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Clinical analysis of arthroscopic modified Mason-Allen suture in the repair of delaminated rotator cuff tears

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Abstract

Purpose To observe the clinical efficacy and safety of arthroscopic single-row modified Mason-Allen(mMA) suture technique in repairing delaminated rotator cuff tears (RCTs).

Methods According to the inclusion and exclusion criteria, a total of 65 selected cases were treated with mMA by a senior physician. Outpatient follow-up visits were conducted at 1.5 months, 3 months, 6 months, and longer after treatment. The postoperative shoulder range of motion (ROM), Constant Murely score (CS), and UCLA shoulder joint score were evaluated by the same examiner. After the follow-up, the data will be summarized and finally subjected to statistical analysis (Fig. 1).

Results Collected 65 patients with delaminated RCTs repaired using arthroscopic modified Mason-Allen suture technique from May 2022 to June 2023. Three were lost to follow-up, leaving 62 patients who were included in the study analysis, including 21 males and 41 females; age ranged from 50 to 81 years old, with a median age of 65 years old; 34 cases in the left shoulder and 28 cases in the right shoulder; 30 cases with a history of trauma and 32 cases with no obvious history of trauma; According to the Cofield classification of RCTs, all were delaminated tears of the rotator cuff. We recorded changes in shoulder range of motion (ROM) and functional ratings for at least 6 months (6 months to 18 months, average 10 months) postoperatively. Shoulder anteflexion improved from 98.06 ± 11.28° to 172.26 ± 6.63° ($P = 0.028$), abduction improved from 69.68°±18.55° to 160.97 ± 9.53° ($P = 0.006$), internal rotation improved from 14.52°±10.35° to 45.81 ± 4.97° ($P = 0.007$), and external rotation improved from 22.42°±8.62°to 51.29 ± 6.14° ($P = 0.027$); CS preoperative 49.08 ± 4.91and at the last follow-up 97.89 ± 1.62 ($P = 0.043$); and UCLA shoulder score, preoperative 15.73 ± 2.60 and at the last follow-up 33.85 ± 0.15 ($P = 0.044$). 3 cases developed adhesive capsulitis symptoms due to inactive rehabilitation activities after the operation, and the symptoms disappeared after standard rehabilitation training (no secondary operation). All patients had no problems such as rotator cuff tearing and anchor removal.

Conclusion The use of mMA suture technique to repair rotator cuff delamination tears can effectively relieve shoulder pain, improve shoulder function, and have fewer complications.

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Keywords Delaminated rotator cuff repairs, Modified Mason-Allen technique, Arthroscopic rotator cuff repair, Shoulder function

Introduction

Rotator cuff delamination tear is a frequent shoulder injury that causes discomfort and disability while substantially hurting the patient's quality of life. Therefore, the major objective of mending a torn rotator cuff is to enhance the patient's quality of life by lowering pain and increasing shoulder function. Stratified RCTs are a common type of rotator cuff tear. They may even be more painful than full RCTs [1–3], resulting in limited shoulder function and, under the influence of a variety of risk factors, can lead to an increase in the area of the rotator cuff involved in the tear, which progresses to a full rotator cuff tear [4]. Since Codman proposed the concept of "rotator cuff repair" at the beginning of the 20th century, rotator cuff repair methods have gone through the development of incision repair, arthroscopic-assisted small-incision repair, and total arthroscopic repair [5]. The literature on arthroscopic rotator cuff repair has reported that the probability of re-tearing of rotator cuff is more than 11.4% [6–8]. Therefore, to maximize healing and clinical results, surgeons need to examine a range of criteria such as patient age, tear size, fatty degeneration of the rotator cuff tissue, tendon retraction, repair structure, and rehabilitation.

In recent years, with the great improvement of arthroscopic technology, total arthroscopic rotator cuff repair has become the mainstream method of rotator cuff repair due to the advantages of less trauma and faster recovery. Currently, mainstream total arthroscopic rotator cuff repair techniques include single-row, double-row, and suture bridge. It has been reported that double-row repair and suture bridge techniques can achieve better biomechanical results and lower re-tear rates [9], while the clinical efficacy of single-row repair techniques compared with them is still controversial [10]. In addition, when compared to single-row repair techniques, the adoption of double-row repair techniques in stratified RCTs has the disadvantage of increasing the operation time, difficulty, and quantity of internal implants. The mMA method is a special single-row suture method, and we retrospectively analyzed the case data of patients with delaminated rotator cuff injuries repaired using the arthroscopic mMA method of repair to compare the preoperative and postoperative shoulder motion scores while evaluating the possible role of the method in stopping progressive RCTs and enhancing the overall strength of the tendon repair [11–13]. The method may play a very effective role in preventing progressive tearing of the rotator cuff, enhancing the overall strength of the tendon repair, eliminating abnormal motion between rotator cuff layers, and promoting the restoration of the inter-layer tissue relationship, and has achieved ideal clinical results in clinical application [14]. It may be used as an effective method for repairing rotator cuff layered tears.

Few studies have been done on the use of the mMA method in the management of RCTs, and It is not clear whether this method has a safe and reliable effect on rotator cuff delamination. The purpose of this study is to observe the efficacy of mMA repair in the treatment of stratified RCTs and to provide new ideas and treatment bases for orthopedic surgeons in the treatment of delamination RCTs.

