Recurrent tears of the rotator cuff: Effect of repair technique and management options

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Abstract

Retears of the rotator cuff, following operative repair, is not an uncommon event. Various factors have been shown to influence recurrence including the technique of repair. Multiple techniques have been performed with varying results and complications. The repair technique significantly affects the rate and pattern of retears. Although risk of retears with double row and suture bridge techniques is relatively low, medial cuff failure is a potential complication which poses significant challenges when revision repair is undertaken. Modifications in surgical techniques in both, double row and suture bridge repairs can help decrease the risk of medial cuff failure. Thorough analysis of retear rates and patterns reported, and their relation with the repair technique, provides new insights about the pathogenesis of rotator cuff retears, their future prevention and appropriate management.

Introduction

Tears of the rotator cuff are a common pathological entity of the shoulder, and are present in 20.7% of the general population.1 Various approaches and techniques have been described to repair a torn rotator cuff. Despite advancements in surgical technique, retear of a previously repaired rotator cuff tendon is a fairly common complication. Although functional outcomes do not always correlate with the structural integrity after repair, several studies reported superior outcomes in intact tendons compared to return ones.2-4 Repair of a recurrent rotator cuff tear (RRCT) is more difficult owing to shorter tendons and excess implant at the footprint. Multiple patient factors and operative techniques affect the rate and pattern of rotator cuff retears. The aim of this article is to review the rates, patterns, and management of rotator cuff retears, and how these factors are affected by different methods of primary repair.

Tendon to bone healing

Animal studies have shown that regeneration of the structure and composition of the normal tendon-bone interface is never achieved after repair of the torn rotator cuff tendon.5 Healing begins with formation of a fibrovascular tissue which acts as a scaffold for gradual bone ingrowth. Finally, collagen fiber continuity is re-established.6 Several genetic factors and inflammatory mediators play important roles during the healing process. Growth factors can potentially be administered to promote tendon healing after repair. In a rat model, addition of transforming growth factor-beta 3 (TGF-β3) to calcium-phosphate matrix improved strength of repair at 4 weeks postoperatively compared to calcium-phosphate matrix alone.7 Similarly, application of fibroblast growth factor-2 to rotator cuff defects reconstructed with acellular dermal matrix in rats accelerated remodeling and improved biomechanical strength.8 In a sheep model, application of bone morpho-genetic protein-12 showed increased formation of new bone and fibrocartilage at the tendon bone interface on magnetic resonance imaging (MRI) and histologic examinations. Additionally, biomechanical testing showed increased load-to-failure.9

The effect of platelet-rich fibrin matrix (PRFM) on the structural integrity of rotator cuff tendons after repair is controversial. Barber et al.10 demonstrated lower retear rates on MRI with the addition of PRFM. On the other hand, it has been shown, in two randomized controlled trials, that PRFM is not beneficial for rotator cuff tendon healing after repair.11,12 Diagnosis of a rotator cuff tear after surgical repair does not always imply failure of healing. It can theoretically be secondary to early mechanical failure due to an unsound repair, biologic failure of healing despite a good repair or recurrent tear after successful healing of the initial tear. Miller et al.13 reported 9 retears, 7 of which were documented during the first 3 months postoperatively, which reflects mechanical failure of repair rather than biological failure of tendon to bone healing. Iannotti et al.14 in a multi-institutional study, had only one out of 19 retears diagnosed later than 6 months postoperatively.

Factors affecting retear rates

A large number of factors affect the rate of RRCT. Increasing patient age has been shown in multiple studies to have a negative impact on tendon healing. The risk of retear progressively increases with increasing age.15 Boileau et al.16 reported significantly lower rates of healing over the age of 65 years. Preoperative images and intraoperative findings can provide clues on the risk of retear. Retears are more likely with larger tears, higher degree of tendon retraction, shorter tendons and more severe fatty degeneration.6,15,17-19 The initial tear size is reported to be the most significant factor that affects tendon healing. The relative risk of retear increases 2.29 times with every 1 cm increase in tear size.15 Fatty degeneration is a powerful prognostic factor. More severe fatty degeneration has been associated with significantly higher retear rates.18 Liem et al. demonstrated higher retear rates with Goutallier stage 2 compared to stages 0 and 1.20 Length of tendon available for repair can also have a direct effect on success, with tendons of lengths more than 15 mm and less fatty infiltration showing better results.19 Radiologically, recent studies showed that high critical shoulder angle or short acromiohumeral interval increase the risk of retear20,21 (Figure 1). Quality of tendon and bone can also significantly influence healing. Bone mineral density was found to be an independent predictor of rotator cuff healing after repair.22 Finally, comorbidities of smoking and diabetes have detrimental effects on tendon healing.23 Neyton et al.24 reported significantly higher retear rates in smokers compared to nonsmokers (Table 1).
Effect of repair technique on rotator cuff retear

