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SHOULDER

# Arthroscopic repair of rotator cuff tear with a modified Mason–Allen stitch: mid-term clinical and ultrasound outcomes

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**Abstract** One of the most discussed point about arthroscopic full-thickness rotator cuff (RTC) repair is the strength of tendon–stitch interface. In the period between November 2003 and September 2004, in a series of 29 patients with primary isolated supraspinatus tear measuring >2 cm a reconstruction using one titanium anchor and a modified Mason–Allen (MMA) stitch was done. These patients were prospectively collected in this study and then retrospectively evaluated. There were 21 men and 8 women with a mean age of 59.3 years. Patients were examined pre-operatively by a single sport medicine doctor, very experienced on shoulder pathology problem. Constant score, University of California at Los Angeles (UCLA) scale and Simple Shoulder Test (SST) were administered. After a minimum follow-up of 24 months patients were revaluated clinically by the same independent examiner. At the same time patients underwent an ultrasound shoulder examination to evaluate rotator cuff integrity. Clinically there was a significant improvement of Constant score, SST score and UCLA scale at follow-up. Twenty-five patients (86.2%) were satisfied, whether the other four patients (13.8%) stated that they would decline procedure. Recurrent rotator cuff tear was found in 11 patients (38%), who were all older than 60. All the patients but one with a pre-operative MRI grade III tendon tissue fatty infiltration, had a cuff re-tear. Arthroscopic supraspinatus tendon repair with one single anchor and MMA stitch is a reliable technique leading to a re-tear of 38% that is comparable with results reported in literature.

**Keywords** Rotator cuff · Arthroscopy · Modified Mason–Allen · Stitch · Shoulder · Repair · Re-tear

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## Introduction

Over the last few years arthroscopy has been introduced to repair rotator cuff tear (RCT). Despite continual improvement in surgical techniques and instrumentation, re-tear of the sutured tendons does still occur in variable but significant percentage of patients [28].

With the development of stronger suture material, the weak link remain principally at the level of the stitch–tendon interface [1, 11, 15, 33, 35]. Biomechanical and clinical studies showed that the modified Mason–Allen (MMA) stitch has the highest ultimate tensile load when compared to other suture techniques [37]. However, because MMA stitch is difficult to perform arthroscopically, different variations of stitch, such as suturing technique combining a horizontal and simple suture has been used in attempt to influence the repair durability and clinical success of a rotator cuff repair [26, 37]. Improvement of tendon–suture interface is a very relevant aspect of cuff repair, because of evidence that functional results after surgery tend to be better in patients showing an integrity of

rotator cuff repair at the follow-up time [1, 4, 24]. At the best of our knowledge, although there are a lot of papers that have addressed clinical results after arthroscopic cuff repair [7, 21, 23, 31, 32, 39], however, a small number report about cuff integrity after surgery evaluating a specific surgical technique [4, 21, 24, 38].

The purpose of this study is to verify the reliability of arthroscopic repair of full-thickness RTC using a MMA stitch, that has revealed in a biomechanical study a high resistance to loading [5], with use of postoperative ultrasound imaging.

The null hypothesis was that this arthroscopic repair shows no difference about rate of cuff integrity respect that reported in literature in previous published series of arthroscopic repair in which a more simple suture configuration was used.

## Materials and methods

In the period between November 2003 and September 2004, 410 primary arthroscopic rotator cuff repair of chronic full-thickness rotator cuff tears were performed at our shoulder unit. In 29 patients repair was done using 1 anchor and a MMA stitch. Patients underwent a this repair showed a full thickness tear measuring intra-operatively >2 cm in large and limited to the supraspinatus tendon.

These patients were operated on when they failed a period of at least 4 months of conservative treatment. There were 21 men and 8 women with a mean age of 59.3 ± 10.9 years. Dominant arm was involved in 19 patients (70%).

Patients were examined pre-operatively by a single sport medicine doctor, very experienced on shoulder pathology problem, which perform a clinical examination. Moreover, a Constant score [10], University of California at Los Angeles (UCLA) scale [12] and Simple Shoulder Test (SST) [25] were administered.