Methods

Patient selection

This study selected hospitalized patients who underwent arthroscopic surgery for rotator cuff injuries in our hospital from May 2022 to June 2023. CS, UCLA shoulder score was given based on preoperative and postoperative shoulder range of motion and pain level.

Inclusion criteria: ① Rotator cuff delamination tear; ② Meet the surgical indications for rotator cuff delamination tear(After 6 months of conservative treatment, the symptoms still did not improve significantly, and even worsened); ③ Use mMA single suture technique to perform total arthroscopic rotator cuff repair; ④ Complete preoperative and postoperative follow-up data (Includes basic information, shoulder range of motion and functional scores).

Exclusion criteria: ① Unable to complete the follow-up on time; ② Previous history of shoulder surgery; ③ Patients diagnosed with "severe osteoporosis" before surgery or found significant osteoporosis during surgery.

All patients signed an informed consent form. The study was approved by our medical ethics committee and all patients signed an informed consent form (Fig. 1).

Surgical procedures

The surgery was performed by the same senior chief physician (Fig. 2a–c). After general anesthesia combined with brachial plexus block anesthesia, take the beach chair position, routine disinfection, and spread towels. A posterior approach was established at 1.5 cm and medial 2 cm below the posterolateral angle of the acromion, and arthroscopy was inserted into the glenohumeral joint and subacromial space to observe the anatomical structure and synovial bursa hyperplasia, and to evaluate the injury of long head tendon of biceps brachii and the degree of acromion hyperplasia and rotator cuff

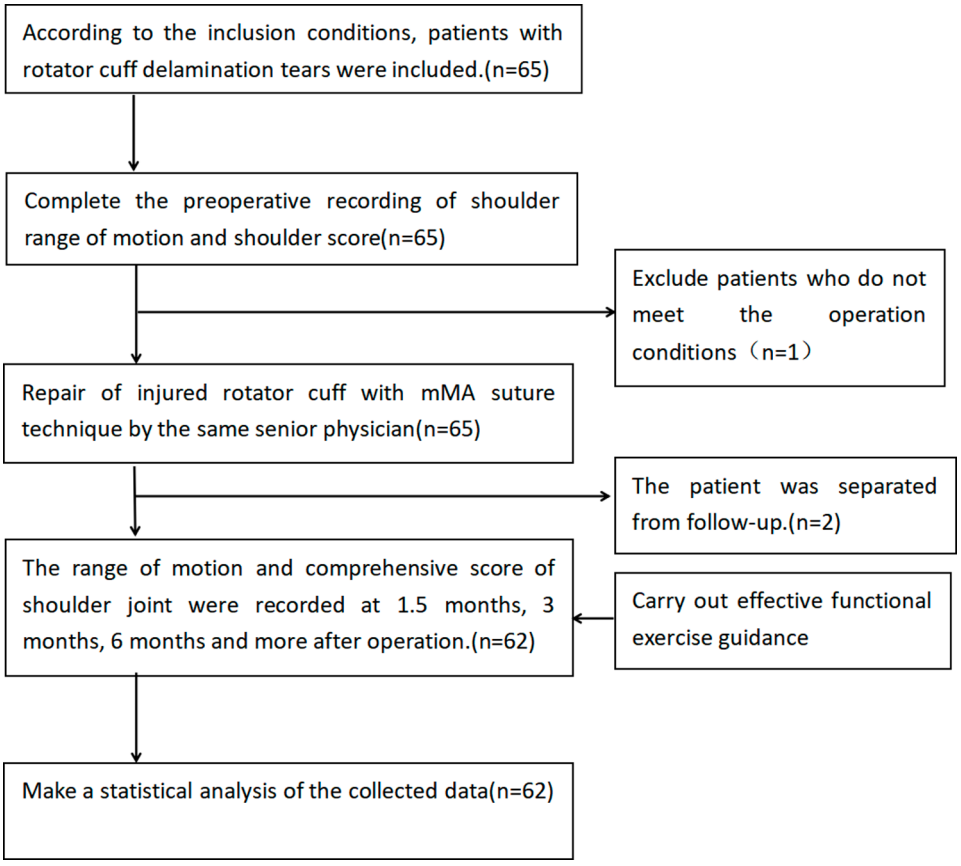

Fig. 1 Research flow chart

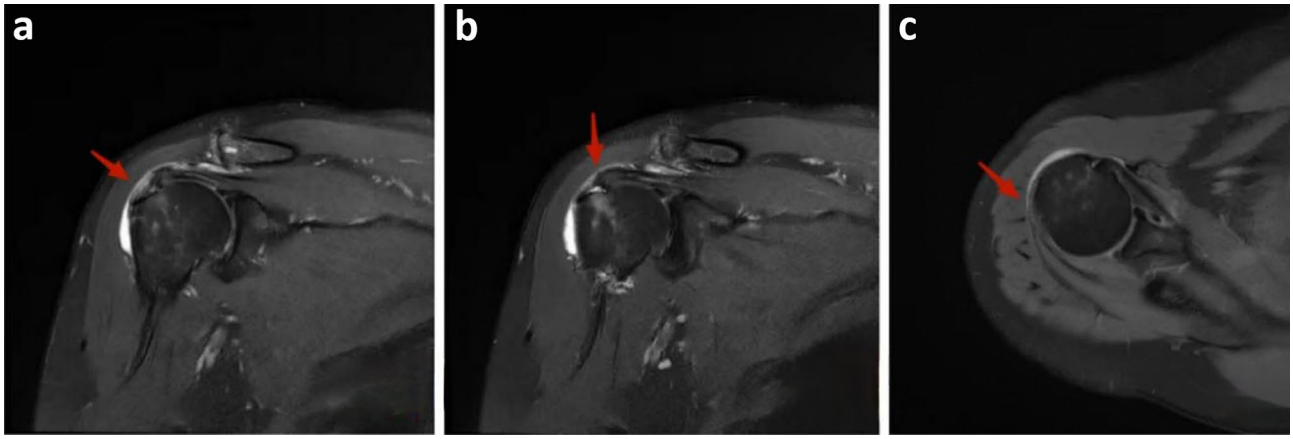

Fig. 2 The patient, a female, 53 years old, had right shoulder pain with limited mobility for more than 6 months. Preoperative MRI showed partial injury of the distal supraspinatus tendon (**a–c**)

tear. Synovial hyperplasia of the shoulder joint, obvious inflammatory hyperemia, mild adhesion around the right subacromial tendon, and a 2.0 cm-sized laceration were seen at the lateral end of the humerus (Fig. 3a,b). The lateral approach was established at the lateral 3 cm of the lateral edge of the acromion, and the anterior approach and other related auxiliary approaches were established slightly above the lateral coracoid process. Subacromial bursa debridement and acromioplasty were performed successively to release and repair the broken end of the injured tendon and the surrounding tissue. The tension of the injured tendon was measured and the position of anchor implantation was marked (Fig. 3c). Then the humerus greater tubercle bone bed was slightly fresh and implanted with a 4.5 mm inner row anchor (Peekzip, Smith&nephew, USA), paying attention to the oblique

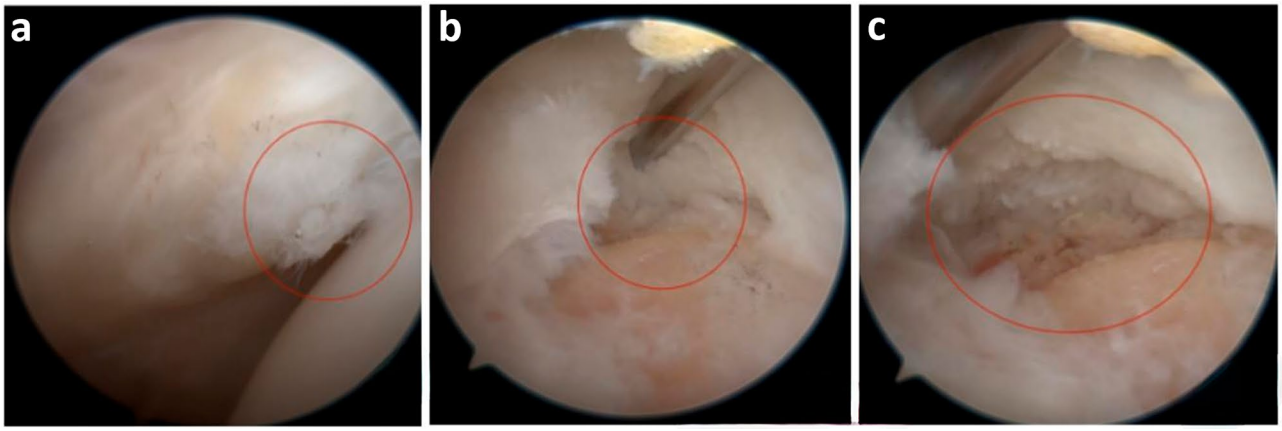

Fig. 3 Intraoperative observation of the posterior-lateral approach to the right shoulder showed a visible tear rupture at the lateral humeral stop, with tension laxity (**a**); the supraspinatus tendon was torn at the layered level (**b,c**)

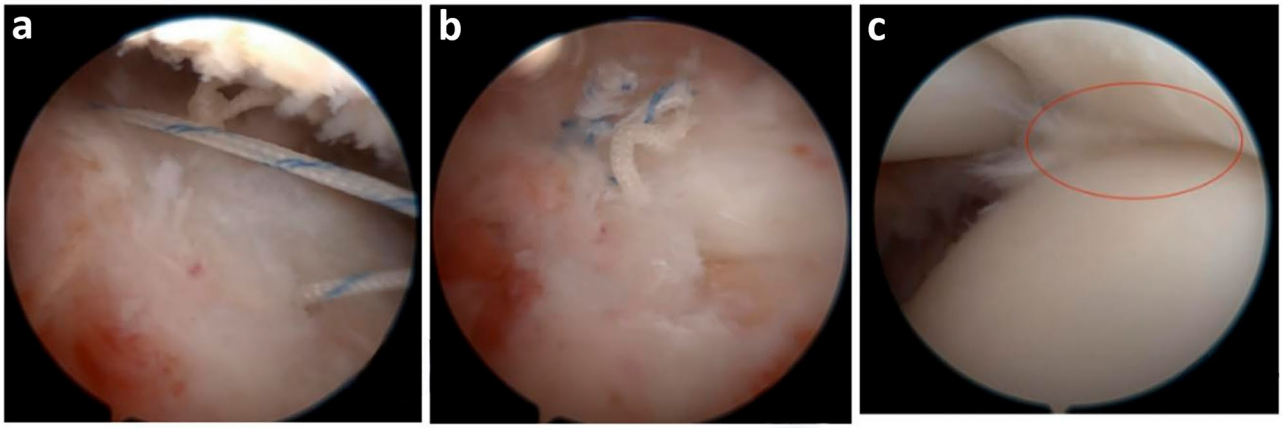

Fig. 4 Intraoperative use of mMA sutures to close the delaminated rotator cuff tears, (**a,b**) with no twisting of the injured tendon and no tension (**c**)

subchondral bone and 45° angle to the longitudinal axis of the humerus. One of the sutures attached to the tail end of the anchor was passed through the broken end of the tendon for horizontal mattress suture, and the other suture was simply sutured vertically at the medial puncture needle of the mattress suture (Fig. 4a,b). After suturing, the rotator cuff repair was checked again through the joint cavity and subacromial region to check the stability of the suture (Fig. 4c), and then irrigation, hemostasis, and suturing were performed. In this study, ten patients had severe frozen shoulder symptoms before surgery, and significant swelling of the synovial membrane was seen during the operation. After removing contraindications related to hormone injection (such as diabetes, poor muscle mass, etc.), six of the patients were injected with steroids(Compound betamethasone injection 1 ml) into the articular cavity after operation (Table 1). After resuscitation, the patient returned to the ward (Fig. 5a,b).

Post-operative rehabilitation

After surgery, we directed patients to place the afflicted limb in an arm sling with an abduction cushion. The patients were also told to do passive anteflexion supination utilizing a continuous passive motion device commencing on the first postoperative day following surgery. The arm sling was retained for 4 weeks following surgery. Thereafter, active assisted range of motion and adherence exercises were begun 4 to 6 weeks postoperatively. Strength and physical resistance workouts are advised after 4 months. After 6 months, the activities were almost completely resumed, including exercise and weight-bearing manual work (Fig. 6).

Statistical analysis

SPSS26.0 software was used for statistical analysis. The experimental results are all shown by the average ± standard deviation ($\chi \pm S$). T-test is used for those whose experimental data satisfy normality and homogeneity of variance, and the Wilcoxon rank sum test is used for those who do not satisfy normality and homogeneity of

Table 1 Baseline characteristics for patients with rotator cuff tear

Categories	Men	Women	Total
Case, n (%)	21 (33.87)	41 (66.13)	62 (100)
Age, years ± SD	67.57 ± 7.15,	64.10 ± 7.18	65.27 ± 7.30
Work type, n (%)			
Farmer	11 (52.38)	22 (53.66)	33 (53.23)
Worker	10 (47.62)	4 (9.76)	14 (22.58)
Housework	0 (0)	15 (36.58)	15 (24.19)
Rotator cuff tear size, n (%)			
Small (<1 cm)	1 (4.76)	3 (7.32)	4 (6.45)
Medium(1–3 cm)	19 (90.48)	36 (87.80)	55 (88.71)
large (3–5 cm),	1 (4.76)	2 (4.88)	3 (4.84)
Diabetes, n (%)			
Yes	2 (9.52)	4 (9.76)	6 (9.68)
No	19 (90.48)	37 (90.24)	56 (90.32)
Hypertension, n (%)			
Yes	6 (28.57)	10 (24.39)	16 (25.81)
No	15 (71.43)	31 (75.61)	46 (74.19)
History of trauma, n (%)			
Yes	9 (42.86)	18 (43.90)	27 (43.55)
No	12 (57.14)	23 (56.10)	35 (56.45)
Frozen shoulder, n (%)			
Yes	2 (9.52)	8 (19.51)	10 (16.13)
No	19 (90.48)	33 (80.49)	52 (83.87)
Postoperative intra-articular injection of steroids, n (%)			
Yes	1 (4.76)	5 (12.20)	6 (9.68)
No	20 (95.24)	36 (87.80)	56 (90.32)

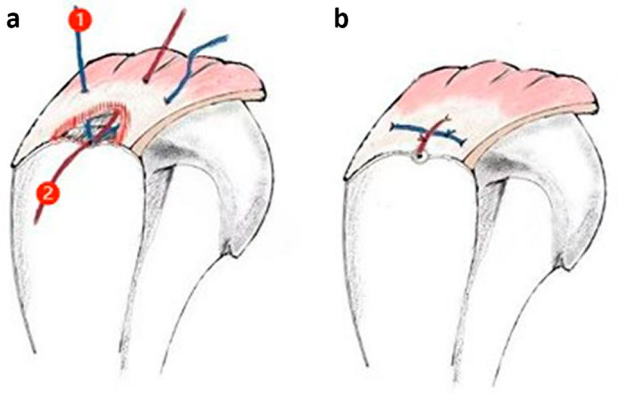

Fig. 5 Schematic diagram of single row mMA Suture technology. (**a**) Horizontal mattress stitches were made by passing a pair of suture limbs through the anterior and posterior bursal-sided flap tissue at a 2.0-cm interval using the suture passer. Then, vertical single stitches were made with 1 suture passing between the previous mattress sutures, approximately 2 to 3 cm more medially through the small window in the articular-sided tendon. (**b**) Complete the mMA suture diagram. Numbers represent the order of sutures passing through the tendon and tie

variance. Initiative ROM was assessed, including anteflexion (AF), abduction (AD), external rotation (ER), and internal rotation (IR). Functional scores were assessed, including shoulder mobility, CS, and UCLA Shoulder Score. The shoulder joint function was evaluated by the same joint specialist at different stages before the operation, 1.5 months, 3 months, 6 months, and longer. A telephone survey of functional scores was conducted for patients who did not participate in the final follow-up. (4 cases, accounting for 6.5% of the total sample size.)

Fig. 6 Example from a patient whose shoulder joint returned to normal activity 6 months after operation, including exercise and weight-bearing manual work

Table 2 Comparison of shoulder range of motion between pre-operation and last follow-up

Follow-up care time	$AF_{(Max180°)}$	$AD_{(Max180°)}$	$IR_{(Max70°)}$	$ER_{(Max60°)}$
Before operation	98.06 ± 11.28°	69.68 ± 18.55°	14.52 ± 10.35°	22.42 ± 8.62°
Last follow-up	172.26 ± 6.63°	160.97 ± 9.53°	45.81 ± 4.97°	51.29 ± 6.14°
P value	0.028	0.006	0.007	0.027

Result

Cases were followed up for 6–18 months (average of 10 months). At the final follow-up, when the indicators were compared with the preoperative period, shoulder AF improved from 98.06°±11.28° to 172.26 ± 6.63°, AD improved from 69.68°±18.55° to 160.97 ± 9.53°; ER improved from 22.42°±8.62° to 51.29 ± 6.14°; IR improved from 14.52° ± 10.35° to 45.81 ± 4.97° (Table 2). Through the result data, we can find that the range of motion of the shoulder joint in the last follow-up is much better than that before the operation. ($P = 0.028$,$P = 0.006$,$P = 0.007$ and $P = 0.027$, respectively) Constant- Murley shoulder score improved from 49.08 ± 4.92 to 97.89 ± 1.62, and UCLA score improved from 15.73 ± 2.60 to 33.85 ± 0.15 (Table 3). Through the changes in the shoulder comprehensive score scale before and after the operation, it can also be found that the comprehensive performance of the shoulder joint is getting better and better after treatment ($P = 0.043$ and $P = 0.044$, respectively). According

Table 3 Comparison of shoulder joint score before operation and the last follow-up

Follow-up care time	$CS_{(Max100)}$	$UCLA_{(Max35)}$
Before operation	49.08 ± 4.91	15.71 ± 2.60
Last follow-up	97.89 ± 1.62	33.85 ± 0.15
P value	0.043	0.044

Table 4 Comparison of shoulder score at 1.5 months and 3 months after operation

Follow-up care time	CS	UCLA
1.5 months after surgery	66.61 ± 11.13	18.23 ± 1.99
3 months after surgery	81.35 ± 8.97	25.77 ± 1.88
P value	0.001	0.001

to the changing trend of shoulder range of motion followed up within 6 months after operation, we found that there was no significant improvement in shoulder range of motion at 1.5 months and 3 months (Fig. 7) nevertheless, we found that there was a significant change in the overall score of the shoulder joint between the two periods. CS increased from 66.61 ± 11.13 to 81.35 ± 8.97 and UCLA increased from 18.23 ± 1.99 to 25.77 ± 1.88 (Table 4, $P = 0.001$, both). And all the special scores are rising steadily. We believe that during this period, the shoulder range of motion of patients does not seem to have been greatly improved, but pain, sleep, mood, and other aspects have more optimistic results. Therefore, as a clinician, we should pay attention to giving patients some instructions during this period, so that they can gain more confidence in the process of recovery.

3 cases (4.8%) developed adhesive capsulitis symptoms due to inactive rehabilitation activities after the operation, and the symptoms disappeared after standard rehabilitation training (no secondary operation). All patients had no problems such as rotator cuff tearing and anchor removal (Fig. 8; Table 5).

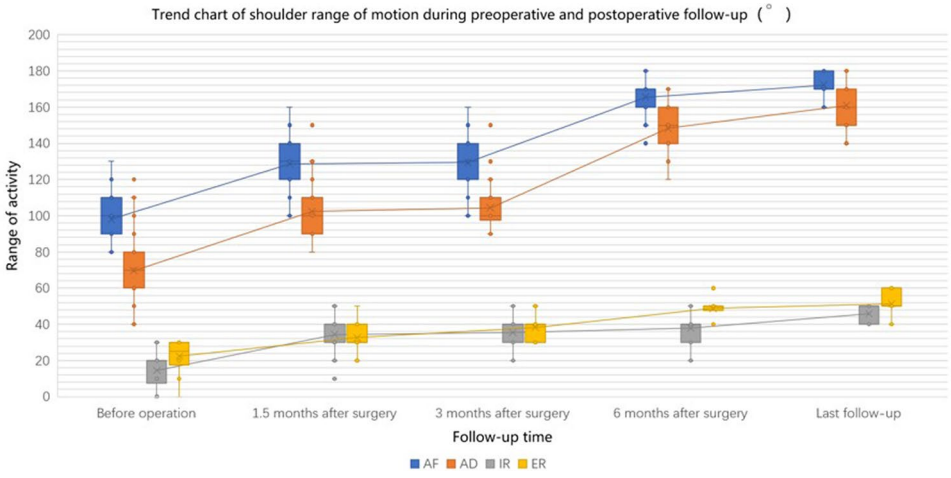

Fig. 7 Changes in average shoulder joint activity at different time intervals before and after operation. The error line represents the range

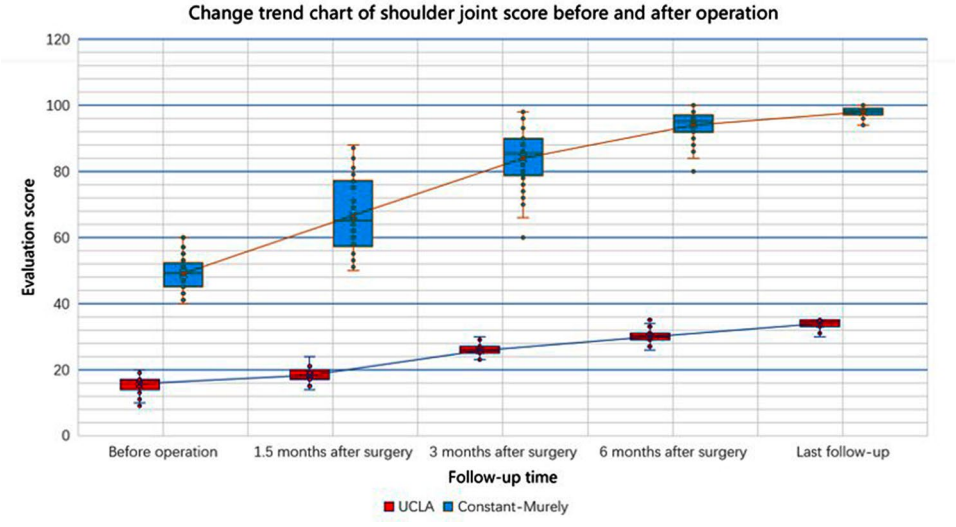

Fig. 8 The changes in average CS and UCLA at different times before and after the operation. The error line represents the range

Table 5 Comparison of preoperative scoring data at the last follow-up between different genders

	CS			UCLA		
Gender	Woman	Man	P value	Woman	Man	P value
Pre-operation	48.61 ± 4.49	50.00 ± 5.66	0.36	15.39 ± 2.77	16.33 ± 2.16	0.15
Last follow-up	97.68 ± 1.68	98.29 ± 1.45	0.15	33.93 ± 1.21	33.71 ± 1.23	0.52
P value	0.000	0.000		0.000	0.000	

Discussion

Arthroscopic repair of rotator cuff delamination tears is a demanding procedure, with many types of repairs, including single-row or double-row, etc. With numerous risk factors and non-standardized functional training, the re-tear rate exceeds 10%, which usually leads to suboptimal clinical outcomes [15, 16]. Gerber [17] has utilized the Mason-Allen approach for the treatment of rotator cuff injuries since 1994 and has obtained good results. With the research and improved implementation of this procedure by many peers, the improvement of implanted anchors and sutures, and the advancement of surgical techniques, the results of rotator cuff repair have continued to improve. Currently, the largest issue in rotator cuff restoration comes in the tendon-suture interface, which expresses itself as a retear of the rotator cuff caused by tendon cuts, necrosis, and so on [18, 19]. Darling, Adams, and other scholars [20, 21] also believe that the key factors affecting the healing of tendon-bone are whether the interface of tendon-bone is fully contracted, whether there is a gap, and whether the space > 5 cm will greatly increase the failure rate of operation. However, rotator cuff delamination tears are more common in rotator cuff tears less than 5 cm, and small tears less than 1 cm are also rare [22]. This feature can also be found in the size of rotator cuff tears in our study samples (Table 1).

The following repair methods are available for the treatment of rotator cuff multilayer injuries [23]: widely used treatments for rotator cuff layered tears include single-row and double-row repair procedures. Kim [24] compared complete versus layered sutures for rotator cuff injuries and found superior ASES ratings and reduced postoperative pain in the layered suture group. However, multilayer suturing has limitations such as difficult operation, high technical requirements for the operator, and extended operation time [10]. The Mason-Allen suture technique was first applied by Gerber [25] in open rotator cuff repair surgery and achieved good clinical results. Scheibel [13] improved its method to make it suitable for arthroscopic operation. This method combines a horizontal mattress suture with a vertical simple suture, which can increase the holding force of a single anchor on the broken end of the tendon, reduce the gap at the tendon joint, and be beneficial to the early stability of the repair site [12]. For medium rotator cuff tears, compared with the simple suture of a single anchor, this method can reduce the suture tension of the broken end of the tendon, reduce the effect of suture on the blood circulation of the broken end, reduce the incidence of aseptic necrosis of the tendon, and promote long-term tendon-bone healing [11].

The rotator cuff exercise regimen performed postoperatively is critical for healing following rotator cuff reconstruction. Early exercise improves the range of motion of the rotator cuff but increases the risk of retearing, while delayed exercise reduces the risk of retearing but decreases the range of motion of the rotator cuff compared to early exercise therapy [26]. Compared to injuries without delamination, patients with delaminated RCTs are older, have longer symptom duration, bigger tendon tears, and higher levels of rotator cuff fat infiltration and degeneration [27]. Therefore, for each decision, it is more important for the clinician to weigh postoperative interventions for the functional exercise of the shoulder joint and the impact on healing, and reasonably standardized postoperative functional exercise must be rationally and scientifically is very necessary.

We administered steroids intra-articularly to treat early stiffness and discomfort after rotator cuff repair to aid patients' early activity and lower the likelihood of joint adhesion [28]. It was noted that 2 patients (33.33%) still reported shoulder discomfort 6 weeks after steroid injection. We performed an MRI examination on the shoulders of these two patients in time, and there was no sign of rotator cuff retear. The pain symptoms disappeared during the follow-up 3 months after the operation. Lin [29] concluded that steroid injection in the shoulder increases the likelihood of rotator cuff retear and that a careful balancing of the advantages and adverse effects of steroids is important before providing injections for shoulder diseases. Kim [30] discovered that intra-articular injection of steroids 2 months after arthroscopic rotator cuff repair did not influence the integrity of the tendon at 6 months following the procedure. Therefore, we should be mindful that while short-term treatment of steroids improves clinical results, we should not dismiss the harmful effects of steroids on patients in the long-term period. How to weigh the usage of steroids in the postoperative phase is also a hot issue for future discussion.

Frozen shoulders (FS) have been reported to be associated with partial RCTs in approximately 15% of cases [31], and frozen shoulders before rotator cuff repair also present with pain, stiffness, and worsening pain at night,

which may mask symptoms associated with partial-thickness RCTs. Although arthroscopic capsular release allows for the treatment of signs and symptoms of acute inflammation, and the mechanical defects of the torn tendon are compensated for by the residual rotator cuff and intrinsic muscles, partial-thickness tears are not "clinically cured," and the tear may progress over time. Management of FS varies depending on the stage of the disease, with early interventions usually consisting of physical therapy, whereas late treatments include manipulation under anesthesia (MUA), arthroscopic capsular release (ACR), extracorporeal shockwave therapy (ESWT), hydrodilatation, and intra-articular corticosteroid injections (IACIs). Despite the wide variety of available therapies, it has not yet been determined that the most effective therapeutic method [32, 33]. What is certain is that patients with RCTs and FS have a better prognosis after arthroscopic capsule release [34]. In our study, 10 RCTs patients had preoperative FS (FS was diagnosed by symptoms and preoperative MRI.) with terrible pain, all of whom had been in the condition for more than 6 months, and who had been treated with conservative treatment (treatment is not effective) and were strongly motivated to undergo surgery (Table 1). We effectively repaired the partially torn rotator cuff at the same time, but also released the capsular membrane, not only to improve the symptoms, to help the shoulder joint with early functional exercise, to avoid the recurrence of frozen shoulder, but also to stop the progression of the partial tear, so that the long-term effect of the treatment is guaranteed.

The vast majority of patients in our study are elderly (Age 65.27 ± 7.30, Table 1). Compared with other age groups, elderly patients have some problems, such as joint degeneration, tissue degeneration of the broken end of the tear, bone mass loss in the footprint area, and more underlying diseases, so the characteristics of these diseases should be fully considered in the repair treatment. In elderly patients, there are often cystic changes in the attachment point of the tendon due to the loss of bone mass in the greater tubercle of the humerus [35]. Therefore, the fresh process of bone in the footprint area of the greater tubercle of the humerus should be moderate, and the bone should be preserved as much as possible. The anchor should be inclined to the subchondral bone at an angle of 45° to the longitudinal axis of the humerus. This can increase the fixation strength of the anchor and prevent the anchor from withdrawing. For elderly patients with a long course of disease and poor tendon condition, the complete coverage of the footprint area should not be excessively forced. the rotator cuff with partial repair and good healing can better meet the functional needs of elderly patients than the torn rotator cuff after operation [36]. From the relevant data, it can be considered that the comprehensive performance of the shoulder joint is close to perfect if CS ≥ 95 [37]. In this study, the CS at the last follow-up was 97.89 ± 1.62, indicating that this technique is effective in the treatment of delamination RCTs. In addition, the range of motion of the patient's shoulder joint is also close to normal, which can meet the needs of daily life and work. Besides, for RCTs smaller than 3 cm, there was no significant difference between single-row anchor repair technique and double-row anchor repair technique in improving clinical symptoms [38, 39]. Based on ensuring the curative effect, Single-row anchor repair technology can reduce the number of anchors, shorten the time of operation, reduce the risk of intraoperative anesthesia in elderly patients, but also reduce the economic burden of patients. Through the results, patients of different genders had significant improvements in the comprehensive scores of pain and range of motion at the preoperative and final postoperative follow-up. However, there were no significant differences between genders (Table 5). At the last follow-up visit, both men, who were mostly farmers and workers, and women, who were mostly farmers and housewives, all said that not only had their quality of life improved after surgery, but they were also competent for their jobs.

In conclusion, arthroscopic application of mMA to repair RCTs can effectively relieve shoulder pain, improve shoulder function, and reduce complications. There are certain limitations in this study, such as the relatively small sample number of patients and the relatively short observation duration, and it is important to raise the sample size and lengthen the follow-up observation time to achieve long-term findings. We obtained data from 4 samples (6.5%) through telephone follow-up, which may increase the risk of recall bias, so the detail of the information was limited.

Author contributions

R.W. and X.F. contributed to the conception and design of the study; R.W. and F.X. contributed to the interpretation of data, as well as drafting and critically revising the article for important intellectual content; G.H. completed the surgical procedure of the study; F.X. and S.X. worked in search policies; L.W. is responsible for the evaluation of shoulder function in follow-up patients. G.H. helped in providing funds. All authors have read and agreed to published manuscript editions.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Ethics approval and consent to participate: The ethics review committee of The First People's Hospital of Xiaoshan District, Hangzhou, China has accepted this research design.

Consent for publication

Not applicable.

Clinical trial number
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. de Castro RLB, Antonio BP, Giovannetti GA, et al. Total healing of a partial rupture of the supraspinatus tendon using barbotage technique associated with platelet-rich plasma: a randomized, controlled, and double-blind clinical trial. Biomedicines. 2023;11(7).
2. Kim KC, Shin HD, Cha SM, et al. Repair integrity and functional outcome after arthroscopic conversion to a full-thickness rotator cuff tear: articular- versus bursal-side partial tears. Am J Sports Med. 2014;42(2):451–6.
3. Kim YS, Lee HJ, Kim JH, et al. When should we repair partial-thickness rotator cuff tears? Outcome comparison between immediate surgical repair versus delayed repair after 6-Month period of nonsurgical treatment. Am J Sports Med. 2018;46(5):1091–6.
4. Ko SH, Jeon YD, Kim MS. Progression of symptomatic partial-thickness rotator cuff tears: association with initial tear involvement and work level. Orthop J Sports Med. 2022;10(6):23259671221105471.
5. Liu G, Huang F, Qin T. Zhongguo xiu fu chong jian wai ke za zhi = Zhongguo xiufu chongjian waike zazhi = Chinese. J Reparative Reconstr Surg. 2011;25(1):61–5. [*Treatment and research progress of massive rotator cuff tears*].
6. Iannotti JP, Deutsch A, Green A, et al. Time to failure after rotator cuff repair: a prospective imaging study. J Bone Joint Surg Am. 2013;95(11):965–71.
7. Ok HS, Kim BG, Choi WC, et al. Clinical relevance of classifying massive rotator cuff tears: results based on functional and radiological findings after arthroscopic repair. Am J Sports Med. 2017;45(1):157–66.
8. Ono Y, Dávalos Herrera DA, Woodmass JM, et al. Can grafts provide superior tendon healing and clinical outcomes after rotator cuff repairs? A meta-analysis. Orthop J Sports Med. 2016;4(12):2325967116674191.
9. Duquin TR, Buyea C, Bisson LJ. Which method of rotator cuff repair leads to the highest rate of structural healing? A systematic review. Am J Sports Med. 2010;38(4):835–41.
10. DeHaan AM, Axelrad TW, Kaye E, et al. Does double-row rotator cuff repair improve functional outcome of patients compared with single-row technique? A systematic review. Am J Sports Med. 2012;40(5):1176–85.
11. Lee KW, Yang DS, Lee GS, et al. Clinical outcomes and repair integrity after arthroscopic full-thickness rotator cuff repair: suture-bridge versus double-row modified Mason-Allen technique. J Shoulder Elbow Surg. 2018;27(11):1953–9.
12. Jung SW, Kim DH, Kang SH, Lee JH. Arthroscopic modified Mason-Allen technique for large U- or L-shaped rotator cuff tears. Knee Surg Sports Traumatol Arthrosc. 2017;25(7):2129–37.
13. Scheibel MT, Habermeyer P. A modified Mason-Allen technique for rotator cuff repair using suture anchors. Arthroscopy: J Arthroscopic Relat Surg. 2003;19(3):330–3.
14. Imbergamo C, Sequeira S, Bano J, et al. Failure rates of suture anchor fixation versus transosseous tunnel technique for patellar tendon repair: a systematic review and meta-analysis of biomechanical studies. Orthop J Sports Med. 2022;10(8):23259671221120212.
15. Dyrna F, Beitzel K, Pauzenberger L, et al. A superolaterally placed anchor for subscapularis leading-edge refixation: a biomechanical study. Arthroscopy: J Arthroscopic Relat Surg. 2019;35(5):1306–e13131301.
16. Jeong JY, Pan HL, Song SY, et al. Arthroscopic subscapularis repair using single-row mattress suture technique: clinical results and structural integrity. J Shoulder Elbow Surg. 2018;27(4):711–9.
17. Gerber C, Schneeberger AG, Perren SM, et al. Experimental rotator cuff repair. A preliminary study. J bone Joint Surg Am. 1999;81(9):1281–90.
18. Christoforetti JJ, Krupp RJ, Singleton SB, et al. Arthroscopic suture bridge transosseus equivalent fixation of rotator cuff tendon preserves intratendinous blood flow at the time of initial fixation. J Shoulder Elbow Surg. 2012;21(4):523–30.
19. Honda H, Gotoh M, Mitsui Y, et al. Clinical and structural outcomes after arthroscopic rotator cuff repair: a comparison between suture bridge techniques with or without medial knot tying. J Orthop Surg Res. 2018;13(1):297.
20. Darling EM, Athanasiou KA. Rapid phenotypic changes in passaged articular chondrocyte subpopulations. J Orthop Res. 2005;23(2):425–32.
21. Adams JE, Zobitz ME, Reach JS Jr., et al. Rotator cuff repair using an acellular dermal matrix graft: an in vivo study in a canine model. Arthroscopy: J Arthroscopic Relat Surg. 2006;22(7):700–9.
22. Sonnabend DH, Watson EM. Structural factors affecting the outcome of rotator cuff repair. J Shoulder Elbow Surg. 2002;11(3):212–8.
23. Park JY, Lhee SH, Oh KS, et al. Clinical and ultrasonographic outcomes of arthroscopic suture bridge repair for massive rotator cuff tear. Arthroscopy: J arthroscopic Relat Surg. 2013;29(2):280–9.
24. Kim YK, Jung KH, Park CK, et al. Morphologic factors related to repair outcomes for delaminated rotator cuff tears: a minimum 2-year retrospective comparison study. Arthroscopy: J arthroscopic Relat Surg. 2019;35(2):332–40.
25. Gerber C, Schneeberger AG, Beck M, et al. Mechanical strength of repairs of the rotator cuff. J bone Joint Surg Br. 1994;76(3):371–80.
26. Houck DA, