

3-in-1 Hybrid Suture Bridge Technique in Posterosuperior Rotator Cuff Tear

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Abstract: Our technique repaired the posterosuperior rotator cuff tear in the full-thickness type. The key successful of the arthroscopic full-thickness rotator cuff repair has several suture techniques. First, it will distribute a tensile force throughout the entire tendon. Second, it will improve tendon healing by getting it closer to the medial anatomical footprint. Third, the suture bridge compression technique has been used to compress all layers of the repaired tendon against the bone with the total contact area. Fourth, it reduces the risk of cut through the rotator cuff and the rate of rotator cuff retear with a tension free repair. We used three suture limbs in one hole to reduce rotator cuff damage and the rate of retear and also only tie three medial row knots. The reasons are to compress anatomically the medial footprint. The configuration suture pattern consists of suture bridges that distribute pressure-tension over a larger contact surface area on the tendon-bone interface, allowing for robust tendon-bone stabilization, better tendon-bone healing, and less retear after repair.

Introduction

Nowadays, the clinical advantages of knotted versus knotless techniques are still debatable, both in terms of clinical outcomes and complications. The ideal rotator cuff repair technique should provide both adequate biomechanical stability and a suitable biological condition in order to encourage subsequent tendon-to-bone healing. The suture bridge technique is used to secure the rotator cuff tissue to the anatomic footprint. Since the tendon tissue is not pierced at the lateral row, tissue strangulation by the knots is reduced, and tendon vascularity is preserved.¹ While the biomechanical superiority of double-row repairs has been revealed, as it provides higher repair strength, reduced gap formation, and wider footprint restoration.² Alternatively, no knot tying in the medial row will reduce excessive strain and tendon strangulation, improve medial row integrity, and

prevent retear rate (type II retear) (Fig 1).³ When using the double row with knot tying suture bridge technique, the most torn tendon is at the medial to a heal footprint, referred to as a type II tear.⁴ After finishing a knotless suture bridge repair, we determined that intra-articular reexamination has a higher insufficiency and distributes the compression medial footprint. Subsequently, the tendon to bone healing of the medial footprint has a poor healing result (Fig 2). Our technique consists of a hybrid of knotless and knotted suture bridge repair techniques, within each combination of advantages and disadvantages. The principles of the 3-in-1 hybrid suture bridge technique are a tension-free repair which leads to less damage to rotator cuff tissue, less strangulation, less blood supply disturbance, less operative time, and a completely compressed medial contact area footprint.

Patient Evaluation, Imaging, and Indications

Most patients underwent magnetic resonance imaging (MRI) in case of failed the conservative treatment with persistent severe shoulder pain. MRI of the rotator cuff pathology was shown, especially the full thickness of the supraspinatus tendon, which is the most common site tear of the rotator cuff tendon (Fig 3).

Surgical Technique

Patient Positions

The patient is positioned on a 70° beach chair after general anesthesia is provided. In the sterile technique, the shoulder is scrubbed and draped. The arm is put on

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Received February 24, 2022; accepted March 22, 2022.

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2212-6287/22293

<https://doi.org/10.1016/j.eats.2022.03.036>

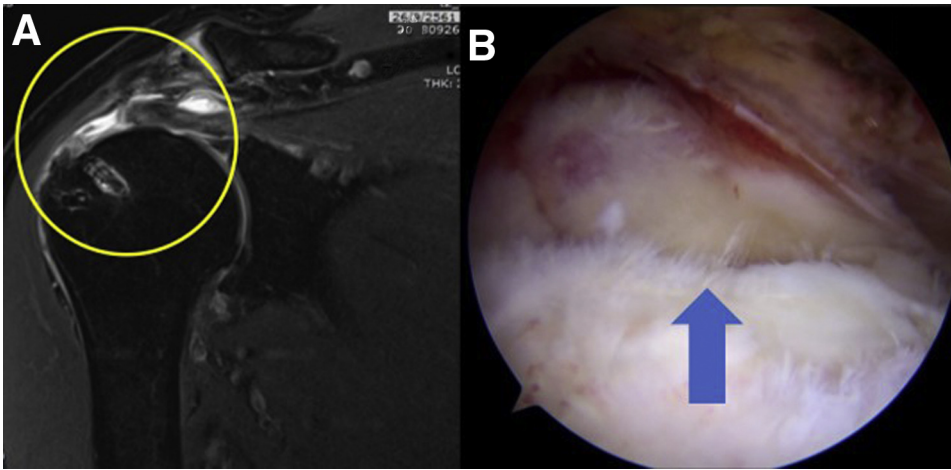


Fig 1. MRI T2 coronal imaging at right shoulder. (A) Type II retear at supraspinatus tendon (yellow circle). (B) Subacromial arthroscopic view from posterolateral view portal showed the full thickness at medial row (musculotendinous junction) supraspinatus tear (blue arrow).