Pre-operatively a radiographs evaluation (anterior–posterior view, axillary and outlet view) and MRI was performed; tendon fatty infiltration was evaluated and registered according to classification system of Goutallier's [17]. After arthroscopic debridement of the degenerated part of tendon, coronal extension of RCT was classified according to Patte [34]. When tendon edge was lying over the greater tuberosity, it was classified as a stage I tear. When the edge is between the lateral aspect of the cartilage edge and apex of head it was classified as grade II. If the edge of tear is medial to the apex of head was classified of grade III and when the tear extended to the glenoid rim it was classified as grade IV. The degree of tendon retraction was routinely reported on the operative protocol of patient at the end of surgical procedure.

### Surgical procedure

A single senior surgeon performed all the procedures with the patient in the lateral decubitus position. Four to five kilogram of balanced suspension were used with the arm in 70° of abduction and 20° of forward flexion using a shoulder traction system. Routine portals were developed and glenohumeral joint arthroscopy was performed at first. In 19 cases a long head biceps (LHB) tenotomy was done because of associated biceps pathology. The scope was then placed into the subacromial space and an acromioplasty was also performed in all the 29 patients. The rotator cuff footprint on the greater tuberosity was lightly abraded down to bleeding bone. The cuff tear configuration and retraction was assessed after debridement. The degree of tendon mobility medial to lateral and posterior to anterior was well evaluated with a grasping tool. We have used a 5 mm self-tapping Revo anchor (Conmed-Linvatec, Largo, Fl) loaded with two no. 2 non-absorbable braided polyester sutures. The shape of the anchor eyelet permits the two sutures to glide freely, which allows suture tying with sliding locking knots. A MMA technique combining a horizontal lateral side-to-side suture and two simples sutures as vertical loops was utilized. This step of cuff repair was performed with the scope through the standard lateral portal. Using the Spectrum suture passing device and shuttle relay system (Conmed-Linvatec, Largo, Fl) one limb of the two sutures of anchor was passed through anterior and posterior limb of cuff tear from bottom to the top approximately 1 cm from the tendon edge. These sutures were not immediately tied. Next, using the curved spectrum suture hook and shuttle relay system (Conmed-Linvatec, Largo, Fl), a horizontal side-to-side stitch using a no. 2 ethibond (Ethicon) suture lateral to other two sutures was placed (Fig. 1). This suture is tied at first from posterior portal. After this step, the scope is moved posteriorly and the other two sutures tied through the lateral portal. The final suture configuration was a modified MMA stitch with one horizontal mattress suture and two vertical (simple) sutures placed medial to the mattress suture (Fig. 2a). The mattress horizontal lateral stitch is always tied first in order to enhance the holding power of the two simple vertical sutures. The horizontal mattress suture serves as a "rip stop stitch" and theoretically reduces the possibility of the simple sutures cutting out, especially in a degenerative tendon (Fig. 2b). In the postoperative time patients worn a shoulder brace with a neutral external rotation and 15° of abduction for a period of 4–5 weeks to protect the repair. Passive auto-assisted range of motion exercises were started the first postoperative day and limited at 80° of anterior flexion and 45° of abduction for 4 weeks. After this time a formal physical therapy was started consisting in gradual gain of range of motion with exercise performed also in

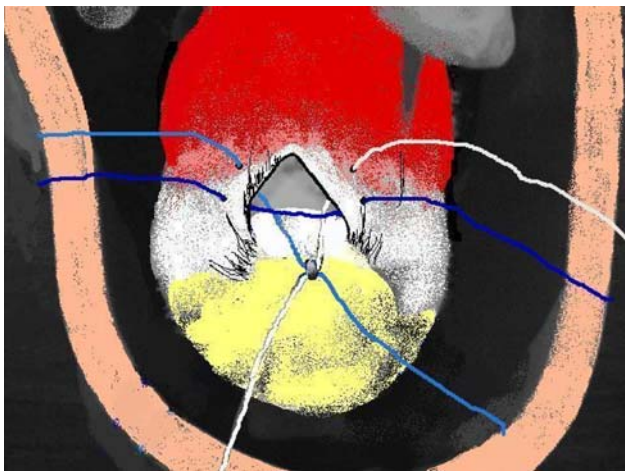

**Fig. 1** Schematic drawing of cuff repair performed with our modified Mason–Allen stitch. The horizontal suture is passed laterally respect to the other two sutures and is used to perform the horizontal side to side suture. The other two vertical suture are used to perform the two simples vertical loops

swimming pool and a 3 months postoperatively a program of strengthening using theraband system was started. Full activities were allowed at the 6th month postoperatively.

