Technical Note

An Arthroscopic Knotless Technique for Anatomical Restoration of the Rotator Cuff and Superior Capsule: The Double-Layer Cinch Bridge

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Abstract: Rotator cuff repairs are the most common procedures in shoulder surgery, but still show long-term retear rates of up to 70%. Nonanatomic reconstruction is one possible cause of repair failure. The rotator cuff histologically consists of 5 separate layers of which 2 are macroscopically identifiable: the superior or tendinous layer and the inferior or capsule-ligamentous layer. In case of rotator cuff tears, these layers are often retracted to different degrees. The intraoperative detectable prevalence of rotator cuff delamination reaches up to 85%. Anatomical rotator cuff repair, which also includes restoration of the layered structure, could re-establish native tendon morphology and thus potentially decreases retear rates. The use of a knotless construct to avoid cuff strangulation and maintaining tendon perfusion could further decrease the risk of repair failure. Double-layer reconstructions are challenging and time consuming because each layer needs to be penetrated separately. Only few studies reported about double-layer reconstruction of the posterosuperior rotator cuff. This Technical Note is the first to present an arthroscopic knotless transosseous-equivalent double-layer repair technique.

Despite advances in rotator cuff (RC) repairs, long-term retear rates are still high with up to 70%.[1] Because intact RC repairs have been showing better clinical outcome,[1,2] special attention should be given to restore the RC's anatomy.[3] The layered structure of the RC has been known for more than 2 decades.[4] Sonnabend and Watson[5] noted that the deeper articular layer was more retracted than the superficial bursal layer. Han et al.[3] suspected that the retracted articular layer is the rotator cable, which is separated from the cuff. Recent studies[6,7] further described the deep layer of the RC as a structure also known as the superior capsule. Moreover, Adams et al.[8] advocated that an RC repair must restore normal capsular anatomy to provide normal biomechanics of the joint and, thus, a positive clinical outcome.

Although preoperatively delamination of the posterosuperior rotator cuff can be seen, especially on the parasagittal sections, it depends very much on the quality of the scans. Up to date, there are no data published investigating the correlation of prevalence of preoperatively detected RC delamination and intraoperative findings. Therefore, the last decision needs to be made during surgery and a comprehensive inspection of the RC is mandatory.

Reports on surgical techniques for knotless anatomical RC reconstruction in delaminated tears are scarce. Only one technique[9] represents a double-row instead of a transosseous-equivalent repair.

In this Technical Note, we propose an arthroscopic technique of a knotless transosseous-equivalent repair, restoring the anatomy of the superior capsule together with the RC.

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Surgical Technique

Preoperative Patient Positioning

The surgery is performed under interscalene nerve block and general anesthesia. The patient is placed in

Table 1. Indication and Contraindications for Arthroscopic Knotless Anatomic Double-Layer Cinch Bridge Repairs

Indication	Relative Contraindications	Absolute Contraindications
Delaminated posterosuperior rotator cuff tear	If the inferior layer cannot be forwarded to footprint	Inferior layer is not present
	Very osteoporotic bone quality laterally	Very poor tissue quality

the beach chair position, and after washing and draping, a standard posterior portal is established.

Diagnostic Arthroscopy

After the introduction of an arthroscope into the joint, a diagnostic arthroscopy is performed (Video 1). Indication and contraindications are summarized in Table 1. The presence of the posterosuperior RC tear is documented and often the inferior layer can already be detected (Fig 1A).

Intra-articular Rotator Cuff Release

An anterolateral portal anterior to the long head of the biceps tendon in the rotator interval is established. With the electrocautery device, just anterior to the medial collateral ligament, the capsule and subsequently subcoracoidal bursa are resected and the base of the coracoid is exposed. The origin of the coracohumeral ligament is released, and in case the inferior layer is retracted, an intra-articular release of the superior capsule is completed by separating the tissue from the glenoid. Meticulous care is taken not to confound the superior labrum with the supraspinatus tendon's deep layer, which can sometimes appear as a double labrum sign in cases where the inferior layer is retracted far medial.