Fig 2. (A) Arthroscopic subacromial view via posterolateral viewing portal at right shoulder after the knotless suture bridge repair was finished. (B) Arthroscopic intra-articular view via posterior viewing portal, medial footprint elevated, and loss of compression effect to the medial footprint (yellow arrow).

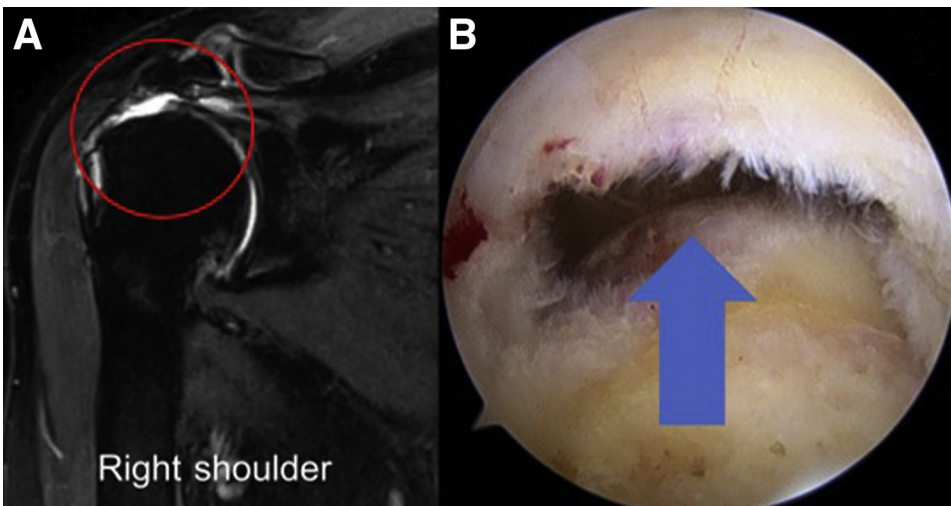
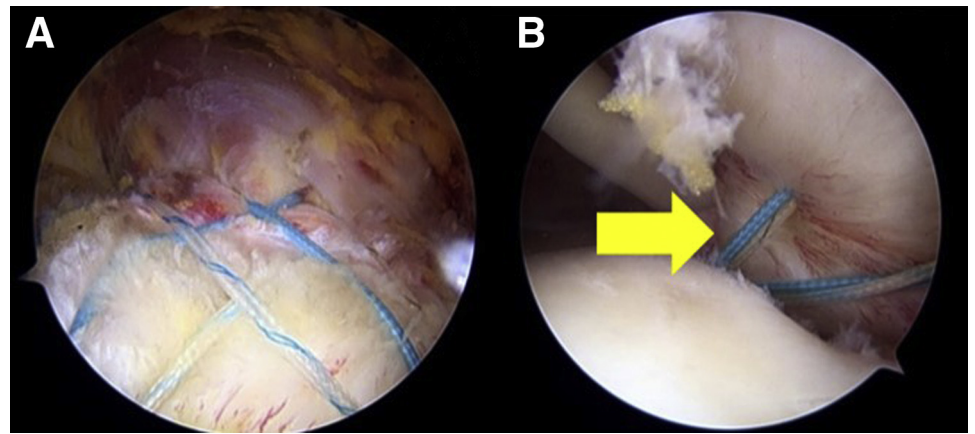


Fig 3. MRI T2 coronal imaging at right shoulder. (A) Before the rotator cuff repaired and full-thickness supraspinatus tendon tear (red circle). (B) Subacromial arthroscopic view from lateral viewing portal showed the full-thickness supraspinatus tear (blue arrow).



Fig 4. The patient is positioned on a 70° beach chair.

a Mayo table with the affected upper limb free. The assistant can assist the surgeon with all aspects of shoulder positioning (Fig 4).

Portal Placement

The planning of shoulder bony prominent landmarks is then drawn following to the clavicle, acromioclavicular joint, coracoid process, lateral and posterior border of the acromion. We use the main four portals to repair the rotator cuff tear. The first portal is the standard posterior viewing portal. The second portal is the lateral portal, which is approximately 2.5 cm from the lateral border of the acromion. The third portal is the posterolateral viewing portal, which is 1 cm from the posterolateral border of the acromion. The fourth portal is the anterosuperior portal, which is 1 cm anterior to the acromioclavicular joint (Fig 5).