The effect of suture position and configuration on retear rates and patterns has been of particular concern. In SR repair, stitches should be positioned just medial to the rotator cuff to decrease risk of cutout of the tendon. Passing sutures lateral or through the cable should be avoided. Double row (DR) repair provide better biomechanical properties compared to single row (SR) in terms of mechanical strength, gap formation, footprint coverage and tendon to bone contact that theoretically leads to improved healing response. The suture bridge (SB) technique can increase footprint coverage and mean pressurized contact area even more, with higher ultimate-to-load failure and mean pressurized contact area even more, with higher ultimate-to-load failure and less gap formation when compared to a DR technique (Figure 2). Also, inserting lateral row anchors away from the top of the greater tuberosity (more lateral) in SB technique potentially leaves more space on the footprint for the tendon to heal. Passing sutures through the lateral edge of the tendon, in DR technique, can be worrisome especially in chronic degenerative tears, whereas bridging sutures over the edge of the tendon, in SB technique, flattens and stabilizes the lateral edge and prevents the tear from catching on impinging structures. Moreover tension mismatch during humeral rotation is less likely with SB owing to the interconnection between anchors.

Suture bridge technique, however, is not without drawbacks. Although contact pressure might be beneficial for healing, it can reduce blood flow to the rotator cuff tendon. Stress concentration and increased risk of retears around the medial anchors have been great concerns since the introduction of DR and SB techniques. A few studies have demonstrated significantly higher rates of medial cuff failure after DR and SB techniques (Table 2). Therefore, it is clear that no technique is optimum in all situations, and the rate and pattern of retear varies according to the initial repair technique.

Effect on retear rates

The incidence of RRCT varies greatly. A systematic review by Duquin et al. evaluated retear rates after different repair techniques. They analyzed the results according to the size of the initial tear to less than 1 cm, 1-3 cm, less than 3 cm, 3-5 cm, more than 3 cm and more than 5 cm. Retear rates were significantly lower for DR compared to SR in all tears more than 1 cm. Hein and colleagues, in a more recent systematic review, followed similar methods to evaluate retear rates after arthroscopic SR, DR and SB techniques. The overall retear rates were 26%, 21% and 21% respectively. Their study included 2048 rotator cuff retears. They reported significantly less retear rates after DR than SR techniques in all tear sizes except those between 3 and 5 cm. Retears after SB technique were also significantly less in all tear sizes except those less than 1 cm and between 3 and 5 cm. Our explanation to these results is that tears between 3 and 5 cm that are repaired arthroscopically might be small enough to get back to the footprint but large enough to be over-tensioned, in case they are anatomically repaired without adequate release. This potentially affects retear rates in DR and SB techniques more than it does in SR. Smaller tears are usually not much retracted and inadequate release may not have a significant negative impact, whereas in larger tears, adequate release is necessary, and not optional, in order to be able to get the tendon back to the footprint. In other words, tears between 3 and 5 cm might be the most vulnerable to repair with excessive tension. Recently, Sobhy et al. in a systematic review of level I randomized controlled trials comparing SR and DR repairs, showed significantly higher partial-thickness retear rates after SR compared to DR. However, the higher number of full-thickness retears after SR was not statistically significant. Despite the decreased overall retear rates with DR and SB compared to SR techniques, the opposite seems to be true in case of short tendons. Kim et al. observed retear rates after repair of larger than medium-sized tears (more than the entire supraspinatus). Retear rate was significantly higher with SB than SR in patients with remnant tendons less than 10 mm in length.