### Postoperative assessment

After a minimum follow-up of 24 months (average follow-up 30.2 ± 4.2 months) a review of these prospectively collected patients was carried-out by the same independent examiner who evaluated them before surgery. Constant score, SST, UCLA score were calculated and degree of satisfaction was investigated. At the same time patients underwent an ultrasound shoulder examination. All ultrasonograms were performed in the real time using a Medison 9900 scanner with a trapezoidal transducer of 12 MHz.

Examination was performed by a very experienced radiologist which was blinded about type of surgery performed on the patients.

### Analysis of data

The analysis was performed using a Student's *t*-test to compare pre- and postoperatively Constant, UCLA and SST score. Measurements are expressed as the mean and the standard deviation (SD).

A significant difference was defined as $p < 0.05$.

Moreover, standardized response means (SRMs) were calculated as the change score (baseline to follow-up) divided by SD of the change. This statistic standardizes change relative to variability so that head-to-head comparisons can be conducted. SRMs reflected variable ability to detect clinical improvement across different outcome scales [27].

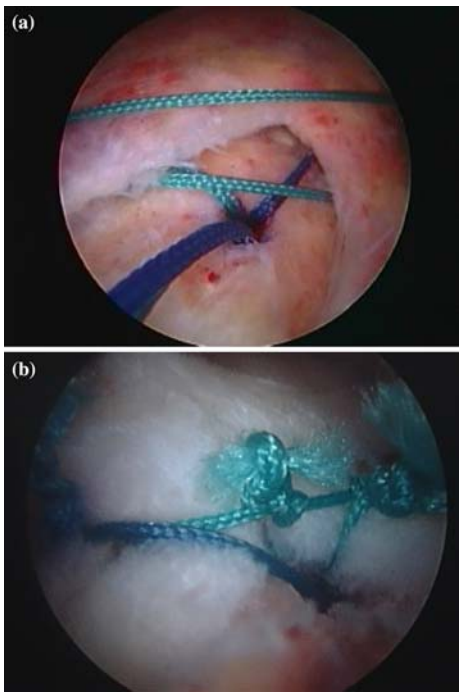


**Fig. 2** **a** This photograph shows a view from arthroscopic midlateral subacromial portal. The horizontal stitch is well visible lateral to the vertical stitches. **b** The vertical stitches are tied after the horizontal stitch. This photograph shows a view final configuration of repair from arthroscopic midlateral subacromial portal

## Results

The main data of patients enrolled in this study are resumed in Table 1.

### Complications

In the patients reported in this series no intra-operative and/or postoperative complication in term of nerve damage, superficial or deep infection were observed.

No patient reports any significant shoulder trauma after surgery.

### Functional outcomes

The average pre-operative Constant score was 37.2 ± 19.5 and average score at follow-up time was 66.1 ± 8.2 ($p < 0.001$). The UCLA scoring system passed from a mean pre-operative value of 14.4 ± 5.2 to a postoperative

value of 30.8 ± 4 ($p < 0.001$). Functional results using SST before surgery and at the time of last follow-up examination showed as the twelve activities were improved after surgery ($p < 0.001$).

SRMs evaluation shows a clinical improvement of 1.8 about Constant score, 1.9 about SST score and 2.6 about UCLA scale.

## Patients satisfaction

Patients were asked whether they were satisfied with the operation and whether they would undergo the procedure again. Twenty-five patients (86.2%) responded yes, whether the other four patients (13.8%) stated that they were disappointed by surgery.

## Ultrasonogram outcomes

Recurrent tear of rotator cuff was detected in 11 patients (38%).

In particular, the radiologist has identified a massive tear in 4 of these 11 patients. These four patients were the same who were unsatisfied by surgery.