Intra-articular Arthroscopic Examination

The glenohumeral joint is first inspected with a 30° arthroscope through the posterior viewing portal, and the subscapularis tendon, long head of the biceps tendon, and the glenoid labrum are inspected. If a large-size, full-thickness rotator cuff rupture is detected, especially the posterosuperior cuff tear, we suggest inspecting the subacromial arthroscopic view first, rather than the intraarticular arthroscopic view, to avoid further damage to the infraspinatus tendon.

Subacromial Decompression

After then, the arthroscope is placed into the subacromial space. The coracoacromial ligament is examined before the lateral portal is created. A complete bursectomy is performed with a 4.5-mm arthroscopic shaver, and the coracoacromial ligament is partially detached where the acromial spur is covered. The acromial spur and acromioclavicular joint are identified using frequency ablation (RF) ablation (The VAPR TRIPOLAR 90 Suction Electrode, DePuy Synthes). The distal clavicle serves as a reference point for completing acromioplasty and avoiding acromial bone over

resection (Fig 6). The arthroscope is then shifted to the lateral portal, where the cutting block technique is used to evaluate the acromioplasty's efficiency.

When attempting to repair a rotator cuff tear, there are a few things to keep in mind. It's critical to have good visualization and control of bleeding. Before attempting to repair the rotator cuff, complete bursectomy and adequate acromioplasty must be performed to provide an adequately decompressed subacromial space. The bursa tissue will block the visual field and can interfere with suture management.

Medial Row Placement

The full-thickness rotator cuff tear is carefully examined for any tear patterns and for the edge of the marginal tear. With bursal tissue attachment, we begin by gradual debridement of the edge of the rotator cuff tear. Using a motorized shaver blade, we decorticate the exposed footprint of the rotator cuff, and a microfracture is made to promote in cuff repair healing. The posterolateral viewing portal is created on the acromion's posterolateral side. At the lateral portal, an arthroscopic cannula is inserted. The full thickness rotator cuff tear would be ready for repair once the footprint preparation is completed. For anchor placement, the medial row footprint is identified. The anterosuperior portal is then created, approximately 1 cm anterior to the acromioclavicular joint, for simple passage and manipulation of the suture hook and put a

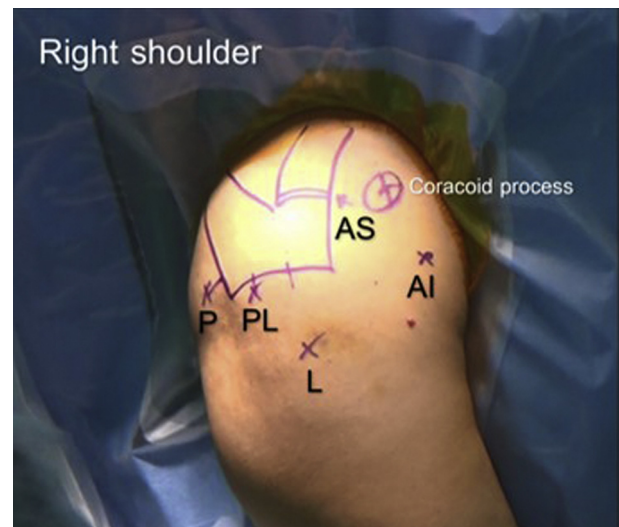


Fig 5. The right shoulder with a portal planning following the posterior (P) portal, the lateral (L) portal, posterolateral (PL) portal, the anterosuperior (AS) portal is located just adjacent to the acromioclavicular joint and the anteroinferior (AI) portal.