Table 1. Preoperative factors affecting rotator cuff retear rates.

| Preoperative factors | SR (%) | SB (%) | K-SB (%) |
|----------------------|--------|--------|----------|
| Age16                | 26     | 21     | 21       |
| Fatty degeneration of rotator cuff13-16 | 10 (40.9) | 12 (54.5) |
| Osteoporosis3         | 13 (59.0) | 9 (40.9)   |
| Smoking23-24          | 1 (4.5)    |         |          |
| Diabetes23            |         |         |          |
| Initial tear size15   |         |         |          |
| Critical shoulder angle21 |         |         |          |
| Acromioclavicular interval17 |         |         |          |
| Length of tendon23    |         |         |          |

Table 2. Rotator cuff retear patterns according to repair technique.

| Authors, year | N. retears | Type | SR (%) | SB (%) | K-SB (%) |
|---------------|------------|------|--------|--------|----------|
| Kim et al., 201441 | 65 | Type 1 | 15 (71.4) | 9 (40.9) | 12 (54.5) |
|               |           | Type 2 | 5 (23.8) | 13 (59.0) |         |
|               |           | Type 3 | 1 (4.7) | 9 (40.9) | 1 (4.5) |
| Lee et al., 201335 | 30 | Type 1 | 10 (33.3) |         |         |
|               |           | Type 2 | 20 (66.7) |         |         |
| Cho et al., 201148 | 29 | Type 1 | 12 (41.4) |         |         |
|               |           | Type 2 | 17 (58.6) |         |         |
| Cho et al., 201044 | 46 | Type 1 | 14 (73.7) | 7 (25.9) |         |
|               |           | Type 2 | 5 (26.3) | 20 (74.1) |         |

SR: single row, DR: double row, SB: suture bridge, K-SB: knotless suture bridge. Type 1: retear at the tendon-bone interface, type 2: medial cuff failure, type 3: unclassified. Studies included in the table are those reporting both repair technique and retear type, with total number of retears more than 20.
Effect on retear patterns

Cho et al.\textsuperscript{40} classified retear patterns as type 1 which is failure at the tendon-bone interface (Figure 3A), and type 2 which is medial cuff failure with remnant cuff remaining attached to the greater tuberosity (Figure 3B). Kim et al.\textsuperscript{41} added type 3 for unclassified patterns. Despite the decreased risk of overall retear rates with the introduction of DR and SB techniques, type 2 retears have evolved and have become more frequent than type 1.\textsuperscript{32-35,40-43}

Medial cuff failure was not reported until Trantalis et al.\textsuperscript{32} recognized 5 cases of medial cuff failure after DR repair. Potential causes postulated for this retear pattern were (1) transferring the tension-bearing row more medial, (2) use of braided suture materials that are ultimately stronger than the diseased tendon and (3) oblique passage of instruments through the tendon which puts more tension on the medial cuff, creates larger holes in the tendon during passage, and compromises the overall integrity of the tendon. Hayashida et al.\textsuperscript{42} reported 7 type 2 out of a total of 13 retears after DR repair. Similarly, when reviewing the retear patterns after SB repair (Table 2), studies suggest that rotator cuff tears repaired with SB technique demonstrated type 2 retears in more than half of the retear rotator cuffs.\textsuperscript{34,35,40,41} Two studies, each included more than 45 total retears, directly compared retear patterns according to repair technique.\textsuperscript{34,41} Both comparative studies showed significantly higher rates of type 2 retears in the SB than in the SR groups (Table 2).

The musculotendinous junction

The musculotendinous junction (MTJ), in particular, is a vulnerable point. Cho et al.\textsuperscript{34} reported 20 type 2 retears out of 27 total retears (74%) after SB repair, in which type 2 retears were mainly at the MTJ. Placing medial row sutures through the MTJ diminishes the holding strength and increases risk of failure compared to sutures placed through the tendon, 5 mm or 10 mm lateral to the MTJ.\textsuperscript{44,45} This is particularly important in chronic degenerative tears that often demonstrate tendon tissue loss and in revision cases. However, in patients with muscle atrophy and/or fatty degeneration, retears occur more often at the footprint because the tendon proper becomes mechanically weaker than the MTJ.\textsuperscript{34,40}

Prevention of medial cuff failure

Despite the relative increase in type 2 retears with SB technique, Neyton et al.\textsuperscript{24} in a study performed on 107 patients treated with SB technique, reported 10 type 1 retears and only one type 2 retear (Table 2). They explained their results with technical modifications that reduced the risk of type 2 retears. In their study, no more than 2 medial row anchors were used, with only one suture on each anchor. Medial row mattress sutures were not over-tensioned. These modifications decreased the amount of mattress sutures and limited the harmful compression that could form zones of necrosis across the footprint. They also penetrated the tendon 5 mm, or more, lateral to the MTJ.

