Technical Note

Arthroscopy Technique: Repair of Musculotendinous Junction Rotator Cuff Tears in the Shoulder Using a Dynamic Convergence Suture Bridge Technique

Cheryl Gatot, M.B.B.S., Hannah Mei En Lie, M.B.B.S., and
Denny Lie Tijauw Tjoen, M.B.B.S., F.R.C.S. (Edin), F.A.M.S.

Abstract: Musculotendinous junction (MTJ) rotator cuff tears in the shoulder are rare injuries in which the tendon fails medial to its tuberosity attachment. There is difficulty in striking a balance between restoring the length—tension relationship of the tendon while avoiding high suture tension at the repair site. In view of the rare incidences of these tears, there is a paucity of literature on their repair techniques. We seek to share our surgical technique in addressing type A MTJ tears—where the medial muscular tear margin is short but remains adequate for suture bridge repair, whereas the lateral tendon remains on the footprint. We used mattress sutures from the medial row of anchors, threaded through the lateral tendon stump, then passed medially to engage the medial stump, before being fixed to a lateral row in a knotless fashion. Pulling on this pair of sutures will thus bring into closer apposition of both medial and lateral tear margins in a dynamic convergence pattern. Our surgical technique is a safe and effective method of repairing type A MTJ tear that confers improved biological and biomechanical advantage via the formation of a dynamic convergence suture bridging technique in addition to a double-row repair construct.

Among the elderly population, degenerative rotator cuff tear is a common cause of shoulder pain and dysfunction, with a lifetime incidence reported to be between 20% and 50% globally.[1,2] Risk factors for rotator cuff tear progression include smoking, presence of a subacromial spur, full-thickness tear, middle-sized tear, osteoarthritic changes, symptomatic pain, arm dominance, occupation, and older age.[3,4]

Apart from the size and location of rotator cuff tears, there are several morphologic variations of rotator cuff tears, such as delaminated tear, "Fosbury flop tears," bipolar rotator cuff insufficiency, or musculotendinous lesions.[5] Most rotator cuff lesions occur at or near the bone—tendon interface. In rare cases, myotendinous junction rotator cuff tear may occur, whereby the tendon fails medially, either in the substance of the tendon or at the musculotendinous junction.[6] These tears may occur primarily from trauma or degeneration, sometimes associated with anatomical factors such as acromioclavicular osteoarthritis with inferior osteophytes. Secondary failures occur when there is a musculotendinous junction (MTJ) tear after a previous rotator cuff repair at a different location.[7,8]

MTJ tears can be classified into 3 grades: grade 1—strains, grade 2—partial tears, and grade 3—complete tears.[9] Most of the tears reported in literature involve supraspinatus or infraspinatus muscle.[9,10]

Arthroscopic rotator cuff repair surgery is one of the most common orthopaedic procedures performed in patients with symptomatic rotator cuff tears. Nonoperative management in complete myotendinous junction tears lead to unsatisfactory outcomes.[8] In contrast to the common cuff repair procedures that involves soft tissue-to-bone fixation, when dealing with MTJ tears, a large focus of the repair technique is dependent on soft tissue-to-soft tissue fixation.[7,11] These tears pose a

From the Department of Orthopaedic Surgery, Singapore General Hospital (C.G., D.L.T.T.); and Lee Kong Chian School of Medicine, Nanyang Technological University (H.M.E.L.), Singapore.

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Address correspondence to Cheryl Gatot, Department of Orthopaedic Surgery, Singapore General Hospital, 20 College Road, Academia, Level 4, Singapore 169856. E-mail: cheryl.gatot2305@gmail.com

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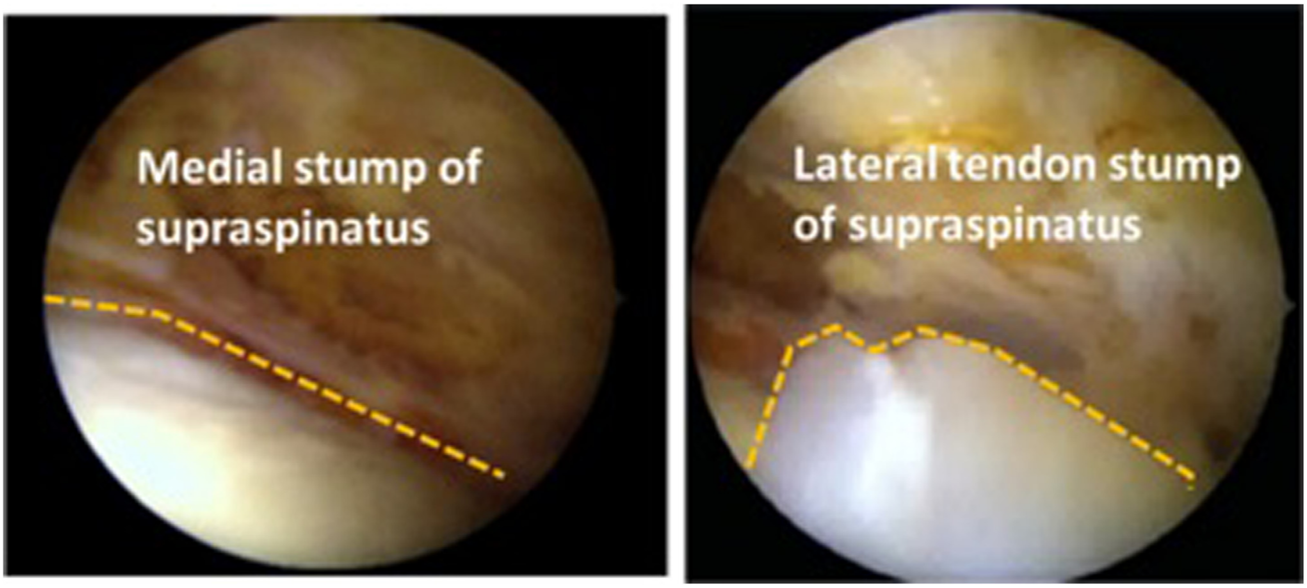

Fig 1. Arthroscopic view of left shoulder from standard anterior viewing portal. A standard diagnostic arthroscopy was performed showing a large retracted type A myotendinous junction tear with a medial stump of supraspinatus muscle and tendon lateral to the tear.