## Factor associated with re-tear

The mean age of patients with re-tear was 68 (range 63–78), significantly higher than that with an intact tendon 49.7 (range 29–62) ($p < 0.0007$). In the group of 18 patients in whom not re-tear was observed there were only three patients who had an age equal or superior to 60 years.

**Table 1** Pre and postoperatively main data of 29 patients

| Patient | Age | Sex | Side | Pre-operative IRM | Rupture type in the coronal plane | Constant pre/post | SST pre/post | UCLA pre/post | Postoperative US | Satisfied |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29 | M | R | G I | II | 36/40 | 6/0 | 14/30 | Ok | + |
| 2 | 60 | F | R | G I | II | 33/49 | 11/3 | 11/33 | Ok | + |
| 3 | 65 | M | R | G I | III | 11/44 | 12/4 | 14/27 | Massive re-tear | − |
| 4 | 56 | M | R | G II | II | 72/82 | 5/2 | 22/30 | Ok | + |
| 5 | 57 | M | R | G II | II | 67/83 | 4/1 | 15/34 | Ok | + |
| 6 | 67 | M | R | G III | II | 50/77 | 5/2 | 17/32 | Ok | + |
| 7 | 56 | F | L | G I | II | 32/80 | 6/3 | 12/30 | Ok | + |
| 8 | 45 | M | R | G 0 | III | 23/81 | 9/0 | 16/30 | Ok | + |
| 9 | 56 | M | R | G 0 | III | 37/83 | 9/0 | 7/32 | Ok | + |
| 10 | 58 | M | L | G II | III | 65/86 | 7/2 | 16/35 | Ok | + |
| 11 | 59 | F | R | G II | III | 69/82 | 5/0 | 9/35 | Ok | + |
| 12 | 59 | M | R | G I | II | 26/75 | 12/2 | 7/30 | Ok | + |
| 13 | 67 | M | R | G II | III | 72/83 | 3/1 | 28/33 | Massive re-tear | − |
| 14 | 76 | F | R | G I | II | 44/67 | 6/3 | 15/28 | Re-tear | + |
| 15 | 67 | M | R | G I | III | 30/47 | 9/0 | 5/23 | Re-tear | + |
| 16 | 63 | M | R | G III | III | 36/76 | 7/2 | 12/30 | Re-tear | + |
| 17 | 65 | F | R | G III | III | 60/61 | 2/2 | 19/22 | Massive re-tear | − |
| 18 | 68 | M | R | G III | III | 37/66 | 7/3 | 13/21 | Massive re-tear | − |
| 19 | 43 | M | R | GI | I | 65/87 | 8/2 | 23/35 | Ok | + |
| 20 | 55 | F | R | GO | II | 37/85 | 7/3 | 11/35 | Ok | + |
| 21 | 40 | M | R | G II | I | 24/86 | 11/2 | 14/30 | Ok | + |
| 22 | 68 | F | L | G II | III | 10/45 | 11/5 | 9/31 | Re-tear | + |
| 23 | 62 | M | R | G I | II | 25/49 | 9/2 | 18/35 | Ok | + |
| 24 | 78 | F | R | G III | III | 20/40 | 9/4 | 21/31 | Re-tear | + |
| 25 | 66 | M | R | G II | II | 12/44 | 10/2 | 20/32 | Re-tear | + |
| 26 | 40 | M | R | G 0 | II | 38/80 | 7/2 | 10/35 | Ok | + |
| 27 | 54 | M | R | G 0 | II | 11/45 | 10/3 | 15/25 | Ok | + |
| 28 | 56 | M | L | G I | II | 18/60 | 9/4 | 9/35 | Ok | + |
| 29 | 65 | M | L | G III | II | 20/35 | 10/2 | 16/35 | Re-tear | + |

Taking in account the total number of 14 patients older than 60 years included in this series, we found that this specific group of patients have only the 22% of chance of rotator cuff tendon integrity after this kind of surgery.

If we look at the three patients older than 60 years who not showed a re-tear at follow-up time, we can observe that they had on the pre-operative MRI a GI grade of fatty infiltration (Fig. 3). On the other hand, into the group of 11 patients with a re-tear there were two patients with a Grade II, and three patients with a GI grade of fatty tissue infiltration.

