

## Technical Note

# Modified Margin Convergence: Over-Under Lacing Suture Technique

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**Abstract:** The principle of margin convergence can be applied to rotator cuff repair to enhance the security of fixation by decreasing the mechanical strain at the margins of the tear. We describe a suture technique, over-under lacing, that reproduces the same margin convergence, with equal tissue tension across the entire surface area of the cuff. A consecutive series of patients affected by massive U-shaped rotator cuff tears were treated by this repair technique. Preoperative diagnosis, tear assessment, and grading of fatty infiltration of the cuff muscles were based on arthro-computed tomography evaluation. The technique passes 2 sutures from the medial to lateral margin of the tear, with a knotless suture anchor for tendon-to-bone fixation. The proposed technique seems to reduce tensile strain on the repaired tendon, can reconstruct the rotator cuff cable, and can attain the balanced pull of the tendon in a medial-to-lateral fashion. The over-under lacing suture technique is both simple and reproducible. This technique may achieve the goals of margin convergence with satisfactory preliminary clinical results for patients with massive rotator cuff tears.

Massive rotator cuff tears have been variably defined as tears exceeding greater than 5 cm in diameter or tears involving the detachment of at least 2 entire tendons.<sup>1</sup> These tears pose a challenging problem for shoulder surgeons. Over the past several years, new technology and advanced techniques have focused on how to optimize the biomechanical fixation of arthroscopically repaired rotator cuff tears. Margin convergence was originally described by Burkhart et al.<sup>2</sup> as a method to bring the free edge of the torn tendon closer to the bone bed to reduce strain on the repair. It is used in U-shaped tears, L-shaped tears, and reverse L-shaped tears. Margin convergence anchorage to bone uses a suture anchor for footprint restoration in combination with side-to-side soft-tissue repair. It was described by Kim et al.<sup>3</sup> as a method to provide medial-row fixation as well as margin convergence in large and massive

U-shaped tears. The principle of margin convergence can be applied to rotator cuff repair as a means to enhance the security of fixation by decreasing the mechanical strain at the margins of the tear. In a U-shaped massive rotator cuff tear, a partial side-to-side repair creates margin convergence of the tear toward the greater tuberosity. This increases the cross-sectional area and decreases the length of the tear, thereby decreasing strain.<sup>2</sup>

The strain reduction should also contribute to pain reduction by virtue of decreased stimulation of mechanoreceptors in the rotator cuff. A less painful shoulder would naturally be a more functional shoulder. The cliché “no pain, no strain” can then be converted to a paradigm by reversal of its components to “no strain, no pain.”<sup>4</sup>

Although a partial side-to-side tendon repair has been a proven technique for margin convergence, it entails bulky overlapping of the rotator cuff, which could eventually lead to tissue necrosis. The aim of this study is to describe a suture technique, the over-under lacing suture technique, that reproduces the margin convergence, with equal tissue tension across the entire surface area of the cuff, in patients with massive U-shaped rotator cuff tears.

## Surgical Technique

A consecutive series of patients affected by massive U-shaped posterosuperior cuff tears were prospectively treated with this technique. The inclusion criteria were as follows:

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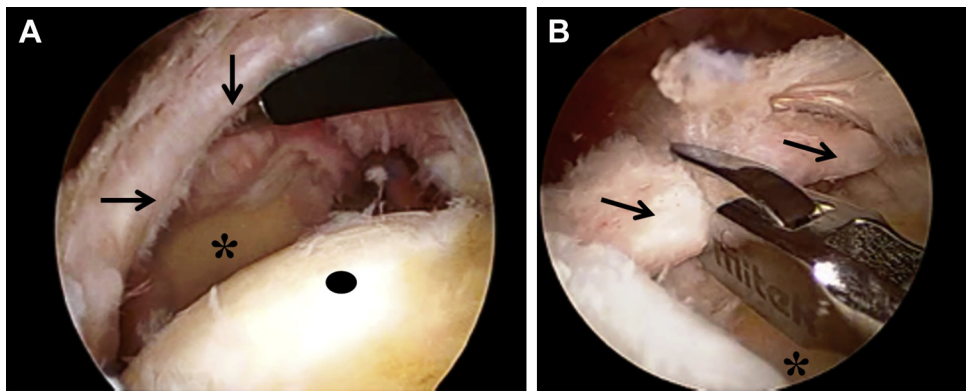
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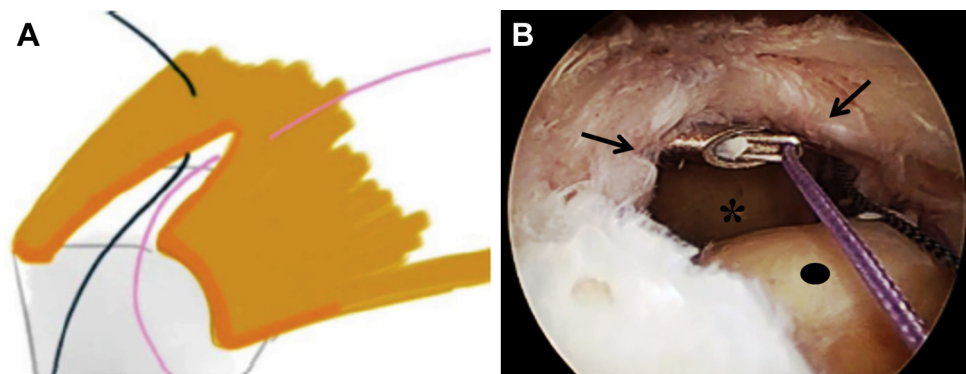
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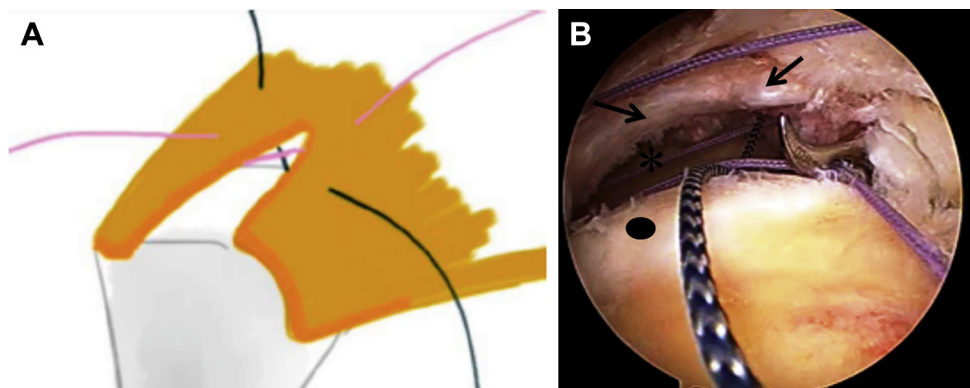
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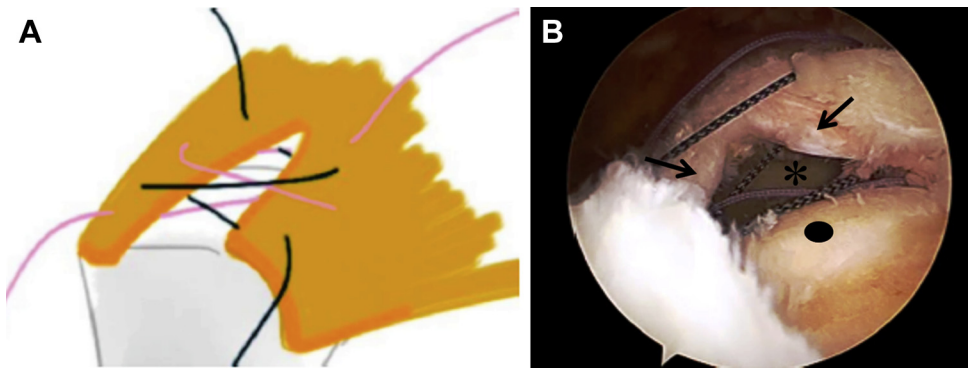
**Fig 1.** Evaluation of the margins (arrows) of the rotator cuff tear with the arthroscope in the lateral portal (patient in beach-chair position, right shoulder). The stump of a massive U-shaped posterosuperior cuff tear is over the glenoid (asterisks), and testing of tear margin mobility and debridement of the tendons are performed. The oval indicates the humeral head.