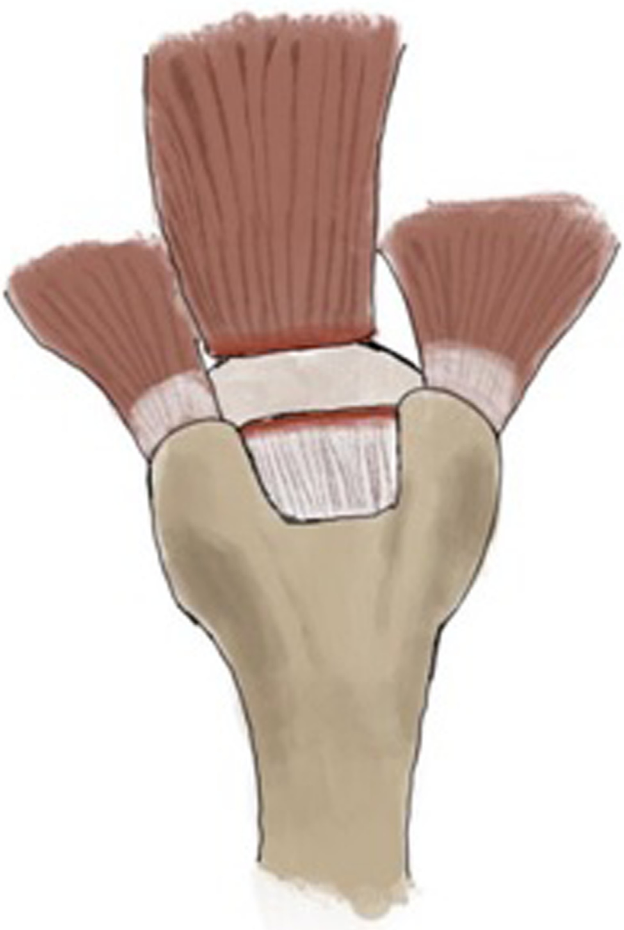

Fig 2. Schematic diagram depicting a type A myotendinous junction tear of the supraspinatus tendon.

challenging surgical case in part due to the short medial tendon stump and risk of suture cut-through in the degenerated medial muscle fibers at the MTJ. There is also difficulty in obtaining a balance in restoring the length—tension relation of the cuff tendon while avoiding high suture tension of the repair site.

In view of the rare incidences of these tears, there is a paucity of literature on the repair techniques and functional outcomes following repair. In 2017, Millett et al.[11] had described 3 major tear patterns in myotendinous junction injuries and the corresponding possible repair techniques that addresses each tear pattern. In all 3 types of tear pattern, the lateral tendon remains on the footprint. In type A tear pattern, there is a short but adequate medial tendon—this can be addressed via a complex suture bridging technique such as a double-row construct with margin convergence suture to compress down and oppose the lateral tendon stump and medial muscular portion. In type B tear pattern, there is a deficient medial tendon, with healthy muscle. For type B tears, a bridging repair with graft augmentation, via an arthroscopic or open procedure method, can be applied. In type C tear pattern, there is deficient medial tendon, with retracted atrophied muscle. Superior capsule reconstruction, latissimus dorsi tendon transfer, or reverse total shoulder arthroplasty are possible treatments suggested for type C tear pattern.[7,11]

We seek to share our surgical technique during which we addressed a type A myotendinous junction tear via a suture bridging technique that uses mattress sutures from the lateral tendon to form a dynamic convergence suture concept to aid in the medial soft-tissue repair,

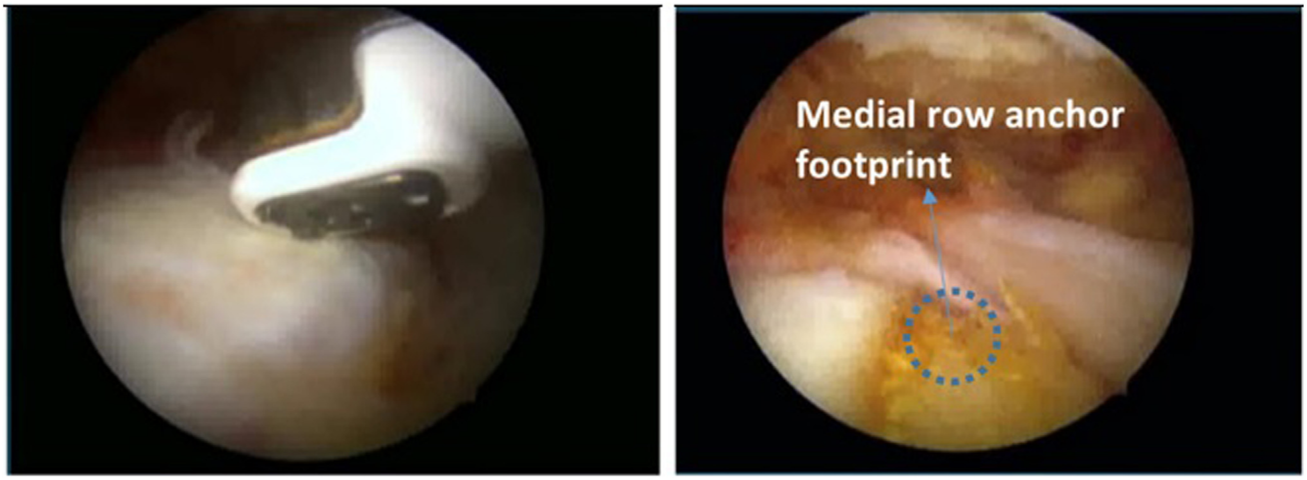

Fig 3. Arthroscopic view of left shoulder from standard anterior viewing portal. A radiofrequency device is used to prepare the medial-row anchor footprint.

with subsequent fixation to a lateral-row construct. In our review of literature, to our knowledge, this surgical technique has not been described previously.