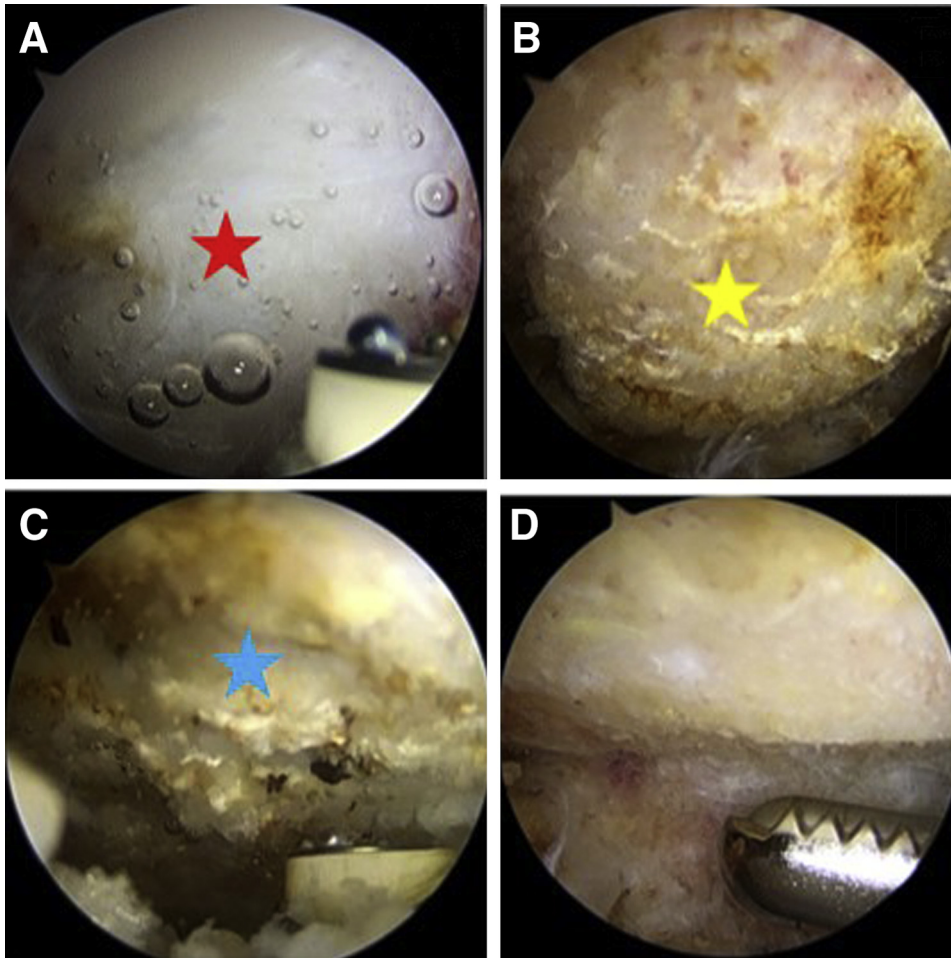


Fig 6. (A) Arthroscopic sub-acromial view of the right shoulder from the posterior viewing portal using a 30°. (B) A coracoacromial ligament (red star). (C) The acromial spur (yellow star). (D) The acromioclavicular joint is the reference line acromioplasty (blue star) after resecting the acromial spur.

medial row anchor placement. Two triple loaded anchors (Y-Knot PRO RC (triple loaded; CONMED) are inserted through the anterosuperior portal as far apart as possible at the near intra-articular humeral head cartilage (Fig 7).

Cuff Suture Procedure

For shuttling, a cuff passer is preloaded with a no. 1 PDS (Ethicon) suture. A suture hook is initially punctured 1.5 cm medial from the torn bursal margin from the posterior portal. After the antegrade suture technique has pierced the entire layer of the cuff, the point of the suture hook is guided to the torn edge, and the PDS suture is relayed. The lateral working portal is then carried out to the margin of the PDS suture. Three heavy strained nonabsorbable sutures are recovered to the lateral portal from the same medial anchor. The PDS shuttle is then relayed to the posterior portal after those strands are tied together in one suture, and two sutures are knotted together in different knots of the shuttle suture. Using a

cuff suture passer, make a second penetration hole about 1 cm from the first. Those steps are repeated in a similar order from posterior to anterior until four cuff penetrations are achieved (Fig 8). The retrograde suture technique is a simple and precise alternative that requires using a FIRSTPASS Suture Passer (Smith & Nephew) from the lateral working portal to bite the rotator cuff tendon tear. The Ethibond no.2 is elevated from beneath the tendon to above it. Three heavy strained nonabsorbable sutures from the same medial anchor are used to send the Ethibond no. 2 suture (beneath tendon part) to the lateral working portal, and the Ethibond no. 2 suture (above tendon part) is brought to the anterosuperior or posterior working portal. The Ethibond no. 2 shuttle is then pulled out to the anterosuperior or posterior portal after those strands are tied together in one suture, and two sutures are linked together in different knots of the shuttle suture. Those steps are repeated in a similar order from posterior to anterior until four cuff penetrations are achieved.



Fig 7. Arthroscopic view of the right shoulder viewed from the posterolateral portal using a 30° arthroscope showing a full-thickness supraspinatus tear and put the triple-loaded suture anchor (Y-Knot PRO RC; triple loaded; CONMED) (medial row) closed the humeral head cartilage.

Tied Cuff Suture Technique

The first knot is tied in the same suture strand posteriorly of the medial row, the second knot in the same suture strand anteriorly of the medial row, and the third knot is tied in a different suture strand between anteriorly and posteriorly of the medial row (Fig 9). The key of tying the knot is to allow space between each knot because if we tied and planned efficiently, we would have a proper distribution of compression force and a lower rate of dog ear formation (Fig 10).