Lateral Viewing Portal Placement

Once the intra-articular tendon release is completed, the arthroscope is switched into the subacromial space and a lateral portal is established. After bursectomy the arthroscope is switched to the lateral portal.

Tear Inspection

The tear is inspected and the rupture configuration examined. According to the author's (P.R.H.) observation, especially in chronic tears, the anteroposterior extension of the superficial layer is often larger than the anteroposterior extension of the footprint, meaning that more tissue than footprint area is present. In fact, when repositioning the RC to the footprint, the well-known "dog ears" are created. The hypothesis behind this observation is that following the anatomic description of Mochizuki et al.,[10] in chronic tears, the retracting supra- and infraspinatus tendons stretch out leading to more, but weaker, tendinous tissue. Therefore, the author (P.R.H.) prefers to perform some kind of interval release between the superficial layers of supra- and infraspinatus tendons excising the aforementioned tendinous tissue as well as the suggested debridement between the 2 layers.[5,11]

Thereafter, an anatomic reposition of the tendons without creation of a dog ear is achievable (Fig 1B).

Footprint Preparation

The footprint is carefully debrided to get rid of all soft tissue and the bone is freshened. Under guidance of a spinal needle a superior portal for anchor placement is created. Through this portal, using a 1.2-mm K-wire, a "Crimson duvet" technique on the footprint is performed.[12,13]

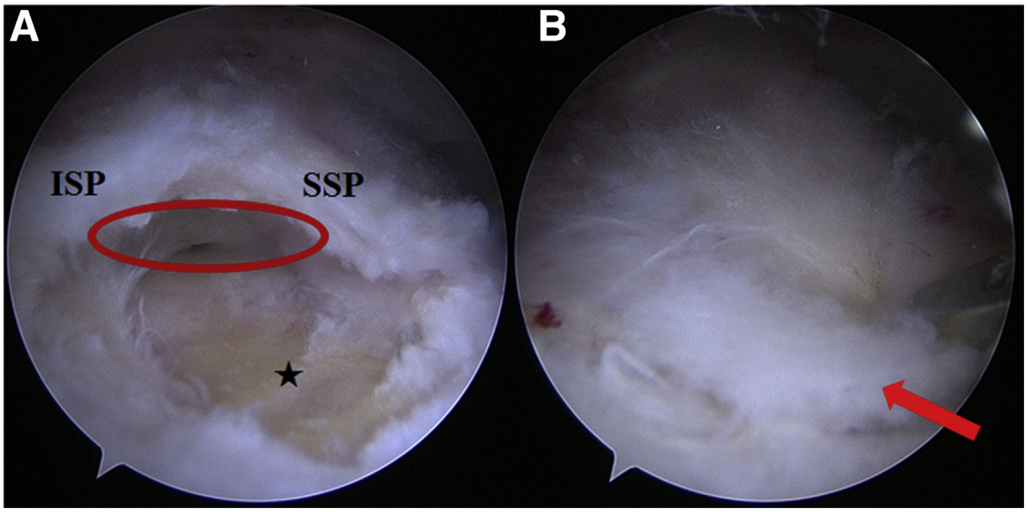

Fig 1. Arthroscopic view of a right shoulder in the beach chair position from the lateral portal visualizing a complete supraspinatus tear (SSP) and partial infraspinatus tear (ISP) with a delamination (red circle showing the inferior layer) with empty footprint (asterisk) before (A) and after (B) repositioning (red arrow).