Surgical Technique (With Video Illustration)

Patient Evaluation, Imaging, and Indications

A thorough history and examination should be performed for all patients presenting with shoulder pathologies. Patient with myotendinous junction rotator cuff tears may experience pain and weakness of the shoulder, similar to conventional rotator cuff tendon tears. Further imaging such as ultrasound or magnetic resonance imaging (MRI) can be obtained to characterize the location, size, and morphology of any possible rotator cuff tears. There would be a greater index of suspicion of a MTJ tear if preoperative MRI depicts the following features: (1) the tear is located several centimeters medially (approximately more than 2 cm) from the tendon insertion zone; (2) there is intact tendon attachments; (3) high-grade fatty infiltration; and (4) acute severe edema.[9]

Following identification of an MTJ cuff tear, with careful evaluation of patient's extent of symptoms clinically, in correlation with the degree of MTJ cuff injury, arthroscopic rotator cuff repair could be offered, with appropriate preoperative patient counseling and planning.

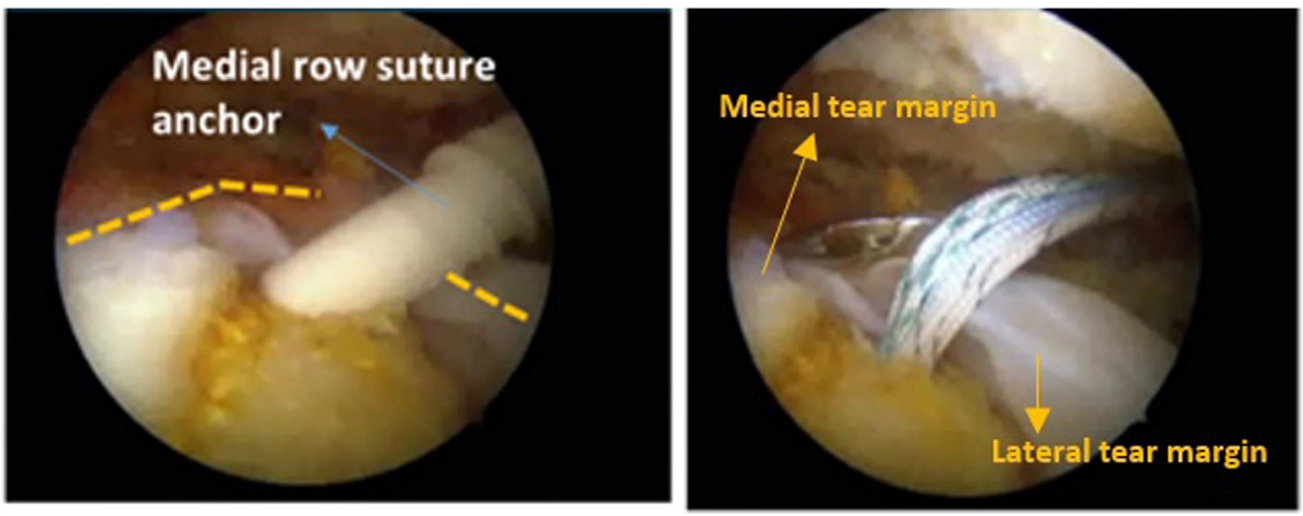

Fig 4. With the camera maintained at the anterior portal, a medial-row triple-loaded suture anchor (HEALIX ADVANCE; DePuy Mitek) is inserted onto the humeral head in between the margins of the MTJ tear. Sutures are subsequently passed through the medial and lateral edge of the torn tendon. There are 3 different-colored sutures—white, green, and blue. (MTJ, musculotendinous junction.)

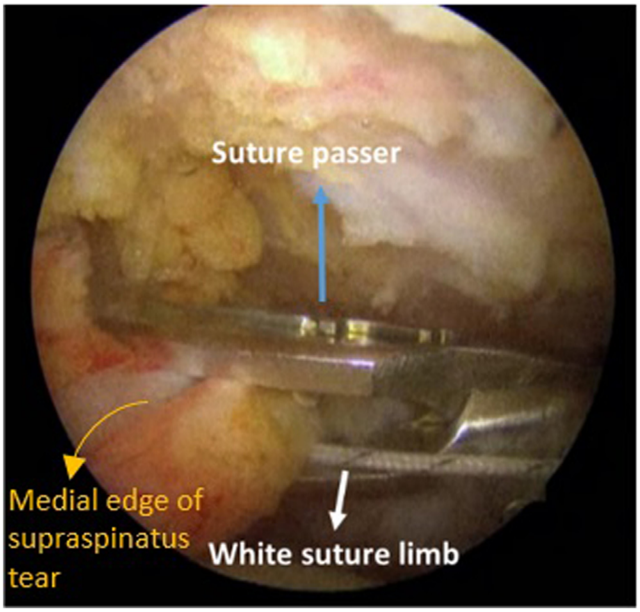

Fig 5. With the arthroscope positioned at the anterior portal, one limb of the white suture is passed through the medial edge of the supraspinatus musculotendinous junction tear using a suture passer (EXPRESSEW; DePuy Mitek).

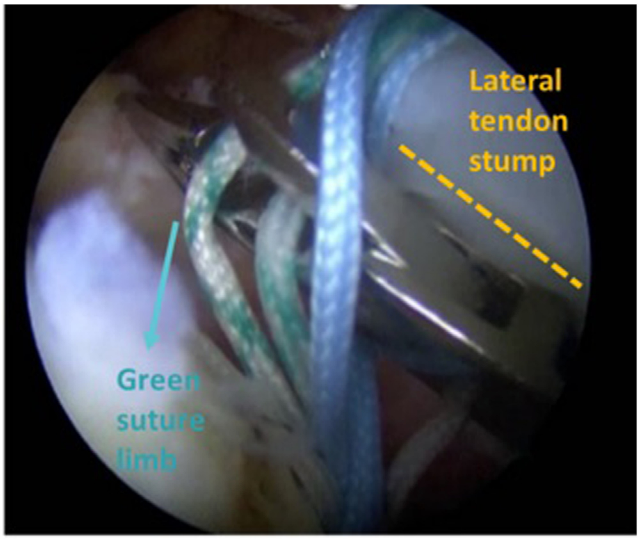

Fig 7. For the green sutures, both suture limbs are first retrogradely retrieved and threaded through the lateral aspect of the tendon using a bird-beak suture retriever device (Penetrating Grasper; DePuy Mitek). The arthroscope is maintained at the anterior viewing portal.

Diagnostic Arthroscopy

A standard shoulder diagnostic arthroscopy is performed with a 30° shoulder arthroscope. Upon creation of the posterior viewing portal and anterior portal, a large retracted type A myotendinous junction tear was identified in our assessment, with the tendon portion seen lateral to the tear (Fig 1). Figure 2 illustrates a schematic diagram of the myotendinous junction tear.

Additional anterolateral and posterolateral working portals are created. A radiofrequency device is used to prepare the medial-row anchor footprint (Fig 3).

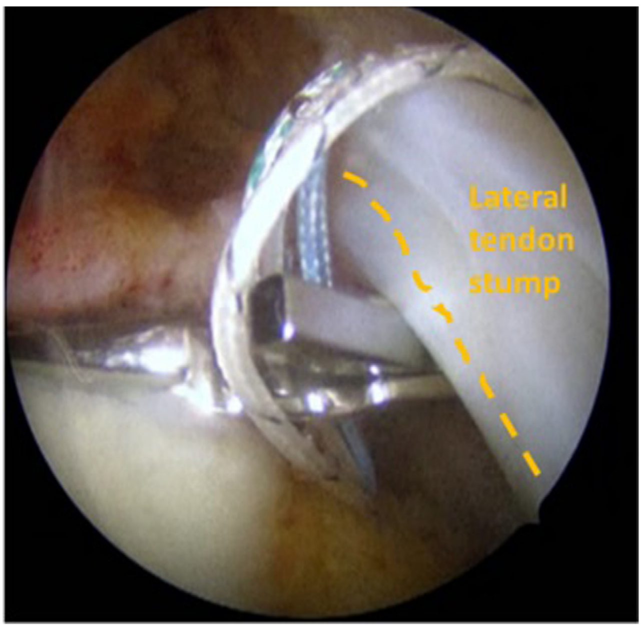

Fig 6. Arthroscopic view of left shoulder from anterior portal. A suture retriever device (DePuy Mitek), entering from the lateral working portal, is used to retrogradely retrieve the second limb of the white suture through the lateral edge of the supraspinatus tendon stump.

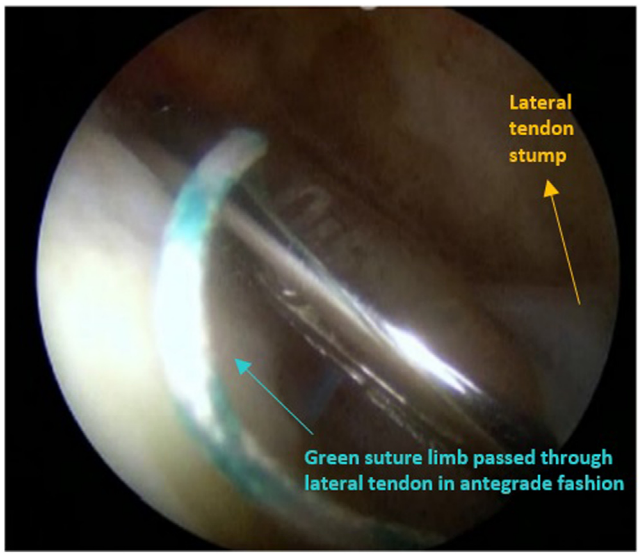

Fig 8. Arthroscopic view of left shoulder from anterior portal. Following retrograde retrieval, both limbs of green sutures are now on the lateral aspect of the tendon, exiting through a lateral portal. Using a bird-beak suture passer device (Penetrating Grasper; DePuy Mitek), each suture limb is then passed individually back into the lateral tendon in antegrade fashion, creating a mattress suture configuration on this aspect.

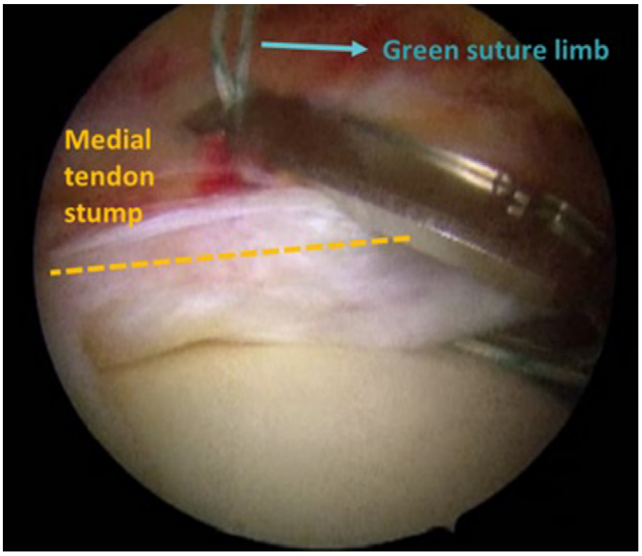

Fig 9. With aid of a suture passer device (EXPRESSEW; DePuy Mitek), each green suture limb from the mattress suture is subsequently passed through the medial tendon in antegrade fashion. The arthroscope is maintained at the anterior viewing portal.

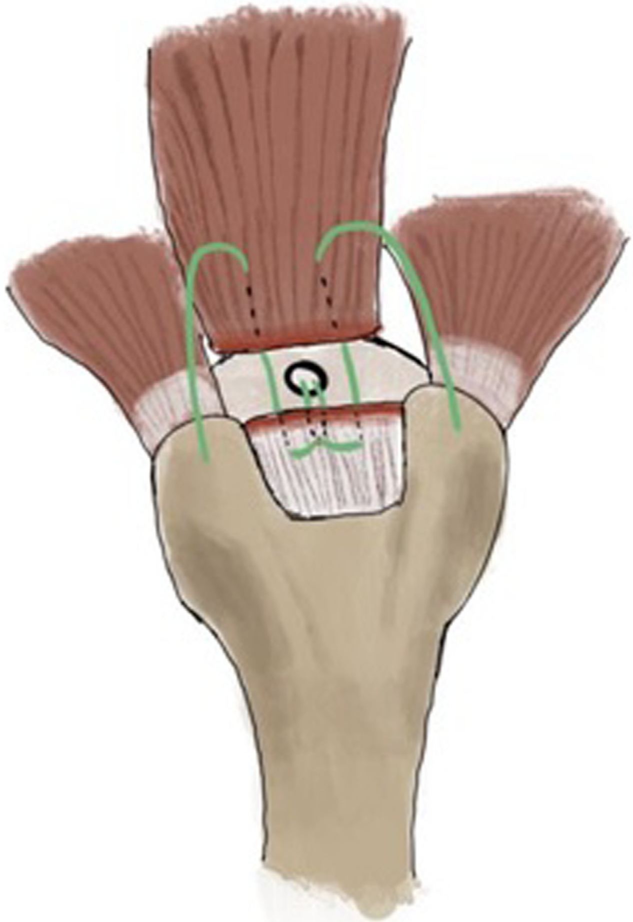

Fig 10. Schematic diagram of green sutures configuration, which gives rise to a dynamic margin convergence pattern, brining tight apposition of both medial and lateral edges of the musculotendinous junction tear.

