Current Concept: Arthroscopic Transosseous Equivalent Suture Bridge Rotator Cuff Repair

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Contents

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Introduction

Surgical repair is recognized as the standard treatment for patients with symptomatic rotator cuff tear. Physiologically young and active patients need early repair of rotator cuff tear to achieve prompt return to daily and sports activities.

More evidences are now available that nonoperative treatment of the rotator cuff tears leads to irreversible changes in the tendon, and to irreparable massive tears [63] Today, even fatty degeneration of muscle belly is no longer regarded as a strict contraindication for rotator cuff repair [16]. On the other hand, in a prospective study, early repair of symptomatic supraspinatus tears has been shown to provide better clinical results and to prevent tear propagation [42]. In the light of these scientific proofs, rotator cuff repair is the preferred treatment in most cases.

Arthroscopic rotator cuff repair has several advantages over open surgical repair. Arthroscopy enables the evaluation and treatment of accompanying glenohumeral joint problems [40]. It also allows better visualization and more comprehensive assessment of rotator cuff. Tendon mobilization may be facilitated precisely to allow tension-free repair. Furthermore, preserving deltoid origin results in less soft tissue damage and less postoperative pain [10].

Evolution of Arthroscopic Rotator Cuff Repair

After 1990, with improvement of arthroscopic techniques and suture anchors, first series of all arthroscopic rotator cuff repairs were published. In the early 2000s Burkhart et al. described principles of rotator cuff repair, such as tear type recognition, correct anchor placement, multiple suture anchor design, and loop and knot security [12]. Despite the use of principle-based repair methods, failure rates in arthroscopic rotator cuff repair series remained high for nearly 10 years [8, 28, 30, 32, 34, 45]. The main problem was retear of repaired cuff. Today, rotator cuff repair

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researches focuses on: (1) biomechanically strong and durable fixation methods and (2) on improving tendon-bone healing by reconstruction of anatomic footprint of rotator cuff.

We will summarize improvements in these fields, evolution of double-row philosophy and our preferred arthroscopic double-row suture bridge transosseous equivalent rotator cuff repair technique.

Biomechanical Improvements

"Transosseous sutures" were the preferred fixation technique in traditional rotator cuff repair. In the beginning of arthroscopic repair procedures, suture anchors played a great role [50]. Several authors showed rotator cuff repair with arthroscopy to be a feasible method [20, 32, 57]. Anchors provided secure fixation on sutures to the bone with minimal invasive methods, without transosseous tunnels.

Due to high failure rates in arthroscopic repair series of larger rotator cuff tears, biomechanical properties of suture anchor repair was questioned. Weakest links in the repair chain were determined as interfaces between anchor–bone, suture–anchor, and suture–tissue [41]. Newer anchor designs had overcome the problem of cutting off from bone. Screw type, 5–6 mm diameter metallic and bioabsorbable anchors are nearly standard devices now. Placing the anchor parallel to the bisector of lines tendon pulling vector and perpendicular to bone (dead man's angle) helped to achieve more stable bony purchase [11]. Older anchor designs might cause suture failure due to friction at the anchor eyelet [5]. But suture fixation in the anchor also was changed and this type of failure also does not occur anymore. Bioabsorbable anchors are being more preferred than metallic ones because they have high failure loads, less complication rates, and build no artifact in postoperative magnetic resonance imaging studies [44].

Tendon grasping and obtaining durable reconstruction with sound knots is technically the most demanding part in arthroscopic repair. Mason Allen type suture was known as the strongest soft tissue grasping method in classic open repair [31]. Due to retrograde and antegrade suture passing devices, arthroscopic methods replicating Mason Allen suture were introduced, by combining one mattress and one simple suture [52]. However, their holding strength did not overcome mattress or simple sutures alone [53]. Secure knots with braided sutures may also be achieved either with locking or non-locking techniques. Knot security problem was solved with well-described methods in the past years [15].

Despite these big steps in arthroscopic repair techniques, high failure rates were still reported especially in large to massive tears series [8, 28, 30, 32, 34, 45]. Ultrasound and MRI evaluations revealed retear rates up to 40–90% [28, 30, 34]. At this point, researchers introduced double-row concept with using medial and lateral row anchor placement to strengthen the initial strength of repair complex [25, 36]. Biomechanical studies revealed that adding lateral row or a transosseous suture to the medial row anchor fixation significantly improves the initial and ongoing strength of repair [6, 21].