Other strategies have been performed to decrease the stress concentration on medial row anchors, and thereby decrease the risk of medial strangulation and necrosis. Knotless suture bridge technique (K-SB) showed lower, but statistically insignificant, type 2 retears compared to conventional SB

| Table 3. Factors influencing the decision to perform reverse total shoulder arthroplasty for recurrent rotator cuff tears. |
|---------------------------------------------------------------|
| **RTSA recommended**                                           | **RTSA not recommended** |
| Good deltoid function                                          | Poor deltoid function    |
| Persistent pseudoparalysis                                     | Axillary nerve injury     |
| Irreparable rotator cuff tears                                | Painful shoulder with good active anterior elevation |
| Rotator cuff arthropathy                                      |

RTSA reverse total shoulder arthroplasty.

Figure 2. Techniques of rotator cuff repair (Single row, double row, suture bridge).

Figure 3. A) Type 1 rotator cuff retear; retear at the tendon-bone interface. B) Type 2 rotator cuff retear; medial cuff failure.

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Revision surgery. Poor prognostic factors include female sex and poor preoperative range of motion. Rotator cuff repair is not recommended in patients with disrupted deltoid origin and those who have had more than one prior cuff repair.

**Tendon augmentation grafts**

Multiple natural and synthetic grafts have been used, demonstrating mixed results, to augment repair of massive rotator cuff tears. Barber et al. in a randomized controlled trial demonstrated higher healing rates and better ASES and constant scores with augmentation of repair using GraftJacket acellular human dermal matrix (Wright Medical Technology, Arlington, TN) compared to repair alone. Similarly, in a retrospective study on 152 patients with massive rotator cuff tears treated by open repair, augmentation of repair with synthetic polypropylene patch (Repol Angimesh, ANGIOLOGICA BM Srl, Pavia, Italy) showed lower retear rate and better UCLA scores, elevation in the scapular plane and abduction strength. Xenografts, however, do not seem to be as efficient. A randomized controlled trial compared augmentation of repair with porcine small intestine mucosa to repair without augmentation failed to show significant differences in functional outcomes or healing rates. Favorable healing rates have also been reported with polyester ligament synthetic graft, as well as with biceps tendon and fascia lata autografts. The latter studies, however, are retrospective studies with less number of patients.

**Superior capsular reconstruction**

Superior capsular reconstruction is also a potential treatment option for revision procedures. Mihata et al. reported favorable outcomes after arthroscopic superior capsular reconstruction using fascia lata for patients with irreparable cuff tears, with significant improvement in ASES scores. Dermal allograft is another option for capsular reconstruction with less morbidity and shorter operative time. A recent multicenter study performed on 59 patients with irreparable cuff tears showed promising results after arthroscopic superior capsular reconstruction with dermal allograft. Added cost, however, is a limitation of dermal allograft compared to fascia lata.

**Salvage procedures**

Tendon transfer can be a treatment option for irreparable cuff tears without arthritis, particularly in young patients in which arthroplasty is not preferred. The location of the tear significantly influence the surgeon’s choice of the donor tendon. For posterosuperior tears, tears with outcomes have been reported with both Latissimus dorsi (LD) and lower trapezius as donor tendons. Lower trapezius is a biomechanically better option because the direction of pull of the lower trapezius is more in line with the native rotator cuff than that of LD. For anterosuperior tears, pectoralis major transfer has been traditionally performed providing improvement in functional outcomes and reducing pain. However, poor outcomes have been reported in patients with anterior subluxation of the humeral head. Latissimus dorsi transfer to the subscapularis insertion is another option that provides a more anatomic transfer owing to the more posterior origin of LD compared to pectoralis major. Latissimus dorsi is more in line with the origin of the subscapularis, therefore more effectively bringing back the humeral head to the center around the glenoid. Elhassan et al. described the feasibility of the latter procedure with or without teres major transfer.

**Conclusions**

Repair technique significantly affects rotator cuff retear rate and pattern after...
arthroscopic repair. Medial cuff failure is gaining more attention in clinical practice and the literature. Although DR and SB techniques decrease the overall rates of retears, the increased risk of medial cuff failure theoretically poses significant revision challenges. Therefore, retear patterns, in addition to retear rates, should be considered when evaluating the outcomes of different techniques of repair. Studies with long term follow up are needed to demonstrate which outcomes are better; less retears that are mostly type 2, or more retears that are predominantly type 1.

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