Lateral Row Placement

Whereas all six suture limbs of each medial row have been relayed, the two lateral footprints for anchor placement have been identified. From the antero-lateral portal, the surgeon needs to determine the lateral row anchor location, which is immediately lateral to the bicipital groove and in front of the infraspinatus insertion. Sutureless lateral row anchors (MULTIFIX S. ULTRA, Smith & Nephew) are used. The anchor is used to pass the threads through. The anchor is placed via the cannula, while the threads are secured firmly in place, ensuring that the anchor slides gently over the threads. The lateral row footprint is cleaned by RF (The VAPR TRIPOLAR 90 Suction Electrode, DePuy Synthes) until it contacts the bone area. The anchor is hammered into the lateral hole until threads begin to enter it. The suture's limbs are then separately

tensioned before each anchor is advanced into the cortex one at a time and fully hammered. The anchor is locked, so that the threads do not loosen after final tightening, and the inserting handle is removed. A knot cutter is used to cut the threads. The remaining threads are extracted through the cannula, and the threads are secured in place with a knotless and knot lateral anchor. The position of the second lateral row, with the suture bridge, is created using the same process. We recommend that the lateral row anchor be positioned as far as possible from both the bicipital groove and the front of the infraspinatus tendon to spread the contact area compression adequately (Fig 11). Reexamination of the medial footprint with an arthroscopic intra-articular view via the posterior viewing portal confirmed that the medial footprint is totally compressed and that there is no medial footprint elevation (Fig 12).

Postoperative Rehabilitation

Postoperative rehabilitation should instruct and restrict for all patients. Patients wear a shoulder abduction brace (The UltraSling III, Donjoy) for 6 weeks. The abduction and external rotation shoulder position will reduce tension in the post operative rotator cuff tendon repair and prevent shoulder stiffness (Fig 13). Periscapular muscle exercise and passive gentle range of motion exercise is started from the first day postoperatively. Active assisted range of motion exercise is allowed from 6 weeks, followed by resisted shoulder motion exercise from 3 months after surgery.

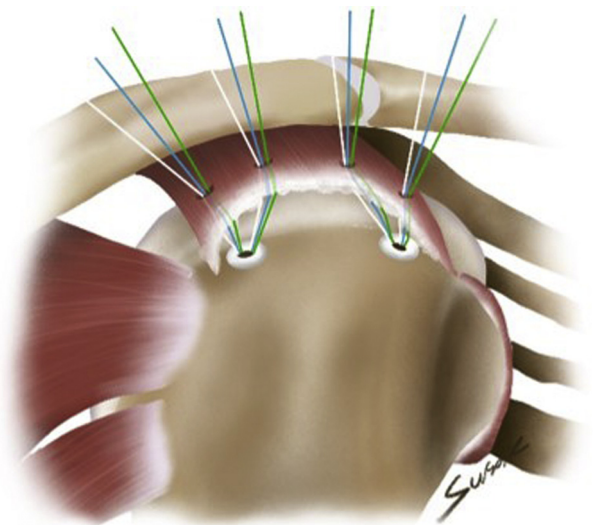


Fig 8. The graphic shows the medial row footprint and three suture limbs in the one penetration hole.