Medial Suture Bridging With Dynamic Convergence

A medial-row triple-loaded suture anchor (HEALIX ADVANCE; DePuy Mitek, Warsaw, IN) is inserted onto the humeral head in between the margins of the MTJ tear (Fig 4). The sutures from this anchor will form our suture bridge that brings both the medial and lateral margins of the MTJ tear together.

With the camera maintained at the anterior portal, a medial-row triple-loaded suture anchor (HEALIX ADVANCE; DePuy, Mitek) is inserted onto the footprint of the humeral head. There are 3 different-colored sutures—white, green, and blue.

Starting with the white suture, one limb of the white suture is passed antegrade through the medial edge of the supraspinatus using a suture passer (EXPRESSEW; DePuy Mitek) (Fig 5). The second limb of the white suture is retrieved retrograde through the lateral edge of the tendon via a suture retriever device (Fig 6).

For the green sutures, both suture limbs are first retrieved retrograde through the lateral aspect of the tendon with a bird-beak suture retriever (Penetrating Grasper; DePuy Mitek) (Fig 7). Each limb is then pierced individually back into the lateral tendon antegrade with a similar suture passer device (Penetrating Grasper; DePuy Mitek), creating a mattress suture configuration on the lateral tendon stump (Fig 8). Subsequently, each green suture limb is passed through the medial tendon in antegrade fashion, using the suture passer (Fig 9).

Pulling on the green sutures will thus bring into tight apposition of both medial and lateral margins in a dynamic convergence pattern, as shown in the schematic diagram in Figure 10.

The third suture from the medial anchor—the blue sutures—are passed through the medial and lateral margins of the supraspinatus tendon in a similar fashion to the white sutures in the first instance (Figs 11 and 12).

A second medial-row suture anchor is inserted over the anterior portion of the tear, with each of the blue, white, and green suture limbs passed through in a similar fashion onto the medial and lateral edge of the tendon, as per previously described.

Medial Knots

Each suture limbs of the blue and white sutures are then tied respectively, with aid of a knot pusher, bringing both the medial and lateral margins of the MTJ tear together. This creates apposition of the medial and lateral edges of the torn tendons in a conventional static margin convergence, the integrity and tightness of the

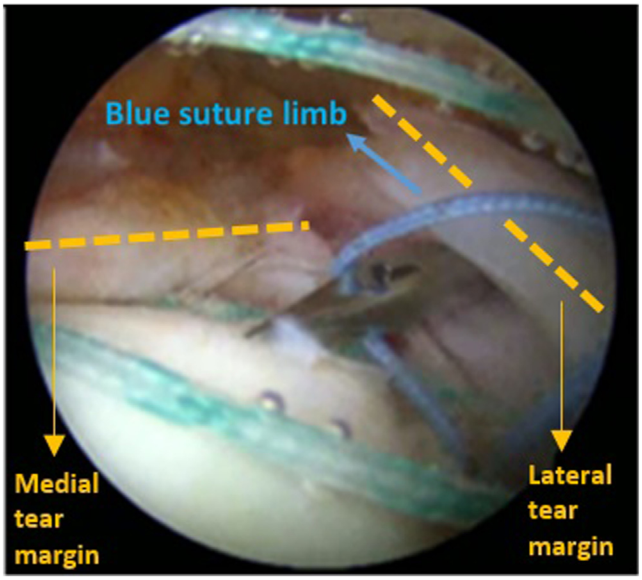

Fig 11. Arthroscopic view of left shoulder from anterior portal following completion of dynamic convergence pattern for the green suture limbs. The blue suture limbs from the medial-row anchor being passed through the medial and lateral margins of the supraspinatus tendon tear, in a similar fashion to the white sutures.

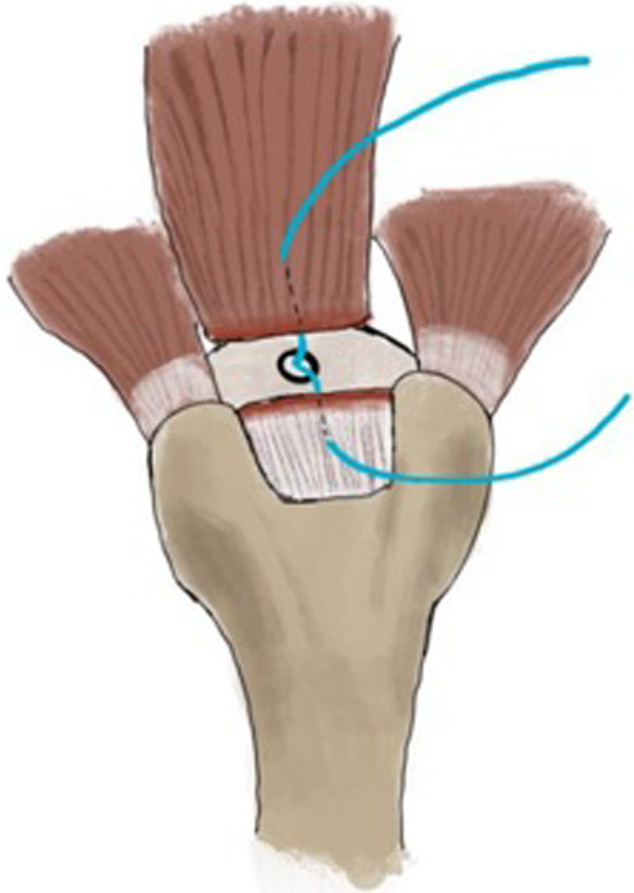

Fig 12. Schematic diagram of blue sutures configuration, which gives rise to a static margin convergence pattern of repair, upon tying both ends of the suture limbs.

repair being dependent on the knot. The Duncan sliding knot was used in this case (Fig 13).