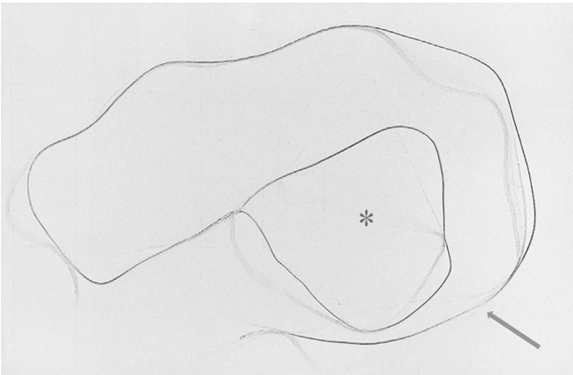

Fig 2. Fiberlink suture with a closed loop on one end (asterisk) and a straight limb on the other end (arrow).

Medial Anchor Placement

Thereafter, 2 medial row anchors (Corkscrew FT III, Arthrex, Naples, FL) are inserted, one on the posteromedial edge of the footprint next to the cartilage-bone interface, and the second anteromedial.

Interchanging of Sutures

Two Fiberwire sutures (Arthrex) are then replaced with 2 loop sutures (Fiberlink [Fig 2] and Tigerlink suture, Arthrex). After assessing the RC tear configuration again, the tendon is repositioned anatomically to establish the future exit points of the sutures in the superficial layer. When in doubt, an absorbable side-to-side suture between the infraspinatus and the supraspinatus part is done.

Inferior Layer Fixation With Cinch Configuration

Consecutively, the inferior layer is penetrated separately with a suture retriever for each suture (Fig 3A). The first limb (without sling) is retrieved and lead through the sling of the second limb of the same suture to create a cinch configuration This results in a total of only 4 suture limbs. When pulling on the straight suture limb the sling shortens, pulling the inferior layer to the cartilage-bone interface over the anchor (Fig 3B). Friction in the eyelet of the suture anchor inhibits the tendon to retract back again.

Superior Layer Penetration

Thereafter, the suture limbs are shuttled through the superficial layer of the RC (Fig 3 C and D).

Establishing a Lateral Row

Finally, by fixing 2 alternating sutures in place with two 5.5-mm biocomposite knotless anchors (Swivelock, Arthrex) lateral to the footprint, a bridging technique is achieved, resulting in a transosseous-equivalent repair configuration (Fig 3E); one anchor is placed posterolateral, and the other anterolateral leading to a knotless anatomic double-layer cinch bridge repair with an intra-articular re-establishment of the inferior layer to the cartilage-bone interface (Fig 3F).

Postoperative Rehabilitation

Postoperatively all patients are prescribed a sling (UltraSling, Breg MDSS, Hannover, Germany) for 4 weeks. Passive motion and closed chain exercises are started immediately, assisted motion exercises from the fifth postoperative week, and active exercises from the seventh postoperative week onward. No weight bearing or strengthening exercises for 12 weeks postoperatively were allowed.

Discussion

Delamination in posterosuperior RC tears occurs in approximately 85% of the cases.[3] Whether reconstruction of the inferior layer is beneficial for centering of the glenohumeral joint is still a matter of debate.[8] The described technique has some advantages and disadvantages (Table 2).

The advancement of the inferior layer to the cartilage-bone interface, where the superior capsule originates,[6] restores the insertion area and the superficial tendinous layer covers the remaining footprint. Because the superior and inferior layers are sometimes retracted in different directions,[14] addressing the 2 layers separately also allows us to reconstruct complex delaminated tears.

Although no biomechanical data regarding the proposed technique have been published so far, a biomechanical investigation of self-cinching stitches showed superior tissue-grip strength at the tissue-suture interface when compared with equivalent non—self-cinching stitches.[15] In addition, the biomechanical principle that the strongest restraint against sutures tearing through the tendon is medial of the rotator cable[16] is respected. Recent biomechanical data could highlight the importance of the superior capsule to avoid superior glenohumeral translation.[17] Normalization of superior glenohumeral translation in motion could potentially decrease retear rates and improve clinical outcome as proposed by Adams et al.[8] Interestingly, the author's (P.R.H.) practical experience, when addressing revision of failed RC repairs, is that the inferior layer often seems untouched. Delamination could be missed because of the surgeon's preferences of viewing portals. Han et al.[3] demonstrated that only 11% of tendon delamination could be detected looking solely from the posterior viewing portal, 70% from a posterolateral portal, and 100% could be observed from a lateral viewing portal.