Anyway, it is also very interestingly to note that all the patients with G III tissue infiltration, but one, showed a cuff re-tear (Fig. 4).

In our series the size of the original tear, in particular, in the coronal plane, has shown to not influence the re-tear ($p > 0.08$).

## Discussion

In this study we have found a 38% of rotator cuff re-tear after arthroscopic supraspinatus repair using a MMA. This result is similar to the one reported after open [8, 14, 18, 22], or arthroscopic [4] rotator cuff repair, so the hypothesis of our study is not confirmed. Similar to other published reports [4, 42] we have found that the results of the rotator cuff repair in term of re-tear in older patients were poorer than those in younger patients, particularly, patients older than 60 years showed a 22% of chance of cuff integrity after surgery. The pre-operative tear size, particularly in the coronal plane has been also recognized as factors influencing the cuff re-tear [9, 16, 20]. Our study not confirm this findings, in fact no correlation was found between the grade of retraction on the coronal plane and re-tear, and of the 12 patients in whom a grade III of retraction was observed, there were four with an integrity of repaired supraspinatus at the time of follow-up. The prevalence of recurrent tears in the present study, compare favourably with results reported in previous series in whom open rotator cuff repair was carried-out [3, 21], was lower than previously reported in other studies [13, 16], but higher than reported in other two more recent studies well documented clinical trials [4, 24] evaluating arthroscopic repair. This data merits two considerations: first of all, differently from other series [4, 24], we also included patients with a grade III tendon fatty infiltration; all these patients but one showed at follow-up a cuff re-tear. Eliminating from our series these patients, the results in term of cuff integrity are much better, and more similar to other studies. Secondly, modern ultrasound technique performed by an experienced physician can be an optimal took to control cuff integrity, better than MRI studies [40].

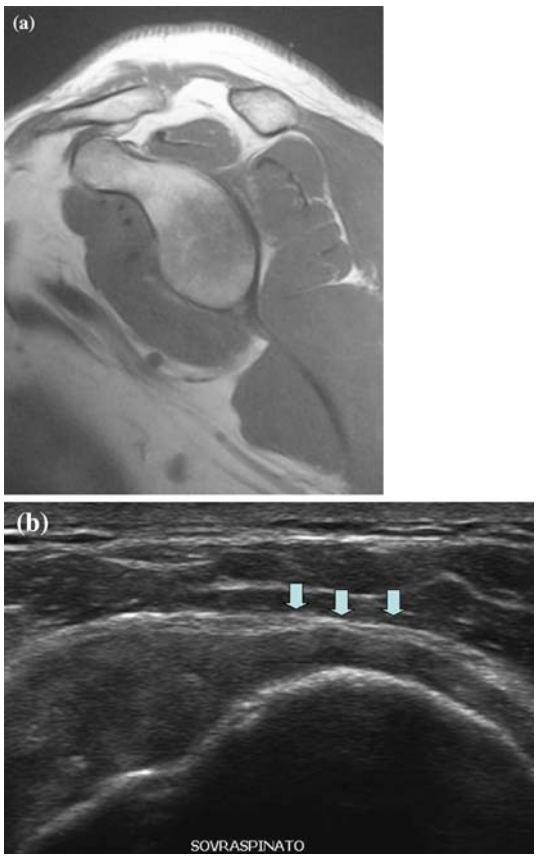


**Fig. 3** **a** Pre-operative MRI showing a grade I degenerative fatty infiltration of supraspinatus tendon. **b** Postoperative ultrasound images of the same patient at follow-up shows a healed tendon (*arrows*)

Our data confirm that the presence of a re-tear not always compromise patients satisfaction. In fact, in our series, only 4 (14%) of the 11 patients with re-tear, those showing a massive cuff re-tear, were disappointed by surgery, confirming that the size of the re-tear influences clinical results.