Both suture limbs of the green sutures are retrieved through the lateral portal, for its eventual anchoring to a lateral-row suture anchor.

Lateral-Row Anchor

A cannula is introduced through the lateral portal and all suture limbs are retrieved through the portal. The green suture limbs from the anterior medial-row anchor, along with one white suture limb, are secured to an anterior lateral-row anchor (Versalok suture anchor; DePuy Mitek). The green suture limbs from the posterior medial-row anchor, together with one blue suture limb from the posterior medial-row anchor, are similarly secured to a posterior lateral-row suture anchor (Versalok suture anchor; Depuy Mitek) (Figs 14 and 15).

As the green sutures are pulled, they bring into a tight apposition both medial and lateral torn edges of the tendon, in a dynamic margin convergence. In a conventional repair, the harder one pulls on the green suture, it is only the medial tendon stump that is pulled laterally. This dynamic convergence enables both the medial tendon stump to be pulled laterally, and the lateral tendon stump to be pulled medially. It avoids excessive traction on the medial tendon stump, while ensuring a tight margin convergence with equal tension on both medial and lateral tendon stumps. As these sutures are secured to the lateral-row anchors, they create a suture bridge over the lateral tendon, ensuring compression as well.

This gives rise to a hybrid suture bridging repair of the type A MTJ tear. This surgical technique is hybrid, employing both static margin convergence repairs (for the white and blue sutures) and dynamic convergence (green sutures). With the double-row construct, the crisscrossing suture configuration compresses the tendon down to bone to allow for healing (Fig 16). A balloon spacer (Conmed, Largo, FL) was subsequently deployed. Video 1 shows a detailed demonstration of our surgical technique.

Rehabilitation

The patient is placed in an arm-sling for the first 2 weeks postoperatively. Thereafter, patient is started on gradual range of motion exercises over the next 2 to 6 weeks, initially starting from passive exercises and progressing to active exercises. In our patient, postoperative MRI showed good healing and apposition of the rotator cuff injury postrepair (Fig 17).

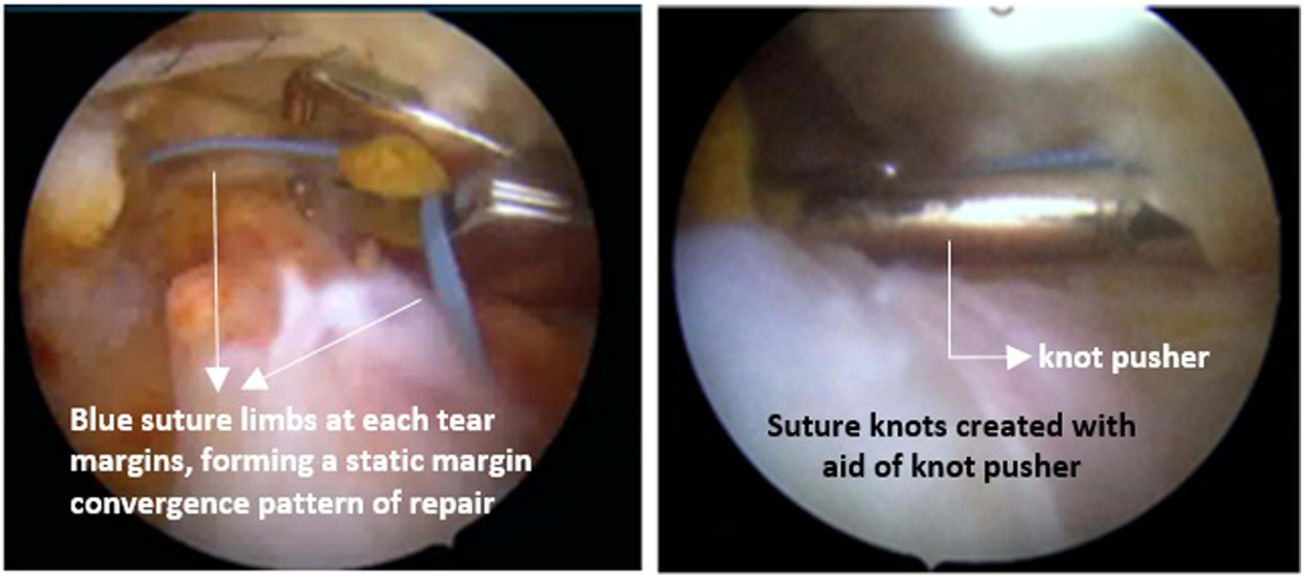

Fig 13. Medial knots (Duncan sliding knots) are created using the white and blue suture limbs, with aid of a knot pusher. This brings the medial and lateral edge of the supraspinatus tendon in close apposition. The arthroscope is maintained at the anterior portal.

Discussion

Due to the rarity of myotendinous junction rotator cuff injuries, there are limited studies detailing its repair techniques and subsequent outcomes. In repairs of myotendinous junction tears, challenges faced include (1) obtaining a balanced biomechanical repair construct with minimal tension and restoration of optimal tendon length, (2) risk of suture cut-through in degenerated medial muscle fibers, and (3) lack of sufficient medial tendon as a working length possibly due to retraction.

Our repair technique aims to prioritize the soft tissue-to-soft tissue repair of the medial and lateral margins in an MTJ tear using sutures from a medial-row anchor, before completing the entire repair construct with fixation to a lateral-row anchor in a double-row fashion.

Repairs using margin-convergence for the medial and lateral edge of the torn tendon have been described previously. We have similarly applied this with 2 of our sutures in the soft-tissue fixation to the medial-row

Fig 14. Deployment of the anterior lateral-row anchor (Versalok suture anchor; DePuy Mitek) is shown, securing the green suture limbs from the anterior medial-row anchor, along with one white suture limb. This is done with the arthroscope positioned at a lateral portal.