Anatomic "Footprint" of the Rotator Cuff and "Double Row" Philosophy

Anatomic studies on rotator cuff insertion had described an area called "footprint." Footprint area of the supraspinatus tendon consists of a mean medial-to-lateral 15 mm width and 21–25 mm anterior–posterior length [19, 23] This area begins immediately at lateral end of the articular cartilage and covers the top of greater tubercle.

Cadaveric and computer model studies revealed that with single-row anchor repair, only 46–67% of original anatomic footprint may be covered [3, 39]. Furthermore, with transosseous repair larger area of contact was obtained [3].

To achieve less failure rates, more anatomic repairs were aimed. Double-row anchor rotator cuff repair was introduced for enlarging the tendon bone contact area and for reducing tension over each suture [25, 36]. Biomechanical evaluations confirmed the hypothesis about contact area. Mazzocca et al. observed that double-row repair consistently restored larger footprint area than single row construct, but they did not find any significant difference between two types of repairs regarding biomechanical properties, such as load to failure and gap formation under cyclic loading [38]. In contrast, other studies reported that double-row constructs achieved superior resistance to gap formation and higher ultimate failure load than single-row repair [6, 37, 56].

Transosseous repair has a long clinical history and have been shown in multiple studies to have superior biomechanical properties when combined with suture anchors. Adding a transosseous suture to the single row suture anchor repair nearly doubled ultimate failure strength [21, 61, 62]. Contact area and pressures were also studied to compare single-row and transosseous repair techniques. Transosseous repair revealed significantly higher contact pressure in a larger area [47]. Some authors placed second-row anchors at the lateral side of the greater tubercle, outside of the foot print area, to mimic a transosseous suture, and they have reported lower failure rates than single-row repair [2, 35]. The studies also showed that repair site integrity was durable during biological healing period. In another study with animal models double-row repair resulted in better biological healing with superior biomechanical properties than the single-row repair [46].

At the same time period, knotless anchors with suture locking with pressure between bone tunnel and anchor were introduced [13]. These types of anchors were used in "transosseous equivalent suture bridge technique." Suture bridge technique was first introduced by Park et al. in 2006 and has become a widely accepted method in the treatment of medium to large tears [48]. Suture bridge is a kind of double-row repair, however, it stands one step ahead of it, due to being less difficult and reproducing larger contact area with higher pressure at the tendon – bone interface [49]. This type of repair allowed less tissue extravasation than simple suture repair in a cadaveric model. Authors concluded that double-row repair may potentially enhance rotator cuff healing [1].

Author's Preferred Technique

We prefer beach chair position in all arthroscopic rotator cuff procedures. Thorough examination of glenohumeral joint and release of intra-articular adhesions in necessary cases is the first step of arthroscopic rotator cuff repair. Medial part of footprint area is debrided from fibrous tissue while the camera is still in the glenohumeral joint (Fig. 1). This step helps to understand the shape and the size of the tear from the articular side (Fig. 2a). Afterward, the camera is moved to the subacromial space. Meticulous debridement of bursal tissue and extra-articular adhesions is essential for mobilization of torn tendon, good visualization, and easier suture passage. Acromioplasty is performed as determined in the preoperative planning. Distal clavicle resection is also added, if necessary. Before the repair, debridement of floppy fibrous tissue at the tendon-end should be done and bleeding surface on the whole footprint area should be ensured.

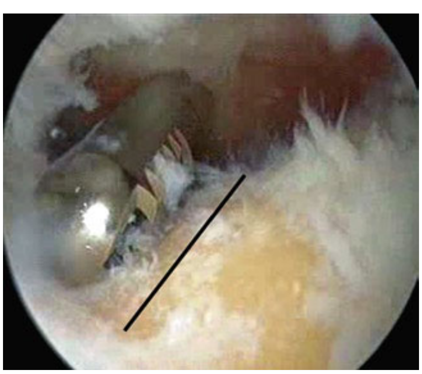

Fig. 1 Debridement of the footprint area. Note the greater tubercle and footprint area (*black bar*)