**Fig 2.** (A) Drawing and (B) arthroscopic view from the lateral portal showing the first step of the over-under lacing suture technique (patient in beach-chair position, right shoulder). Two Orthocord No. 2 (5 metric) sutures, preferably of different colors, are passed on each leaf of the tear at the medial portion using the Cleverhook (working first from the posterior portal and then from the anterior portal), with 1 suture from the posterior margin and 1 suture from the anterior margin of the tear. The arrows indicate the margins of the tear; asterisk, glenoid; and oval, humeral head.

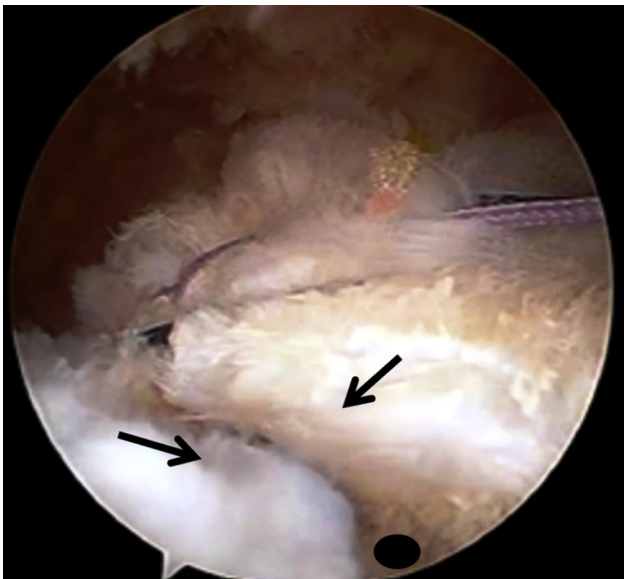


**Fig 3.** (A) Drawing and (B) arthroscopic view from lateral portal showing the second step of the over-under lacing suture technique (patient in beach-chair position, right shoulder). After step 1, the sutures are shuttled to the opposite side of the cuff (from anterior to posterior and vice versa) using the Cleverhook or a suture retriever following the principle of over-under lacing. (In this case, over-under lacing has been performed twice for each suture, with the Cleverhook ready to perform the third passing of the suture in the anterior margin of the tear.) The arrows indicate the margins of the tear; asterisk, glenoid; and oval, humeral head.



**Fig 4.** (A) Drawing and (B) arthroscopic view from lateral portal (patient in beach-chair position, right shoulder). Each Orthocord suture is passed 3 times on each margin of the tendon following the principle of the over-under lacing suture technique until the lateral portion of the tear is reached. The arrows indicate the margins of the tear; asterisk, glenoid; and oval, humeral head.

- Age between 45 and 65 years
- Preoperative diagnosis of posterosuperior cuff tear based on arthro-computed tomography scan, with a maximum of grade III Goutallier fatty degeneration<sup>5</sup>
- Intraoperative arthroscopic findings of a massive ( $\geq 5$  cm involving the supraspinatus and infraspinatus tendons) U-shaped posterosuperior cuff tear
- Patients who followed a conventional postoperative rehabilitation program, with (1) 3 weeks of immobilization in a neutral rotation sling with 20° of abduction; (2) passive exercises until recovery of full range of motion; (3) active range of motion allowed at 6 weeks postoperatively; and (4) recreational activities, including sports, allowed at 6 months postoperatively.

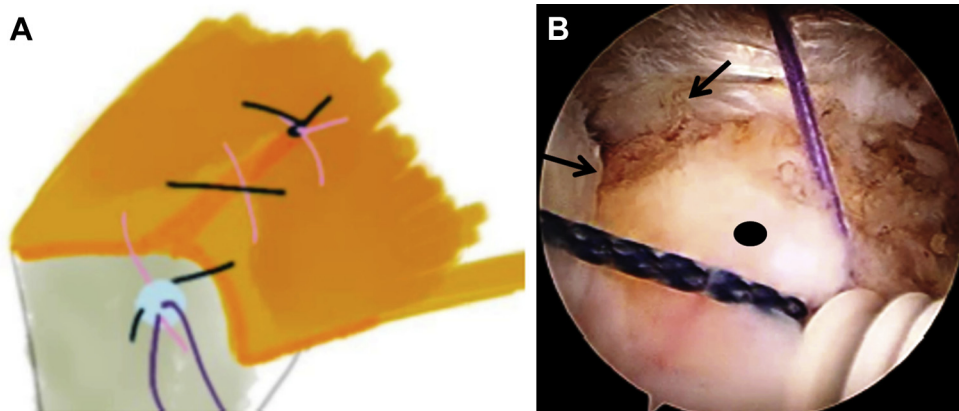


**Fig 5.** Arthroscopic view from lateral portal (patient in beach-chair position, right shoulder). After passing of the sutures on each leaf of the tendon, the suture limbs are retrieved at the lateral end of the tear and tightened to evaluate the integrity of the margin convergence. The arrows indicate the margins of the tear, and the oval indicates the humeral head.

The exclusion criteria were as follows: previous shoulder surgery, degenerative arthritis and inflammatory arthritis, cervical spine lesion, auto insurance or industrial accident compensation insurance claim, and diagnosis of neuropsychiatric problems.

Surgery was performed with the patient in the beach-chair position and under general anesthesia and an interscalene block. For antibiotic prophylaxis, 2 g of cefazolin was administered intravenously 30 minutes preoperatively and 12 hours postoperatively. The technique requires the standard shoulder arthroscopy instruments. A standard posterior viewing portal is created approximately 2 cm inferior and 2 cm medial to the posterolateral border of the acromion. The arthroscope is introduced into the glenohumeral joint, and a diagnostic arthroscopy is performed. A standard anterior portal is created just lateral to the tip of the coracoid, and a probe is introduced. A lateral portal is also created at the midglenoid level in the sagittal plane. With the arthroscope in the lateral portal, complete arthroscopic bursectomy and subacromial spur removal with preservation of the coracoacromial arch are performed. After the bursectomy, debridement of the nonviable edges of the rotator cuff is performed. Preparation of the footprint and greater tuberosity are carried out with a burr (5.5-mm Elite Acromionizer; Smith & Nephew, Andover, MA). With a shaver (Dyonics Shaver; Smith & Nephew), soft-tissue release follows, and removal of scar tissue is performed to allow adequate mobility to the prepared greater tuberosity. Evaluation of the margins of the rotator cuff tear is then performed, with testing of tear margin mobility and debridement of tendons (Fig 1).

