; giving up the suture-bridge repair due to insufficient cost will no longer exist. Fourth, the balanced and controllable pressurization process of DPSB repair, which will reduce tendon tension of medial-row and type 2 retear rate, is performed by manual pulling the suture and knot pusher. Fifth, knotless suture-bridge of DPSB repair will be obtained due to the sliding suture on the anchor eyelets, further reduces type 2 retear rate.

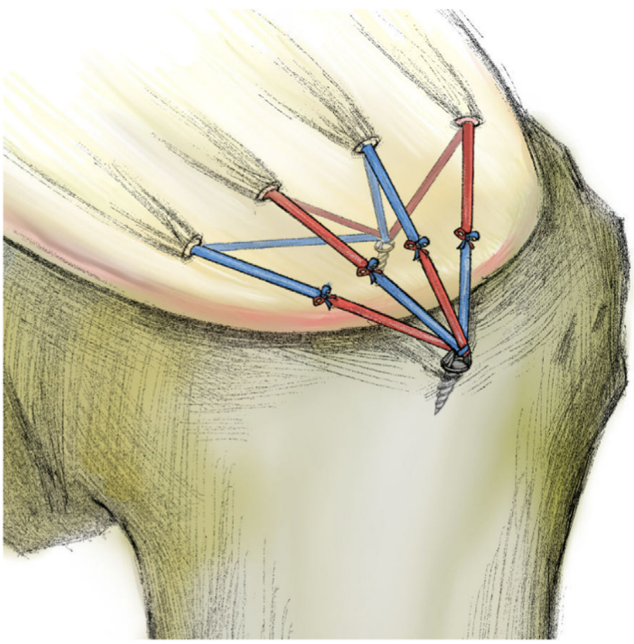

Fig 4. Another schematic diagram of the double-pulley suture-bridge repair.

Nevertheless, the DPSB repair still has some shortcomings: First, only one each of medial- and lateral-row anchors is used in the DPSB repair, forming a limited coverage area on the footprint, and cannot be applied to the tear width more than 2 cm. Second, in addition to the risk of knotting off, the knot on blue-white suture-bridge may also cause joint adhesions and subacromial impingement.[20] Third, the suture anchor is at risk of being pulled out from the footprint due to the outward traction strength in the pressurization process, especially in patients with osteoporosis. Fourth, the ultimate pressurization effect of hammering lateral-row anchor cannot be acquired. Fifth, the fault-tolerant ability of DPSB repair is very low, once the suture is locked and cannot slide, the operation will fail.

References

1. Kunze KN, Rossi LA, Beletsky A, Chahla J. Does the use of knotted versus knotless transosseous equivalent rotator cuff repair technique influence the incidence of retears? A systematic review. *Arthroscopy* 2020;36:1738-1746.
2. Shi BY, Diaz M, Binkley M, McFarland EG, Srikumaran U. Biomechanical strength of rotator cuff repairs: A systematic review and meta-regression analysis of cadaveric studies. *Am J Sports Med* 2019;47:1984-1993.
3. Shin SJ, Kook SH, Rao N, Seo MJ. Clinical outcomes of modified Mason-Allen single-row repair for bursal-sided partial-thickness rotator cuff tears: Comparison with the double-row suture-bridge technique. *Am J Sports Med* 2015;43:1976-1982.
4. Imam M, Sallam A, Ernstbrunner L, et al. Three-year functional outcome of transosseous-equivalent double-row vs. single-row repair of small and large rotator cuff tears: a double-blinded randomized controlled trial. *J Shoulder Elbow Surg* 2020;29:2015-2026.
5. Dukan R, Ledinot P, Donadio J, Boyer P. Arthroscopic rotator cuff repair with a knotless suture bridge technique: Functional and radiological outcomes after a minimum follow-up of 5 years. *Arthroscopy* 2019;35:2003-2011.
6. Arrigoni P, Brady PC, Burkhart SS. The double-pulley technique for double-row rotator cuff repair. *Arthroscopy* 2007;23:675.e1-675.e4.
7. Cho NS, Lee BG, Rhee YG. Arthroscopic rotator cuff repair using a suture bridge technique: Is the repair integrity actually maintained? *Am J Sports Med* 2011;39:2108-2116.
8. Choi S, Kim MK, Kim GM, Roh YH, Hwang IK, Kang H. Factors associated with clinical and structural outcomes after arthroscopic rotator cuff repair with a suture bridge

technique in medium, large, and massive tears. *J Shoulder Elbow Surg* 2014;23:1675-1681.
9. Sano H, Tokunaga M, Noguchi M, et al. Tight medial knot tying may increase retearing risk after transosseous equivalent repair of rotator cuff tendon. *Biomed Mater Eng* 2017;28:267-277.
10. Yamakado K, Katsuo S, Mizuno K, Arakawa H, Hayashi S. Medial-row failure after arthroscopic double-row rotator cuff repair. *Arthroscopy* 2010;26:430-435.
11. Takeuchi Y, Sugaya H, Takahashi N, et al. Repair integrity and retear pattern after arthroscopic medial knot-tying after suture-bridge lateral row rotator cuff repair. *Am J Sports Med* 2020;48:2510-2517.
12. Park MC, Peterson AB, McGarry MH, Park CJ, Lee TQ. Knotless transosseous-equivalent rotator cuff repair improves biomechanical self-reinforcement without diminishing footprint contact compared with medial knotted repair. *Arthroscopy* 2017;33:1473-1481.
13. Şahin K, Şentürk F, Ersin M, Arzu U, Chodza M, Erşen A. Repair integrity and functional outcomes between knot-tying and knotless suture-bridge arthroscopic rotator cuff repair: A prospective randomized clinical trial. *Orthop J Sports Med* 2021;9:23259671211002482.
14. Smith GCS, Bouwmeester TM, Lam PH. Knotless double-row SutureBridge rotator cuff repairs have improved self-reinforcement compared with double-row SutureBridge repairs with tied medial knots: A biomechanical study using an ovine model. *J Shoulder Elbow Surg* 2017;26:2206-2212.
15. Dey Hazra RO, Ernat JJ, Rakowski DR, Boykin RE, Millett PJ. The evolution of arthroscopic rotator cuff repair. *Orthop J Sports Med* 2021;9(12):23259671211050899.
16. Boyer P, Bouthors C, Delcourt T, et al. Arthroscopic double-row cuff repair with suture-bridging: A structural and functional comparison of two techniques. *Knee Surg Sports Traumatol Arthrosc* 2015;23:478-486.
17. Takura T, Miki K. The future of medical reimbursement for orthopedic surgery in Japan from the viewpoint of the health economy. *J Orthop Sci* 2016;21:273-281.
18. Abdelshahed M, Mahure SA, Kaplan DJ, et al. Arthroscopic rotator cuff repair: Double-row transosseous equivalent suture bridge technique. *Arthrosc Tech* 2016;5:e1297-e1304.
19. Terhune EB, Cannamela PC, Johnson JS, et al. Surgeon-directed cost variation in isolated rotator cuff repair. *Orthop J Sports Med* 2016;4:2325967116677709.
20. Kim SH, Kim J, Choi YE, Lee HR. Healing disturbance with suture bridge configuration repair in rabbit rotator cuff tear. *J Shoulder Elbow Surg* 2016;25:478-486.