Margin Convergence in Rotator Cuff Repair: The Shoelace Technique

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Abstract: The concept of margin convergence for side-to-side strain reduction in massive U-type rotator cuff tears has been used to protect the free margin repair to bone. Data in the literature show favorable outcomes for this method of repair. However, one of the challenges when performing side-to-side repair has been the dog-ear deformity that forms at both the convergence split and marginal ends. We present a method of single-suture convergence using a “shoelace” weaving technique, which seems to decrease the incidence of dog-ear deformity, decreases margin strain, and can be incorporated into current transosseous-equivalent rotator cuff repair configurations. The technique is simple and reproducible for large or massive tear patterns.

Margin convergence for U-shaped rotator cuff tears was first described by Burkhart et al.¹ in a 1996 arthroscopic techniques article where he eloquently explained strain reduction. Partial side-to-side repair of an anterior-posterior split within rotator cuff tendons reduced strain by increasing the cross-sectional area and decreasing the length of the tear. This technique was found to be protective against suture repair and free margin repair to bone. Decrease in strain was also thought to decrease pain by the method of lessened mechanoreceptor stimulation.¹ Since its description, multiple variations of margin convergence have been used in large and massive rotator cuff repair procedures. The over-under lacing technique for modified margin convergence has been described by Metais et al.,² who used 2 individual sutures interwoven from the medial to the lateral margin of the tear. After convergence integrity is assessed and accepted, the medial suture tails are tied and the lateral tails are positioned within a knotless suture anchor implanted into the lateral footprint of the rotator cuff. Next, as in the modified suture bridge technique described by Ryu et al.,³ a final suture is passed in a horizontal mattress configuration at the lateral free end of the cuff margin to complete the repair.

The above technique is reproducible but uses 3 sets of permanent suture, 2 for side-to-side repair and 1 for lateral free edge fixation. This described “shoelace” weave technique is simple, less time consuming, and accomplishes all aspects of margin convergence with the use of a single permanent suture.

Surgical Technique

The technique is shown in Video 1.

Patient Preparation and Portal Placement (1-5)

1. Preoperative preparation begins with general anesthesia and interscalene block.
2. The patient is positioned in the lateral decubitus position with a bean-bag to suction for support. Padding is placed to protect the peroneal nerve of the down leg and an axillary roll for the nonoperative brachial plexus.
3. Skeletal traction (female 10 lb, male 15 lb) is applied to the operative limb at 45° abduction and 15° forward flexion.
4. A spinal needle is introduced into the joint and 40 to 60 mL of normal saline is introduced to distend the joint capsule.
5. The shoulder joint is accessed throughout the procedure using posterior, anterior, lateral, and accessory lateral portals.

**Diagnostic Arthroscopy, Rotator Cuff Assessment, and Preparation (6-10)**

6. Diagnostic arthroscopy assesses the labrum, chondral damage, and rotator cuff tear. Procedures to treat concomitant pathologies are revealed and determined by the findings in the diagnostic arthroscopy.
7. If a diagnostic arthroscopy reveals a large or massive rotator cuff tear, the arthroscope is positioned into the subacromial space via the posterior portal, a lateral portal is created, and bursectomy is completed for improved visualization.
8. Acromioplasty and greater tuberosity footprint decortication is completed in preparation for rotator cuff repair.
9. The large or massive rotator cuff tear is assessed and nonviable tissue is debrided (Fig 1).
10. Adequate mobility of the rotator cuff lateral margin is confirmed.

**The Shoelace Technique for Margin Convergence (11-16)**

11. A single permanent No. 2 suture is passed using a scorpion suture passer (Arthrex) in a horizontal mattress fashion starting at the medial edge of cuff tear (Fig 2).
12. Working medial to lateral, each suture limb is passed crisscross following the shoelace principle toward the greater tuberosity footprint.
13. Care is taken to avoid locking of suture limbs.
14. Step 12 is performed as many times as necessary until the anterior and posterior margin of the rotator cuff tear is passed with the suture.
15. Traction is then applied to both suture limbs evenly to assess side-to-side repair and margin convergence (Fig 3).
16. If satisfactory, the suture limbs are set aside to be tied later in case.

**Rotator Cuff Repair (17-22)**

17. Two (or 3) medial row suture anchors are placed just off the articular margin in preparation for double-row rotator cuff repair with suture bridge configuration.
18. Medial anchor suture limbs are passed with a Scorpion (Arthrex) suture passer in a horizontal mattress fashion from the anterior to posterior direction. We prefer to alternate each color of the double- or triple-loaded suture anchor limbs, so that each medial row knot provides a rip-stop configuration (Fig 4).
19. Care is taken to avoid penetration or laceration of the shoelace convergence suture.
20. After passage of all the medial row sutures, traction is applied to the shoelace stitch and the limbs are tied using an arthroscopic knot pusher, completing
the side-to-side repair of the rotator cuff and margin convergence (Fig 5).

21. Medial row suture anchors are tied.

22. A single limb of shoelace stitch and each medial row knot is loaded into 2 separate knotless corkscrew anchors and implanted into the greater tuberosity lateral row, completing the double-row rotator cuff repair with margin convergence (Fig 6).

