19 Delaminated Tears of the Rotator Cuff: The Rationale and Techniques for the Double-Row Repair

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19.1 Introduction

The rotator cuff is constituted by the tendons of the supraspinatus, infraspinatus, and teres minor muscles, and it has more than one layer. Delamination represents a horizontal separation of the tendon layers in the setting of a ruptured rotator cuff. Histologically, delamination occurs between two layers of collagen fibers with a different fiber orientation [1].

Although delamination is frequently observed during arthroscopic surgery (38–82% of the cases), only a few reports describe the layers involved and the retraction patterns of the delaminated cuff tendon. In addition, there is a lack of well-founded recommendations regarding the most appropriate surgical technique to anatomically repair these cases [2].

The physical exam of patients who suffer from rotator cuff tears does not vary if the tear is delaminated or not. Standard magnetic resonance imaging (MRI) usually does not demonstrate the tendons delamination, while MRI with either intra-articular or intravenous contrast injection enables differentiation between both types of tears.

In 2001, Sonnabend et al. [1] first reported a laminated lesion in a patient with rotator cuff tear injury, while Boileau et al. described the healing of the supraspinatus following arthroscopic repair. Their findings demonstrated that tendon recovery was poorer in case of subscapularis or infraspinatus delamination [3].

According to Sang-Won Cha et al. [4], comprehension of the delamination process and the retraction patterns allows for an anatomical balanced repair of each layer.

In occasions where two tendon layers are found at the rotator cuff tear site, the upper layer is recognized as the supraspinatus or the infraspinatus and the lower part of the horizontal tear as the superior glenohumeral capsule. A surgical technique entailing independent repair of the infraspinatus and the articular capsule was described by Mochizuki et al. [2]. The objective is to restore the static function of the capsule and the dynamic function of the rotator cuff. By doing so, the technique may lead to better clinical outcomes [5].

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19.2 Imaging: Findings and Classifications

Contrast MRI of the shoulder represents the best imaging study for the identification of delaminated tears. The sensitivity and specificity for the detection of delaminated tears with this technique are 92% and 94%, respectively [6]. Recently, an MRI classification for this type of tears has been described (Table 19.1) [6].

Cha et al. classified tears according to the lesion pattern of the delamination (Table 19.2) [4]

Table 19.1 Choo, Kim et al. radiological classification for partial or complete delaminated tears

Type 1	Completely delaminated rotator cuff tears
1a	The deep or articular layer is more medially retracted than the superficial or bursal layer, with or without the horizontal image
1b	The superficial or bursal layer is more medially retracted than the deep or articular layer, with or without the horizontal image
1c	The superficial or bursal layer is equally retracted than the deep or articular layer, with or without the horizontal image
Type 2	**Partially delaminated rotator cuff tears**
2a	The delamination is only of the deep or articular layer and medially retracted; the superficial or bursal layer is normally inserted, with or without the horizontal image
2b	The delamination is only of the superficial or bursal layer and medially retracted; the deep or articular layer is normally inserted, with or without the horizontal image
2c	The delamination is interstitial; it is between layers both deep or articular layer and superficial or bursal layer

Table 19.2 Tear pattern of delaminated rotator cuff tears. Himchan classification

Type D	The observed pattern retraction of the deep layer
D1	Supraspinatus and infraspinatus lesion, with posterior-medial retraction
D2	Supraspinatus lesion, anterior medial retraction
Type S	**The observed pattern for the superficial layer**
S1	The lesion is more infraspinatus than supraspinatus with posterior-medial retraction
S2	The lesion is more supraspinatus than infraspinatus, with anterior medial retraction
S3	The lesion is equal for the infraspinatus and the supraspinatus, with retraction anteriorly and posteromedially

19.3 Surgical Treatment

Currently described arthroscopic techniques must be tailored to each specific injury pattern. We depict below the most commonly used:

19.3.1 Technique by Suyaga et al. [7]

The authors reported two alternative techniques:

19.3.1.1 Dual-Layer Double-Row (DLDR)

- To perform the DLDR, the surgeon repairs the deep and superficial layer separately based on the direction of the tear and the retraction pattern of each layer.
- One or two anchors at 0–5 mm articular margins are inserted. The articular surface of the deep layer and the superior capsule are taken, and after delivering the sutures through the tissue, a knot is tied.
- One to three anchors are inserted at the lateral margin of the greater tuberosity to fix the superficial or bursal layer.

19.3.1.2 Dual Layer Suture Bridge (DLSB)

DLSB technique is assumed to be an effective surgical method if the tear retraction pattern of both (deep and superficial) layers runs in the same direction.

Place two anchors at the medial row. Penetrate the articular surface of the deep layer and the superior capsule with a mattress stitch. Make a knot. Do not cut the tied suture limbs.

Pass the medial row tied sutures through the superficial layer. Place a knotless anchor at the lateral part of greater tuberosity to complete the suture bridge configuration.

19.3.2 Technique by Mochizuki et al. [2]

The deep layer is treated as the articular capsule. It is pulled laterally across the glenoid and fixed at the articular edge of the great tuberosity.

The superficial layer is treated as the infraspinatus. It is pulled anterolaterally up to the edge of the bicipital groove and stabilizes with an anchor.