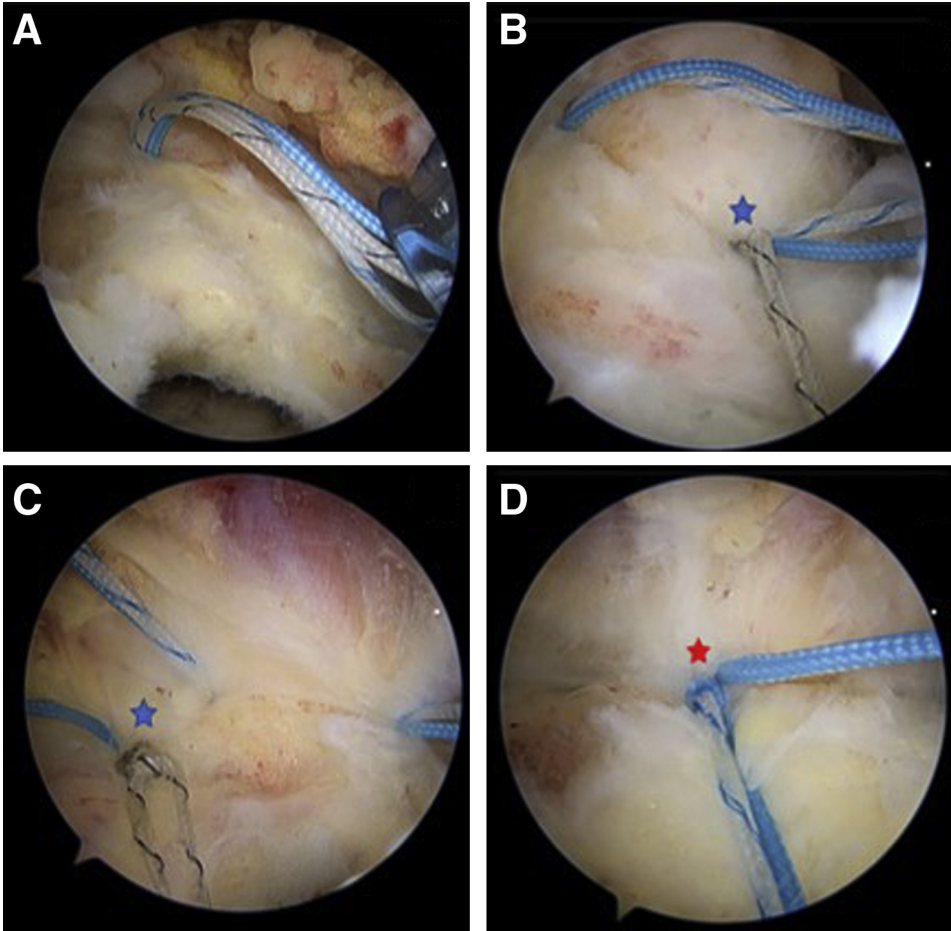


Fig 9. Arthroscopic subacromial view via posterolateral viewing portal (A): three-limb suture in the one hole penetration, (B,C) tied the one knot in the same suture anchor (blue star), (D) and tying the one knot in the between suture anchors (red star).

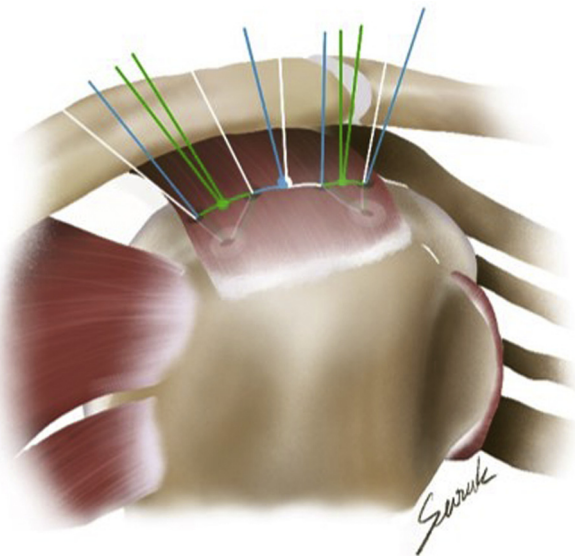


Fig 10. The graphic shows tying only three knots and balancing the space of knot tying for better compressed distribution.

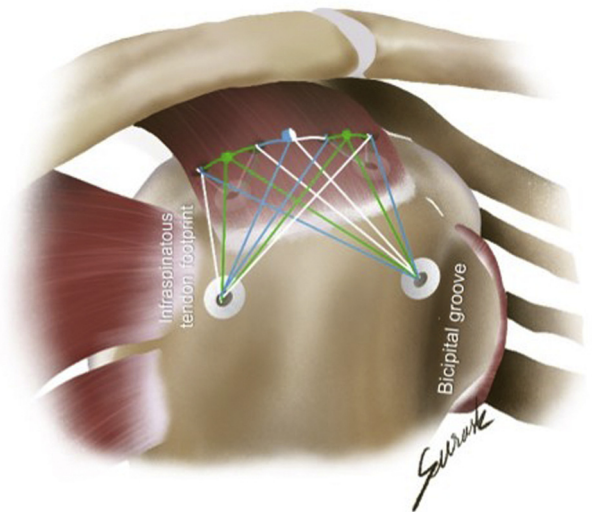
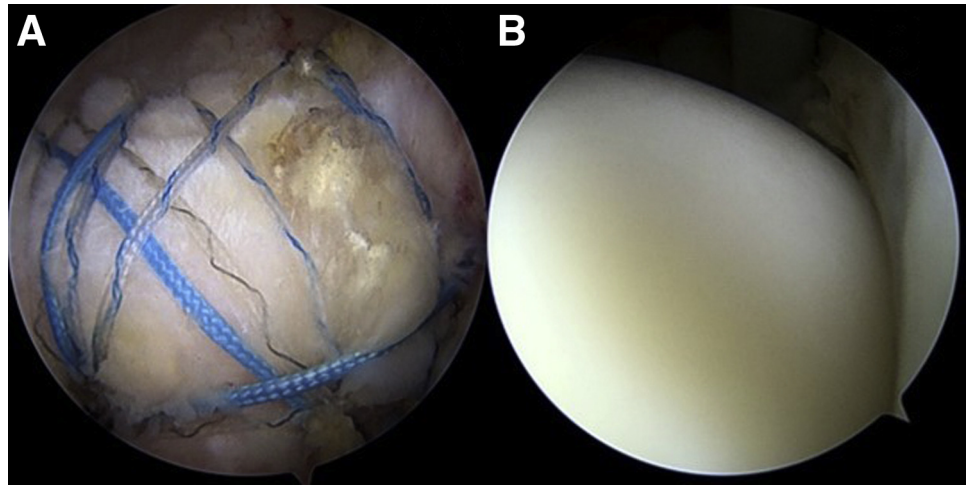