Next, the over-under lacing suture technique is started. In step 1, we pass 2 Orthocord No. 2 (5 metric) sutures (DePuy Mitek Sports Medicine, Raynham, MA), preferably of different colors, on each leaf of the tear at the medial portion (1 suture from the anterior side and 1 suture from the posterior side of the medial margin of the tear) using a Cleverhook device (DePuy Mitek Sports Medicine) (Fig 2). In step 2, the sutures



**Fig 6.** (A) Drawing and (B) arthroscopic view from lateral portal (patient in beach-chair position, right shoulder). The lateral sutures are placed in a knotless suture anchor into the lateral footprint of the rotator cuff. The arrows indicate the margins of the tear, and the oval indicates the humeral head.

are shuttled to the opposite side of the cuff (from anterior to posterior and vice versa) using the Cleverhook or a suture retriever (Suture Passer; DePuy Mitek Sports Medicine) following the principle of over-under lacing (Fig 3). Steps 1 and 2 are performed as many times as the sagittal length of the tear requires, usually 3 times, until each anterior and posterior margin of the tear is completely passed by the sutures. Accordingly, the over-under lacing pattern is continued until the lateral portion of the tear is reached (Fig 4). The suture limbs are then retrieved at the medial and lateral ends of the tear. The lateral sutures are tightened to evaluate the integrity of the margin convergence (Fig 5); if satisfactory, the medial sutures are tied together using simple knots, and then the lateral sutures are placed in a knotless suture anchor (Healix Advance Knotless; DePuy Mitek Sports Medicine) into the lateral footprint of the rotator cuff (Fig 6). To conclude the cuff repair, we augment the lateral end of the tear with a mattress suture (Orthocord No. 2 [5 metric]) from the same suture anchor (Fig 7). The steps of the technique are illustrated in Video 1 and summarized in Table 1.

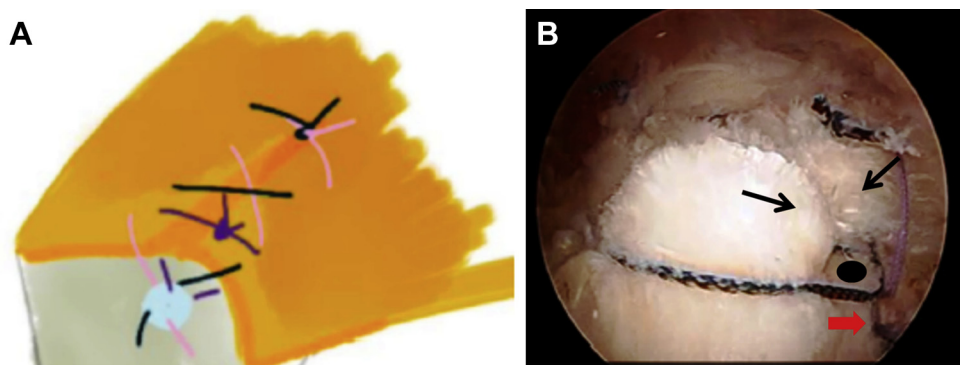
After surgery, the arm is immobilized in a neutral rotation sling with 20° of abduction for 3 weeks (IMB 800 Multisas; FGP, Dossobuono, Italy). Full active range

of motion is allowed at 6 weeks postoperatively, all activities of daily living are generally resumed by 12 weeks, and the patient is allowed to return to all activities at 6 months.

## Discussion

Large and massive rotator cuff tears pose a challenging problem for orthopaedic surgeons. Over the past several years, there have been emerging technology and more advanced techniques to optimize the biomechanical fixation of arthroscopically repaired rotator cuff tears, including margin convergence, massive cuff stitch, double-row suture anchor configuration, transosseous-equivalent suture bridge, and so on. Repairing a large U-shaped tear by securing tendon to bone with suture anchors alone results in high tension at the tendon-bone interface with high rates of failure. Margin convergence has been reported by Burkhart et al.<sup>2</sup> as a means of closing massive U-shaped rotator cuff tears while simultaneously decreasing the strain along the newly converged margin of the rotator cuff. If the free tendon edge is repaired to the osseous footprint after margin convergence, less tension is placed on the tendon-bone interface.<sup>6</sup> In addition, it has been shown recently that repairing the anterior rotator cuff with

**Fig 7.** Arthroscopic view from lateral portal (patient in beach-chair position, right shoulder). After the knotless suture anchor is inserted into the footprint of the rotator cuff, the cuff repair is augmented with a mattress suture from the same suture anchor. The black arrows indicate the margins of the tear; oval, humeral head; and red arrow, knotless suture anchor inserted into rotator cuff footprint.