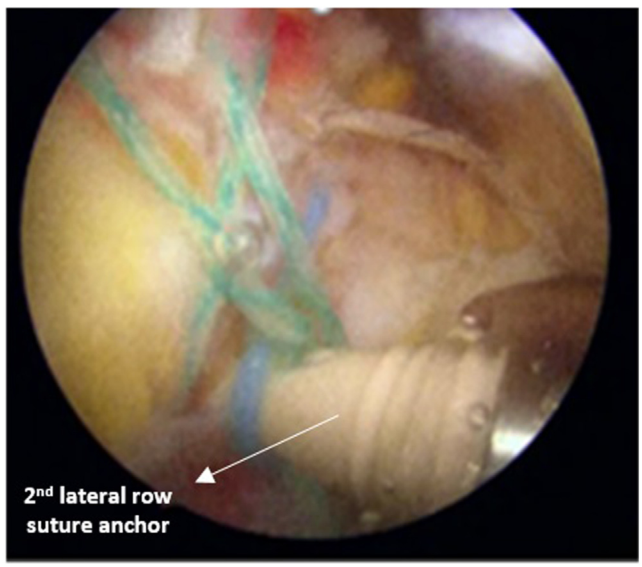

Fig 15. Deployment of the posterior lateral-row anchor (Versalok suture anchor; DePuy Mitek) is shown, securing the green suture limbs from the posterior medial-row anchor, along with one blue suture limb. This is done with the arthroscope positioned at a lateral portal.

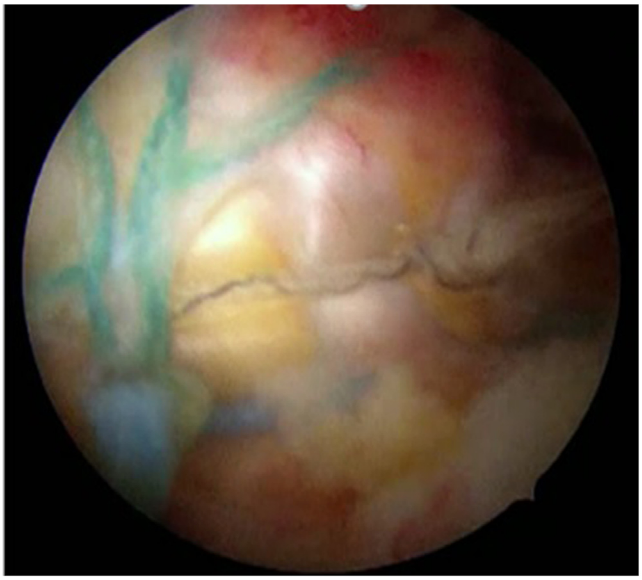

Fig 16. With the scope placed on the lateral portal, this shows the eventual formation of a hybrid suture bridging repair of a type A myotendinous junction tear, involving a double-row construct.

Table 1. Advantages and Risks/Limitations

Advantages
- Our technique places emphasis on soft tissue-to-soft tissue repair of the medial and lateral margins in a type A musculotendinous junction (MTJ) tear, by promoting closer apposition and tendon healing via application of a both conventional static margin convergence sutures, with a dynamic convergence suture bridge system.
- Optimal cuff tendon length is preserved.
- Ensures tight margin convergence with equal tension on both medial and lateral tendon stumps. This avoids tension at repair site.
- A double-row construct allows entire suture bridge configuration to compress the tendon down onto bone. This improves the biological quality the repair.
- Such suture bridge hybrid construct allows increased resistance to multivector load and bone-to-tendon failure, highlighting its biomechanical advantage.
- Minimally invasive, arthroscopic cuff repair has low risk of surgical-site infection.
Risks/limitations
- MTJ tear morphology may differ. This technique may not be applicable in type B or type C MTJ tears.

triple-loaded anchor. In order to further promote tendon-to-tendon healing and to bring the 2 ends in closer apposition, we propose a suture bridge hybrid that entails creation of mattress sutures over the lateral tendon margin that will then be passed medially and engage the medial stump, before being fixed to a lateral row in a knotless fashion. Upon tightening of the lateral-row fixation, the suture configuration will bring the 2 ends of the MTJ tear closer together in dynamic convergence pattern. This dynamic margin convergence technique has not been described previously.

We believe that our technique provides both biological and biomechanical benefits and advantages. Formation of a suture bridge hybrid construct involving conventional static margin convergence, augmented with a dynamic convergence system, increases success of cuff healing with greater apposition of the tear margins. Each suture bites were placed at appropriate widths apart and engaged upon good tissues at both medial and lateral tear margins. The overall repair aims to preserve optimal cuff tendon length with no excessive tension at the repair site, and this reduces risks of suture cut-through as well. Minimizing intraoperative repair tension during arthroscopic cuff repair has been shown to uphold postoperative repair integrity of the rotator cuff.[12]

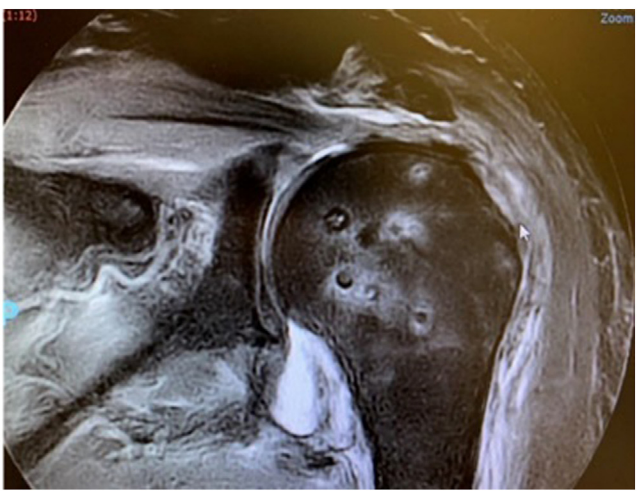

Fig 17. Postoperative T2-weighted coronal magnetic resonance imaging (MRI) showing intact cuff repair integrity.

The repair integrity is further maintained via a double-row construct that maximizes the contact area between tendon-to-bone. With the optimal placements of the lateral suture anchors in the best bone quality of the greater tuberosity, the tendon is compressed down onto bone with a crisscross suture configuration on the bursal surface, minimizing interruption of healing by foreign materials at the cuff—bone interface.[13,14] This improves the biological quality of the repair.