19.3.3 Technique by Burkhart et al. [8]

Load-sharing ripstop (LSRS) is described to improve fixation strength in delaminated cuff tears associated with poor tissue quality. A 2-mm suture tape is placed in anterior-posterior direction as an inverted mattress stitch in the rotator cuff.

Medial row sutures coming from two anchors are passed through the deep and superficial layers of the cuff medial to the tape. First, the ends of the tape are fixed to the greater tuberosity with a knotless anchor. Lastly, the medial row sutures are tied.

19.3.4 Technique by Mori et al. [5], Triple Row (Picture 19.1)

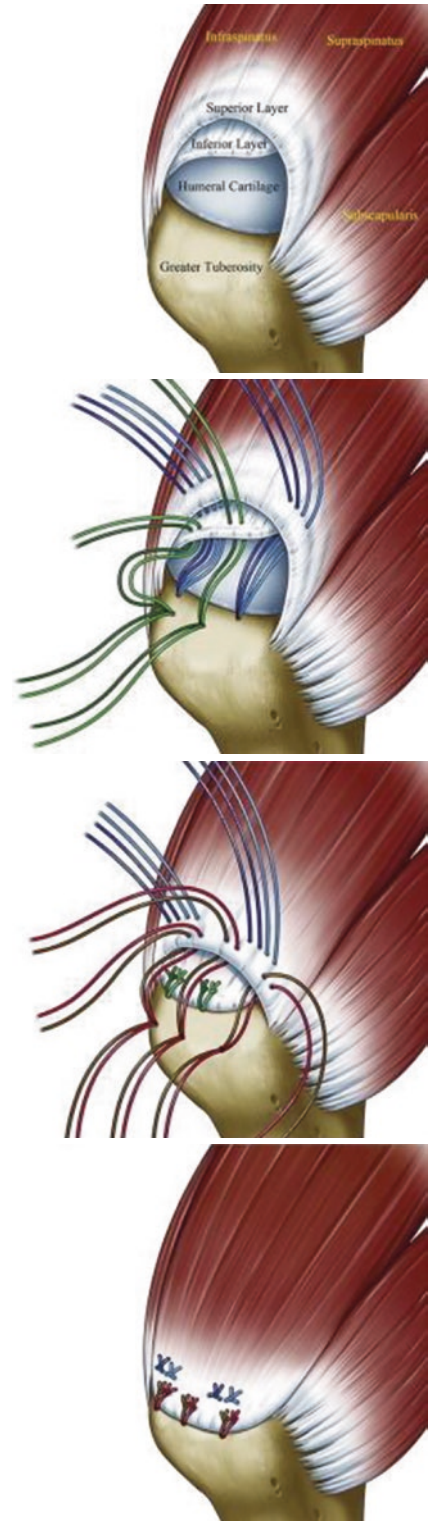
Medial row sutures are passed through the inferior (articular side) and superior (bursal side) layers in a mattress fashion.

Lamina-specific lateral-row simple sutures are passed through the inferior layer.

Lateral-row simple sutures are passed through the superior layer.

19.4 Rehabilitation

The rehabilitation program depends on the tissue quality and the fixation strength. Commonly, after a period of immobilization of 4 weeks, a gentle passive motion with a stable scapula is recommended for at least 8 weeks.



Picture 19.1 Scheme of tripe-row delaminated rotator cuff repair. Courtesy of: Mori, Funakoshi, Yamashita. Arthroscopy Techniques 2014

19.5 Discussion

Several studies have consistently shown a horizontal split between the different layers of a teared rotator cuff, with a delamination rate of 71%. Such rate did not vary by gender, age, handedness, worker compensation status, or tear size. MacDougal [9] stated that the presence of delamination did not influence the total Western Ontario Rotator Cuff score or physical symptoms subsection score either preoperatively or at 2 years following arthroscopic repair. However, other studies have shown that the presence of cuff delamination increases procedural risk and impairs long-term outcome.

Although contrast MRI can't detect cuff delamination and help typify them, its use in every single patient with shoulder pain appears excessive, increasing health cost. In contrast, arthroscopic examination remains the best way to determine the various retraction patterns of delamination [6, 10–12].

Regarding the infraspinatus muscle, it is critical to recognize its precise insertion site at the top of the greater tuberosity, its layers, and its retraction patterns. Such data enable the restoration of native insertions sites and natural biomechanics which will ultimately lead to better clinical results.

Kim et al. [13] compared double-layer double-row repair versus conventional en masse repair in patients with delaminated cuff tears. Although both techniques shared similar range of motion and functional scores, double-layer double-row repair lead to lower visual analog scale score for pain. Meanwhile, on a recent systematic review including ten papers [14], the authors found no clear difference in clinical outcomes among single-row, double-row, or triple-row techniques in patients with delaminated tears except for an improvement in short-term structural integrity with double-row technique. However, many of the abovementioned publications studies did not report the precise tear pattern orientation, its reinsertion site, as well as technical details regarding the double- row technique. Therefore, the role of double- and triple-row fixation techniques still needs to be tested on a standardized fashion and with longer follow-up.

19.6 Final Thoughts

Delaminated rotator cuff tears are relatively common during arthroscopy. The deep or articular layer seems to be part of the superior capsule, whereas the upper or bursal layer arises from the infraspinatus. The surgical goal is to recognize the tear patterns and the retraction of each layer to reduce and repair the different layers appropriately. Further research is needed to really know if these new ways to approach these tears will lead to better clinical outcomes.

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