We usually place one anchor per 1 cm of tear. If the tear size is between 1.5 and 2.5 cm in anterior to posterior dimension we prefer to use two anchors (Fig. 2b) and if the tear size is 2.5–3 cm we prefer to use three bioabsorbable screw-type anchors at the medial row. Anchors are placed more than 6 mm apart from each other (Fig. 3). Entry hole is immediately at the articular cartilage and to achieve dead man's angle, the arm is adducted during their insertion. Every anchor is loaded with two sutures with different colors. Initially, posterior sutures are passed in U- or V-shaped tears. In L-shaped tears, where the corner of the tear has to be fixed to the anterior part of the foot print, anterior sutures might be passed first. Good tendon grasping is achieved by rotating the arm for finding the best place to pass the suture. Free bird-beak-type suture graspers (Arthrex, Naples, Florida, USA), clever hook (Depuy Mitek, Raynham, Massachusets, USA), Suture Lasso (Arthrex, Naples, Florida, USA) (Fig. 4), or Scorpion (Arthrex, Naples, Florida, USA) (Fig. 5)-type suture passing devices with different shape and angles can be used. Medial row sutures are passed at least 1 cm medial than the lateral end of tendon tissue. Arthroscopic knots are tied in sliding or non-sliding fashion by respecting the row of suture passing (Fig. 2c). First passed sutures are tied first. For each anchor one knot is left with suture ends, while the suture ends of the other knot is cut with arthroscopic scissors (Fig. 6). Remaining four suture ends from two sutures, with different colors, are used to build suture bridge (Fig. 2d). One end from the anterior and the other from the posterior anchor are fixed to the lateral cortex, approximately 1 cm lower than lateral end of the footprint, using Pushlock (Arthrex, Naples, Florida, USA) suture locking-type anchor (Figs. 2e and 7). Same step is repeated at a more posterior (7–10 mm) point on the lateral cortex. Step is repeated if three anchors were used, at a more posterior point. At the end of procedure, repair construct should look like letter "M" (Figs. 2f and 8).

More recently, in cases with large to massive tears, we prefer to use tape-like suture material, Fibertape (Arthrex, Naples, Florida, USA), fixed in a tunnel with bioabsorbable screw (Bio Swivel Lock (Arthrex, Naples, Florida, USA) to build medial row (Fig. 9). Sutures are passed through the tendon and knotting is not performed. Lateral row is established using the tape-like sutures from the medial row again with knotless anchors as described before. This completely knotless repair helps to accelerate the procedure with passing fewer sutures and surpassing knotting step. Since the material is much broader than braided conventional sutures, contact area at the repair site increases. Knotless repair with tape-like suture was biomechanically tested earlier and the study showed that this type of repair complex had presented no disadvantage against double-row repair with classical suture anchors with knots [58].