It is additionally biomechanical advantageous in that the crisscrossing suture configuration adds resistance to multi-vector load and resistance to bone-to-tendon failure due to sharing of forces amongst the entire construct.

The myotendinous junction unit is an integral component that works to transmits force from a contracting muscle, through tendon, to bone.[15] Restoration of its biomechanical properties is thus crucial to ensure the best possible outcomes of the repair.

This repair technique demonstrated can be carried out arthroscopically, with careful suture management. Minimally invasive arthroscopic methods have a lower

Table 2. Surgical Pearls and Pitfalls

	Surgical Pearls	Surgical Pitfalls
Diagnostic scope and assessment of cuff pathology	- Accurate identification of type of musculotendinous rotator cuff tear morphology - Thorough assessment of rotator cuff tear configuration and tendon quality during diagnostic arthroscopy will aid in planning of repair	- In situations in which the medial tendon stump may be too deficient, is significantly retracted, or of poor quality, suture bridge repair may not be applicable
Planning of margin convergence sutures	- Ensure each suture is engaging good tendon tissue for both the medial and lateral margins of the musculotendinous junction tear - Ensure appropriate width between each suture on the tear margins of the tendon	- Unequal placement of suture bites or inadequate engagement of good tendon tissue leads to unequal tension distribution and increase risk of suture cut-through
Formation of dynamic convergence sutures	- Careful placement of mattress suture configuration on lateral tendon stump tissue, will allow smooth transition of subsequent appropriate antegrade suture bites of the medial tear margin - Use of 2 additional lateral working portals will aid in suture management	
Suture anchor placement	- Anchors should be placed in areas with good bone quality - Optimal placement of medial and lateral-row anchors allows for formation of a hybrid suture-bridge construct with increased biomechanical advantage	- Poor placement of lateral-row anchors may cause overtensioning of repair site

risk of surgical-site infection, compared with open rotator cuff repairs.[16]

MTJ tears may differ in terms of the degree of tendon retraction, tendon working length, and tendon quality. This technique was applied to a type A MTJ tear; however, it may not be applicable in type B or type C MTJ tears.

These advantages and limitations of our technique are summarized in Table 1. We have also summarized a few surgical pearls to adhere to while performing this repair technique, along with some surgical pitfalls to take precaution from during the course of the procedure. These surgical pearls and pitfalls can be found in Table 2.

In conclusion, MTJ rotator cuff tears are rare injuries and are difficult to repair. There is a paucity of literature in its repair techniques and outcomes. Our surgical technique is a safe and effective method of repairing type A MTJ tear that confers improved biological and biomechanical advantage via the formation of a dynamic convergence suture bridging technique and double-row repair construct.

References

1. Yamamoto A, Takagishi K, Osawa T, et al. Prevalence and risk factors of a rotator cuff tear in the general population. *J Shoulder Elbow Surg* 2010;19:116-120.
2. Varkey DT, Patterson BM, Creighton RA, Spang JT, Kamath GV. Initial medical management of rotator cuff tears: A demographic analysis of surgical and nonsurgical treatment in the United States Medicare population. *J Shoulder Elbow Surg* 2016;25:e378-e385.
3. Ichinose T, Shitara H, Tajika T, et al. Factors affecting the onset and progression of rotator cuff tears in the general population. *Sci Rep* 2021;11:1858.
4. Yamaguchi K, Ditsios K, Middleton WD, Hildebolt CF, Galatz LM, Teefey SA. The demographic and morphological features of rotator cuff disease. A comparison of asymptomatic and symptomatic shoulders. *J Bone Joint Surg Am* 2006;88:1699-1704.
5. Lädermann A, Burkhart SS, Hoffmeyer P, et al. Classification of full-thickness rotator cuff lesions: A review. *EFORT Open Rev* 2017;1:420-430.
6. Lädermann A, Christophe FK, Denard PJ, Walch G. Supraspinatus rupture at the musculotendinous junction: An uncommonly recognized phenomenon. *J Shoulder Elbow Surg* 2012;21:72-76.
7. Hall T, Danielson K, Brandenburg S, Matelic T. A case series of recurrent myotendinous rotator cuff tears repaired and augmented with dermal allograft: Clinical outcomes at two years. *J Shoulder Elbow Surg* 2020;29:2264-2271.
8. 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.
9. Taneja AK, Kattapuram SV, Chang CY, Simeone FJ, Bredella MA, Torriani M. MRI findings of rotator cuff

myotendinous junction injury. *AJR Am J Roentgenol* 2014;203:406-411.

10. Walch G, Nové-Josserand L, Liotard JP, Noël E. Musculotendinous infraspinatus ruptures: An overview. *Orthop Traumatol Surg Res* 2009;95:463-470.
11. Millett PJ, Hussain ZB, Fritz EM, Warth RJ, Katthagen JC, Pogorzelski J. Rotator cuff tears at the musculotendinous junction: Classification and surgical options for repair and reconstruction. *Arthrosc Tech* 2017;6:e1075-e1085.
12. Takeda Y, Fujii K, Suzue N, Miyatake K, Kawasaki Y, Yokoyama K. Repair tension during arthroscopic rotator cuff repair is correlated with preoperative tendon retraction and postoperative rotator cuff integrity. *Arthroscopy* 2021;37:2735-2742.
13. Dey Hazra RO, Ernat JJ, Rakowski DR, Boykin RE, Millett PJ. The evolution of arthroscopic rotator cuff repair. *Orthop J Sports Med* 2021;6(9):23259671211050899.
14. Millett PJ, Mazzocca A, Guanche CA. Mattress double anchor footprint repair: A novel, arthroscopic rotator cuff repair technique. *Arthroscopy* 2004;20:875-879.
15. Kim WJ, Kim GH. A bioprinted complex tissue model for myotendinous junction with biochemical and biophysical cues. *Bioeng Transl Med* 2022;5(7):e10321.
16. Wang KY, Agarwal AR, Xu AL, et al. Increased risk of surgical-site infection and need for manipulation under anesthesia for those who undergo open versus arthroscopic rotator cuff repair. *Arthrosc Sports Med Rehabil* 2022;4:e527-e533.