Reduction of tendon perfusion through medial knots could be a biologically limiting factor in common RC reconstructions. Knotless techniques potentially maintain perfusion and less likely compromise tendon tissue.

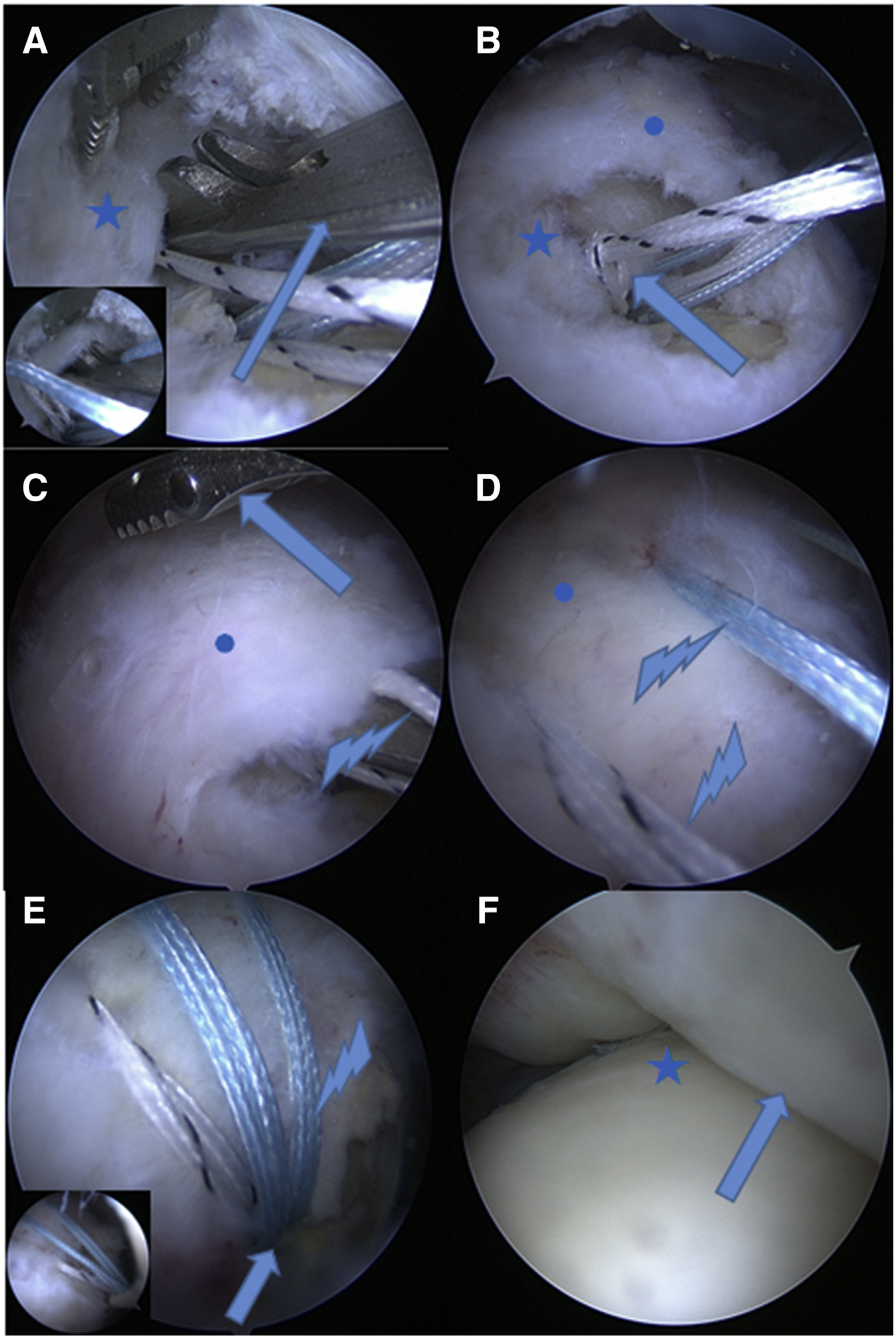

Fig 3. Arthroscopic view of a right shoulder in the beach chair position from the lateral portal showing (A) Fiberlink sutures shuttled through the inferior layer (asterisk) with an antegrade suture passer (arrow). (B) Bringing the straight end of the suture through the loop and pulling on it closes the cinch (arrow) and bringing the inferior layer (asterisk) over the anchor at the cartilage-bone interface, whereas the superior layer (dot) remains untouched. Because of the friction between the suture filaments, the layer stays almost by itself in place. (C) After the inferior layer is secured in cinch configurations, the remaining suture limbs (flash) are shuttled through the superior layer (dot) with a suture passer (arrow). (D) The free ends of the Fiberlink sutures (flash) are then shuttled through the superior layer (dot). (E) In a last step, the Fiberlink sutures (flash) are then secured laterally with a knotless suture anchor in a transosseous-equivalent-type technique (arrow). (F) The intra-articular view shows an anatomic re-establishment of the superior capsule (arrow) at the cartilage-bone interface (asterisk).

Christoforetti et al.[18] showed that after a suture bridge repair, tendon perfusion is reduced by nearly 50%. Although a completely knotless repair construct shows a significantly inferior load to failure and higher gap formation compared with medially knotted techniques, clinically, knotless techniques seem to provide the same, or even lower, retear rates as knotted transosseous-equivalent repair techniques.[19,20] This fact might be attributed to less tendon strangulation resulting in better blood perfusion.

Table 2. Advantages and Disadvantages With the Arthroscopic Knotless Anatomic Double-Layer Cinch Bridge Repair

Advantages	Disadvantages
Anatomical repair	Time-consuming technique because of suture shuttling through the anchor