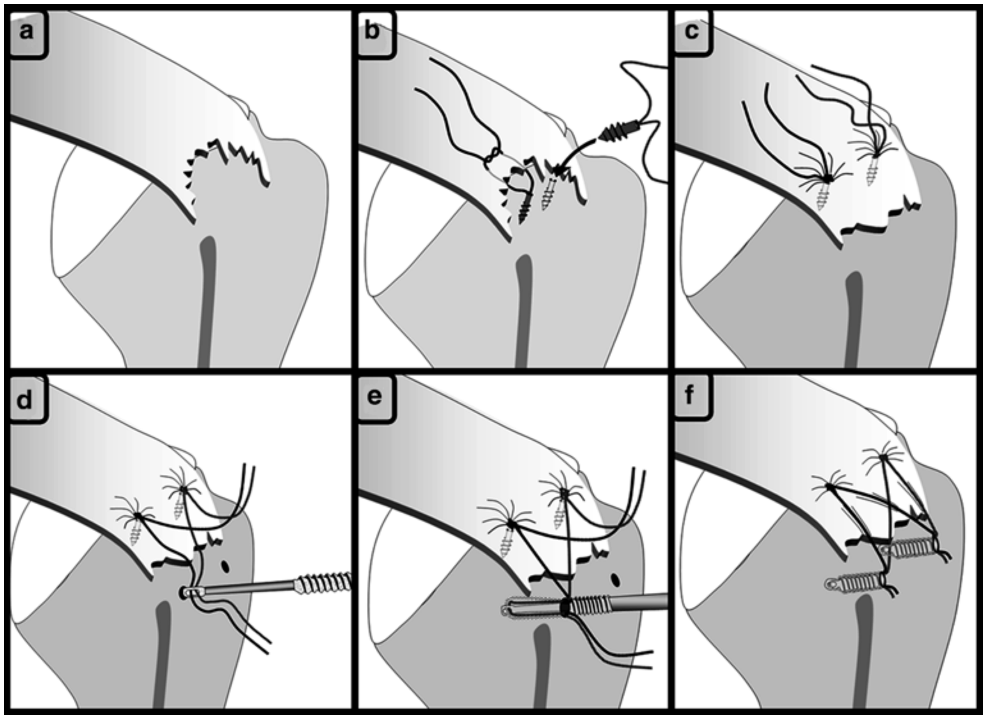

Fig. 2 (**a**) Footprint area and tendon ends are debrided before the repair. (**b**) Insertion of the medial row anchors. (**c**) The knots are tied and medial row repair is completed. (**d**) Four suture ends from two sutures are used to build suture bridge. (**e**) The suture ends of the medial row anchors are fixed with a pushlock to the lateral cortex for the lateral row repair. (**f**) At the end of procedure repair construct should look like letter "M"

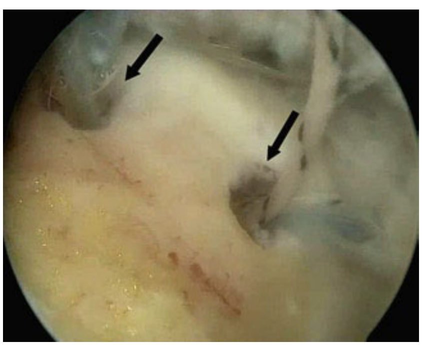

Fig. 3 Medial row anchors (*black arrows*) are placed more than 6 mm apart from each other

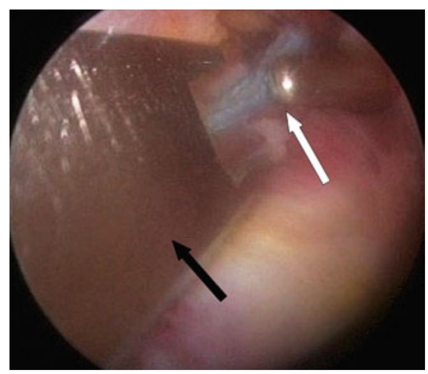

Fig. 5 Use of Scorpio (*black arrow*) for suture passing. A grasper (*white arrow*) catches the tip of the passed suture

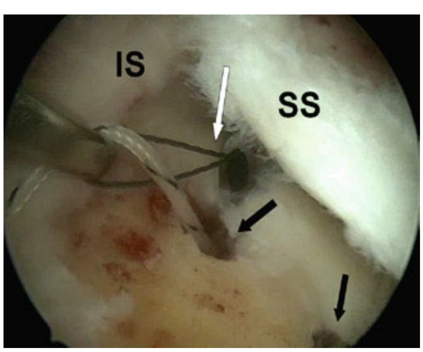

Fig. 4 Use of a suture lasso (*white arrow*) to pass the sutures of the medial row anchors (*black arrows*). *IS* infraspinatus, *SS* supraspinatus

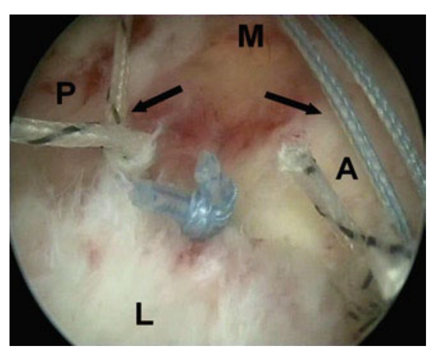

Fig. 6 For each anchor one knot has been left with suture ends (*black arrows*), while the suture ends of the other knot has been cut. *P* posterior, *M* medial, *A* anterior, *L* lateral

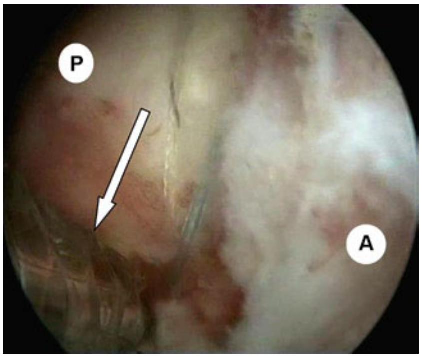

Fig. 7 One end from anterior and the other from posterior anchor are fixed to the lateral cortex with a Pushlock (*white arrow*). *P* posterior, *A* anterior