Fig 11. The graphic shows how the lateral-row footprint was created at the lateral row at bicapital groove and in front of the infraspinatus tendon.

Fig 12. (A) Arthroscopic sub-acromial view via posterolateral viewing portal. (B) After finishing the suture bridge technique and completely covering the footprint, arthroscopic intra-articular view is shown via posterior viewing portal, the medial footprint is completely compressed, and there is not any suture material in the joint.



Discussion

We also concluded that subacromial decompression and acromioplasty are still required. In a coronal view shoulder radiography evaluation, we found that 74% of the study group had an acromion spur, with 40.7% of them being classified as acromial pathologic spur.⁵ The reoperation rate was increased in the group undergoing rotator cuff surgery without acromioplasty, according to previous randomized controlled trials.⁶

If the tendon-suture junction at the medial row is repaired without undue tension, the conventional knot-tying suture bridge will have a satisfactory outcome.⁷ The tension of the lateral row, which increased the pull-out strength and loosening suture anchors, were biomechanical disadvantages of knotless.⁸ The medial compression effect of the knots provided more fixation stability and isolation, allowing for a better healing environment free of synovial fluid, which inhibited the tendon-to-bone healing process.⁹

The knotless suture-bridge repair technique provided good pressure distribution but had less medial

compression, resulting in rotator cuff repair failure. As a result, because I tied the appropriated distribution knot but reduced the number of knots, my technique does not affect compression force from medial footprint to lateral footprint, lowering the rate of type II retear from MRI reevaluation postoperative imaging (Fig 14). Several studies revealed no significant difference in retear rate between knotted and knotless repair techniques, although there was a higher risk of retear rate in knotted repair technique.^{3,10} With less knots tied, the risk of tissue strangulation is reduced, which could further compromise the rotator cuff's vascular supply. There is less chance of knot impingement on the acromion's underside due to other reasons. This approach keeps the rotator cuff footprint's original length and width, reducing cuff length-tension mismatch. With less knot tying, this approach reduces the tension created at the footprint and eliminates tissue strangulation, allowing the rotator cuff tissue to heal properly at the medial row site. Pirateb et al. showed in a meta-analysis of eight studies that there was no significant difference in functional outcomes post-operatively comparing knotted and knotless suture bridge repair techniques, including Constant score, University of California, Los Angeles (UCLA), and American Shoulder and Elbow Surgeons score. Otherwise, both techniques remain a controversial issue with no definitive conclusion.¹¹ Takeuchi et al. proposed that a knotted/knotless ratio of 1/3 might result in good functional outcomes (The Japanese Orthopaedic Association score and UCLA), as well as radiography results. Retear rate (type II tear) was 15.6%, which is lower than knotted suture bridge repair techniques. If the patient had a retear type II, the functional outcomes were significantly worse.¹² So that the limited medial knot tying might produce less strangulation, less stress concentration on



Fig 13. Shoulder abduction brace.