**Table 1.** Key Points of Over-Under Lacing Suture Technique

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Debridement of tendon tear with removal of scar tissue
Evaluation of tendon tear quality and mobility
One suture on each anterior and posterior medial margin of tear
Suture passing following principle of over-under lacing
Evaluation of tension of suture and adequate coverage of footprint
Lateral sutures placed in knotless suture anchor; medial sutures then tied together
Lateral end of tear augmented with mattress suture

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margin convergence anchorage to bone may improve clinical outcomes of a massive tear repair.<sup>7</sup> Mazzocca et al.<sup>8</sup> have shown that margin convergence causes marked reduction in overall strain (up to 58%). However, after the size of the rotator cuff tear is reduced using margin convergence, a conventional side-to-side repair using a single-row technique with suture anchors may sometimes result in incomplete footprint reconstruction.<sup>3</sup> Anyway, we agree that, even for a large to massive tear that appears irreparable, attempting to repair it as much as possible to possibly convert it into a functional rotator cuff tear by re-creating a balanced forced couple can be helpful in reducing pain, as well as improving functional outcomes.<sup>9</sup> The technique described in this article may help the surgeon to repair an irreparable tear.

The concept of a so-called suspension bridge could be applied to margin convergence for repairing massive rotator cuff tears, reducing tensile strain on the repaired tendon, and re-creating the rotator cuff cable and balanced force couple.<sup>2</sup> The described technique achieves these goals while also attaining the balanced pull of the tendon in a medial-to-lateral fashion, without entailing bulky overlapping of the rotator cuff. Because the over-under lacing suture crosses the entire surface area of the tendon, it pulls the tendon closer to the footprint with a homogeneous reduction of the tension at the tear margin. Accordingly, we believe that the main advantage of this technique is the enhanced stability of the repair with respect to traditional margin convergence.

The proposed technique has some limitations and risks that need to be addressed. When the surgeon is passing the sutures in the medial margin, there is a risk of failure occurring at the muscle-tendon junction; thus the quality of the tissue has to be carefully evaluated because failure of even 1 suture passing in the over-under lacing pattern could alter the tension of the entire repair and, consequently, the coverage of the footprint. For this reason, we usually do not perform this repair in case of severe tendon degeneration and muscular fatty infiltration (maximum of grade III Goutallier fatty degeneration).<sup>5</sup> A crucial point is the evaluation of the tissues after scar removal and debridement of the tear margin (Table 2).

**Table 2.** Surgical Pearls for Over-Under Lacing Suture Technique

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Indications
Large to massive posterosuperior cuff tear with adequate mobility
Contraindications
Subscapularis tear
Severe tendon degeneration
Goutallier grade IV fatty degeneration
Advantages
The suture crosses the entire surface area of the tendon, pulling the tendon closer to the footprint with a homogeneous reduction of the tension at the tear margin.
This suture technique attains the balanced pull of the tendon in a medial-to-lateral fashion, without entailing bulky overlapping of the rotator cuff.
Disadvantages
Failure of 1 suture passing in the over-under lacing pattern could alter the tension of the entire repair and, consequently, the coverage of the footprint.

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In conclusion, the over-under lacing suture technique is both simple and reproducible. It achieves the goals of margin convergence with greater stability and lower formation of a bulky overlapping tendon margin, with preliminary satisfactory clinical results in patients with U-shaped massive rotator cuff tears.

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**Video 1.** Main steps of over-under lacing suture technique (patient in beach-chair position, right shoulder, arthroscope in lateral portal). Two Orthocord sutures are passed following the principle of the over-under lacing suture technique on the anterior and posterior leaf of the tendon from the medial to lateral margin of the tear, and the sutures are finally placed in a knotless suture anchor.