Discussion

Modern arthroscopic rotator cuff repair has evolved with the development of multiple techniques to augment biological fixation, specifically in large or massive-type tears. Treatment strategies include margin convergence and interval slides combined with transosseous-equivalent repair techniques to name a few. Double-row repair techniques use medially and laterally positioned suture anchors to establish bridging compression atop the torn tendon thereby enhancing contact with the prepared footprint.

Bridge constructs have been shown to exhibit enhanced contact characteristics and biomechanical properties compared with other commonly used techniques. However, bridging also requires adequate approximation and mobilization of the rotator cuff lateral free edge and secure medial anchor fixation. In cases of large or massive U-, L-, and reverse L-type tears, side-to-side repair has been biomechanically shown to reduce strain by increasing the cross-sectional area and decreasing the length of the tear.

![Fig 3.](image1.png)
(A) Arthroscopic view from the posterior portal showing completion of side-to-side repair using the shoelace technique with a single permanent No. 2 suture passed in an alternating crisscross fashion from the medial to the lateral cuff margin (cadaver in lateral decubitus position, right shoulder). (B) Arthroscopic view from the lateral portal showing reduced side-to-side tear with no dog-ear deformity. (Ant, anterior rotator cuff margin; GT, greater tuberosity; Med, medial apex; Post, posterior rotator cuff margin; S, shoelace stitch.)

![Fig 4.](image2.png)
Arthroscopic view from the posterior portal showing passage of all medial row sutures in a horizontal mattress rip-stop configuration (cadaver in lateral decubitus position, right shoulder). (Ant, anterior rotator cuff margin; Post, posterior rotator cuff margin; S, shoelace stitch.)

![Fig 5.](image3.png)
Arthroscopic view from the lateral portal showing passage of all medial row sutures and tension applied to the shoelace suture limbs showing side-to-side tear reduction with no dog-ear deformity (cadaver in lateral decubitus position, right shoulder). (Ant, anterior rotator cuff margin; GT, greater tuberosity; Post, posterior rotator cuff margin; S, shoelace stitch.)
Margin convergence of anterior-posterior tendon split can be challenging if tissue quality is of concern. After assessment and a decision to proceed, options for repair include interrupted side-to-side sutures or the over-under lacing technique. Although interrupted sutures can lead to dog-ear deformities, the over-under technique requires 2 separate permanent sutures tied together medially and weaved in a lateral direction. If a dog-ear is present with this technique, a third suture must be incorporated into lateral margin repair. The shoelace technique requires a single suture that does not require knot tying at the medial apex of the anterior-posterior tendon split, which can lessen the chance of undersurface knot-abrasion of the acromion. Additionally, this technique is useful in preventing dog-ear formation as the shoelace suture limbs are tied to each other laterally along the free edge margin placing perpendicular tension to the rotator cuff repair sutures (Table 1).

**Table 1. Pearls and Pitfalls of the Shoelace Technique**

**Pearls**
- Careful evaluation of tendon tear and mobility toward greater tuberosity footprint
- Use single No. 2 permanent suture starting at the apex of the medial tear margin
- Care is taken to avoid locking of suture limbs during alternating passes
- Avoid penetration of shoelace suture during passage of medial row sutures
- After all sutures are passed, tie the shoelace stitch first to prevent dog-ear formation
- Lateral row sutures are placed into knotless anchor

**Pitfalls**
- Poor mobilization of retracted tendon tears
- Locking or amputation of shoelace suture
- Improper suture management

The shoelace technique for margin convergence requires less overall suture material and is technically simple to learn and reproduce. There are, however, some careful considerations that are important to discuss when using this technique. Tissue quality and mobilization is of utmost importance to achieve adequate side-to-side approximation and lateral margin tendon repair. Also, the surgeon must be careful not to lock a passing suture limb, which would prevent equal tension application along the shoelace mechanism. We recommend passing from an inferior to superior direction to obtain visual confirmation of nonlocking technique. Lastly, when passing the rotator cuff repair sutures, one must avoid inadvertent penetration or laceration of the previously placed shoelace suture. Failure of this construct could significantly increase strain of tendon repair and lead to early failure or irreparable (Table 2).

**Table 2. Advantages, Risks and Limitations of the Shoelace Technique**

| Advantages                  | Risks                                     | Limitations                             |
|-----------------------------|-------------------------------------------|-----------------------------------------|
| Single permanent suture     | Failure of single shoelace suture could   | Poor tissue quality at anterior-posterior split which cannot accept single suture tension |
| technique for margin        | affect the overall cuff repair integrity  |                                        |
| convergence                 | Improper starting point of shoelace stitch |                                        |
|                             | can prevent a balanced side-to-side repair|                                        |
|                             |                                            |                                        |
| Shoelace suture can be used |                                            |                                        |
| as traction stitch          |                                            |                                        |
| during medial row suture    |                                            |                                        |
| passage                     |                                            |                                        |

The shoelace technique for margin convergence is simple to learn and reproduce. It performs side-to-side repair of anterior-posterior tendon tears without abrasive knot stacks or dog-ear deformities and can be incorporated into modern single- or double-row suture anchor repair methods. This technique will likely lead to improved clinical results in patients undergoing repair of large or massive rotator cuff tears.

**References**

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