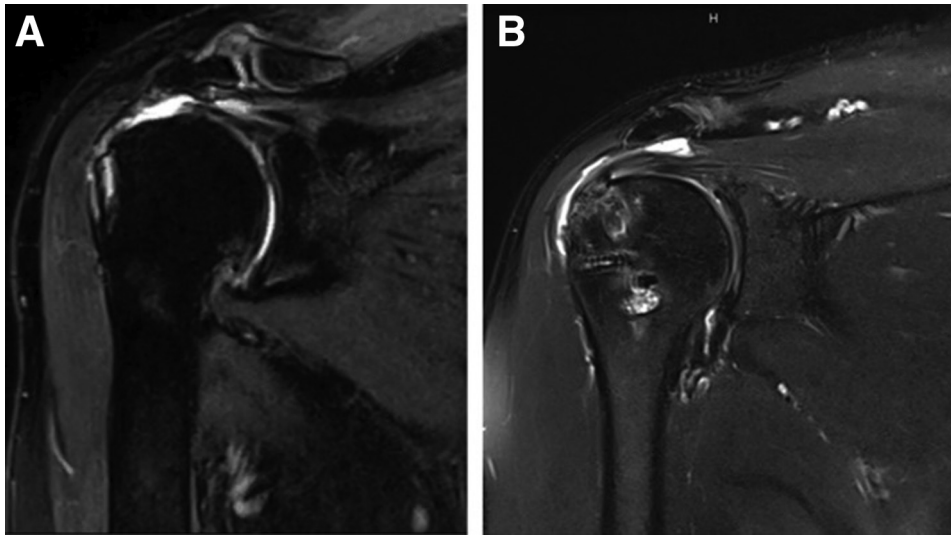


Fig 14. MRI T2FS coronal imaging at right shoulder. (A) Before the rotator cuff repair and full-thickness supraspinatus tendon tear. (B) The rotator cuff has completely healed, and the supraspinatus tendon footprint shows good medial compression healing after four months of repair.

the lateral row, while yet keeping medial compression. When compared with knotted techniques and knotless approaches, the 3-in-1 hybrid suture bridge technique

can easily manage suture limb management, as well as reduce operation time and cost effectiveness in patients.¹³

Table 1. Step-by-Step Summary, Pearls, and Tips

Surgical Step	Pearls and Tips	Pitfalls
1. Arthroscopic examination	Always be able to identify various intra-articular structure pathology and repair these structures.	In the case of a large rotator cuff tear, we recommend performing a subacromial examination first to avoid future infraspinatus tendon tears.
2. Subacromial decompression	<ul style="list-style-type: none"> - The pathologic acromial spur is resected while the visualization is improved. - Suture management has been simplified as a result of the increased working space. 	<ul style="list-style-type: none"> - Overresecting the acromial spur might result in acromial fracture. - Before resecting an acromial spur, determine the reference line at which the distal clavicle places closed the acromioclavicular joint.
3. Medial row placement	<ul style="list-style-type: none"> - The native rotator cuff tendon is reduced anatomically. 	<ul style="list-style-type: none"> - Carefully insert the suture anchor in cases of osteoporotic bone; you can avoid the suture anchor pulling out so you can put it close to the subchondral bone, which has a higher bone mass.
4. Cuff suture procedure	<ul style="list-style-type: none"> - Four holes provide less cuff trauma, which can lead to lower rates of rotator cuff retear (Type II retear) - When compared to conventional suture bridge approaches, it is easier to plan the optimum distance between each of the suture limbs before you tie the knot. 	<ul style="list-style-type: none"> - Instead of shuttling three suture limbs at once, shuttle two suture limbs first in a PDS is (PDS® (polydioxanone) Suture 2-0, Ethicon) knot and one suture limb in a second PDS knot using PDS to reduce the extent of the cuff injury caused by the larger knot.
5. Tied cuff procedure	<ul style="list-style-type: none"> - Only three-knot tying produces less strangulation and reduced rate of retear (Type II retear). - The medial footprint compression force is still present, given the fact that the medial row is not elevated. 	<ul style="list-style-type: none"> - The key to lateral row achievement is a well-planned strategy for balancing spread distance and knot tying to avoid the dog ear formation.
6. Lateral row placement	<ul style="list-style-type: none"> - Make the lateral row as wide as feasible to ensure proper pressure distribution at the rotator cuff tendon's lateral end. 	<ul style="list-style-type: none"> - Because osteoporotic patients are more likely to pull out the lateral row, we recommend putting the lateral row close to the bicipital groove and infraspinatus tendon insertion, where the bone mass is stronger.

Table 2. Advantages, Limitations, and Disadvantages**Advantages**

- Less trauma to rotator cuff.
- Less blood supply disturbance.
- Less strangulation.
- Less operative time.
- Better contact area and healing outcomes.

Limitations and disadvantages

- Difficult suture management because we used two triple-loaded suture anchor (Y-Knot PRO RC (triple loaded; CONMED) at the medial row
- When tying the knot, careful planning and imagination are required.
- Because insufficiency balanced the spread of medial distribution compression, the large rotator cuff tear pattern is not appropriate to use.

Conclusion

In a 3-in-1 hybrid suture bridge technique, the balance of knotted and knotless sutures can eliminate the weak points in both. This procedure preserved the principles of success in rotator cuff repair, such as a lower rate of medial row retear (type II tear), which is the leading cause of late problems following repair, and a better chance of healing. Providing less rotator cuff trauma, less blood supply disturbance, less medial row strangulation, and staying less operative time (Table 1 and Table 2).

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