The main purpose of this study was to evaluate if a new stitch configuration could improve arthroscopic rotator cuff repair. At the light of recent progress in suture and anchor material, the stitch–tendon interface remain the weakest in the chain of repair [11, 33, 35]. The MMA stitch has been reported to improve the ultimate tensile strength for sutures in the tendon, but the holding strength of open fixation technique was greater than that of arthroscopic technique [37]. Because of the difficulty to perform MMA arthroscopically, simpler configurations have been sought. A stitch combining a simple and one horizontal stitch has been showed to have a good biomechanical property [26]. In our study we used a suture technique combining a horizontal loop and two vertical loop at the site of a rotator cuff repair; in a previous in vitro study, this stitch has showed a resistance to loading similar to the MMA [5]. We

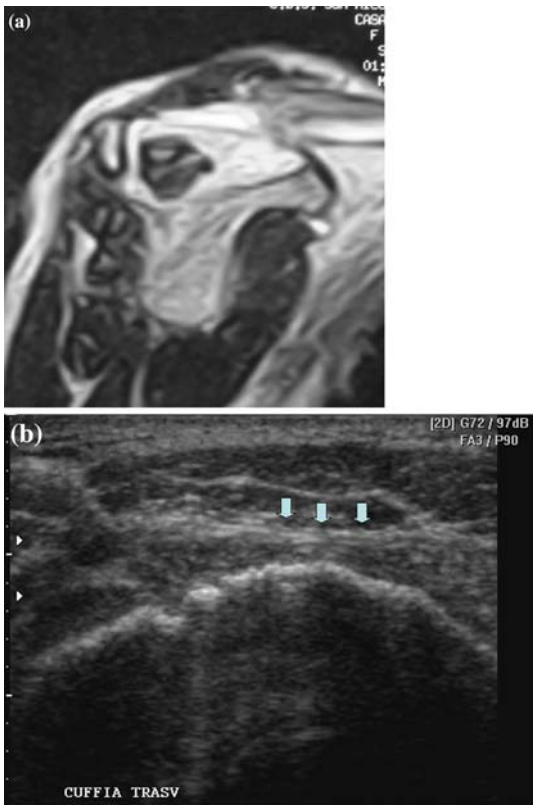


**Fig. 4** **a** Pre-operative MRI showing a grade III degenerative fatty infiltration of supraspinatus tendon. **b** Postoperative ultrasound images of the same patient at follow-up shows a re-tear of tendon (*arrows*)

suppose that this suture configuration combining a horizontal loop and a two vertical stitch at the site of a rotator cuff repair may also allow for a more anatomic reproduction of the rotator cuff footprint. In vitro studies showed that contact area is greater with double row techniques showing a greater fixation strength [29, 41], however both single and double row fixations showed high stress concentration that might be a cause of tendon re-tear [36]. Previously published studies have identified in size and extension of tear the more important factors [2, 4, 16, 19], but, in our series we have found that also a big cuff tear can heal. We suppose that tendon tissue and also bone quality, as evidenced by other authors [4, 30] could be two critical factors involved into tendons re-tear. Nowadays we can identify this feature only looking at MRI image evaluating the degree of tendon fatty tissue infiltration. Certainly, this tool can help surgeon to make diagnosis and prognosis about cuff tear, however evaluation of this imaging studies is subjective and the quality of images is depending by instrumentation.

This study has a lot of weakness. The investigation was retrospective although patients were collected prospectively by the senior author; furthermore, a comparative, control group, operated on with a different suture anchor or double row technique is lacking. The small number of patients do not allow to perform a multivariate analysis to detect all the variables influencing cuff re-tear limiting the conclusions of study. Follow-up period can be short, but we think that a minimum follow-up of 2 years can be enough to study rotator cuff repairs in term of re-tear as confirmed by Galatz et al. [13]. The strength of this study is represented by the presence of a quite homogenous study group, a single surgeon performing a standardized technique, use of different scores to evaluate patients and an independent blinded high definition ultrasonogram evaluation performed by a very experienced radiologist.

In summary, this study shows the reliability of arthroscopic cuff repair performed with the presented MMA stitch with a structural integrity of cuff in the 62% of patients at a minimum 2 years of follow-up. A 86% of patients were satisfied by surgery with a significant improvement in SST, UCLA and Constant score, and the only group of unhappy patients was the one in whom a massive rotator cuff re-tear with no gain in shoulder strength was found.

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