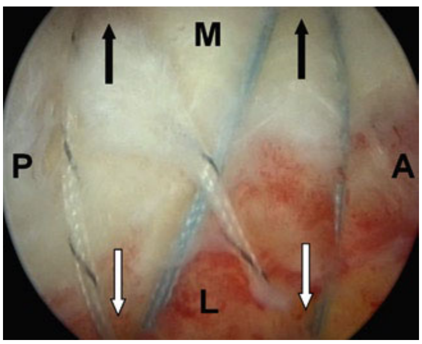

Fig. 8 The final "M"-like view of the double-row suture bridge rotator cuff repair. *Black arrows* point medial anchors, and *white arrows* lateral pushlocks. *P* posterior, *M* medial, *A* anterior, *L* lateral

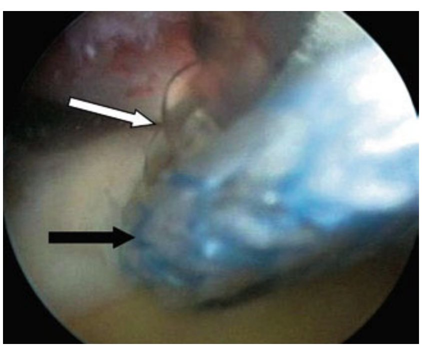

Fig. 9 Fiber tape (*black arrow*) is a tape-like suture materal suitable for the large and massive rotator cuff tears. A Bio Swivel Lock (*white arrow*) can be used for the fixation of the fiber tape in the medial row repair

Clinical and Anatomic Outcomes of Series

Results of clinical series with double-row repair usually revealed good results [35, 48, 59]. However, series with control group of single-row repair reported contradicting results. A systematic review of five comparative studies revealed no difference between single- and double-row repair groups in terms of clinical outcome and failure rates [43]. Some series advocated better healing and less failure rate [18, 24, 59], others concluded that there was no difference between double-row and single-row repair groups [4, 27]. Another recent systematic analysis studied six prospective randomized trials with a total number of 388 patients revealing that there appears to be a benefit in structural healing when an arthroscopic rotator cuff repair is performed with double-row fixation as opposed to single-row fixation. However, they found little evidence to support any functional differences between the two techniques, except, possibly, for patients with large or massive rotator cuff tears. They have concluded that double-row fixation may result in improved structural healing at the site of rotator cuff repair in some patients, depending on the size of the tear [51] Burkhart and Cole [14] criticized some of these studies because of small patient numbers [27, 60] and comparing single-row repair and not the standard double-row technique [17, 38]. Authors concluded that the only prospective randomized trial with proper power analysis revealed retear rate in transosseous equivalent suture bridge group which is significantly lower than single row repair group [29]. It has been emphasized that great advantage of cuff repair is gaining strength, and the only way to assess tendon healing clinically is improved muscle forces. Therefore, they suggest that there is a need for developing new outcome tool that addresses quantifying postoperative gains in strength [14].

Despite all efforts, failures, even though their percentage declines, still do occur following arthroscopic rotator cuff repair. Patient series with long follow-up have investigated prognostic factors that might affect clinical results. Larger defects, interstitial delamination of cuff tissue, fatty degeneration, older patients, and late admittance for surgery were determined to be the main poor prognostic factors [9, 26, 45, 55]. Surgeons should consider these factors before consulting their patients about rotator cuff repair and its results.

Future Aspects

While attempts are made to improve mechanical strength and enlarge contact area in the repair site, investigations are also continuing to get better and more rapid biological healing. Therefore, derivates like bone morphogenetic protein (rh BMP) [54], insulin-like growth factor (IGF-1) [22], and matrix metalloproteinase inhibitors (Alpha-2 macroglobuline) [7] were studied in animal models. All studies obtained encouraging results regarding mechanical and histological evaluations. However, mesenchymal stem cell application at the rotator cuff repair site brought no advantage yet in another animal study [33].

Summary and Conclusion

Clinical outcome of arthroscopic rotator cuff repair is proven to be successful as traditional open or mini-open techniques in long-term follow-up. For patients, early recovery and less postoperative pain, for surgeons, better visualization and tendon mobilization, are the main advantages of the arthroscopic method. Today more anatomic and stronger repair is possible with transosseous equivalent suture bridge technique. The technique had been nearly a standard operative procedure in arthroscopic repair of medium to large sized rotator cuff tears in our hands. With longer follow-up, importance of transosseous equivalent suture bridge repair will be better understood. In future, rotator cuff investigation will focus on the methods to achieve better tendon-to-bone biological healing and recover fatty infiltration at the muscle unit.

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