Potentially improved structural healing	Often difficult to recognize tear anatomy
Maintenance of tendon perfusion	Failure of lateral fixation leads to failure of total repair construct
Potentially restores stable fulcrum	Suture interposition between 2 layers
Possible high pullout strength	
Possible high foot print coverage	

To our knowledge, only one other knotless reconstruction technique addressing both layers has been published so far.[9] However, the technique resembles more a classic double-row repair with 4 points of fixation without including a bridging construct like modern transosseous-equivalent reconstructions. Only biomechanical, but no clinical data for this technique have been reported. This might be due to a limited indication for the mentioned technique, because personnel communication from the author that corresponds also with the present study author's experience is that the used knotless anchors, where the sutures are running outside the anchor, are prone to pullout by the leverage of the sutures, especially in osteoporotic bone.

Biomechanical and short-term clinical data regarding the cinch bridge technique have been generated and are prepared to be published. Our knowledge of pearls and pitfalls with the knotless double-layer cinch bridge technique is outlined in Table 3.

The knotless double-layer cinch bridge technique enables anatomical reconstruction of the superior joint capsule and the adjacent RC tendons, normalizing the glenohumeral joint's translation and avoiding tissue strangulation, which potentially could lead to a lower retear rate and better clinical outcomes.

Table 3. Pearls and Pitfalls With the Arthroscopic Knotless Anatomic Double-Layer Cinch Bridge Repair

Pearls	Pitfalls
Leaving some slack of the suture when retrieving Fiberlink prevents breaking of the loop at the splice	Bad tissue quality may lead to cutting through cinch stitch
Using suture anchors with large eyelets avoids that Fiberlink gets stuck when shuttled through	Osteoporotic bone quality may lead to suture loosening by cutting through the bone
Pretension cinch before establishing a lateral row	

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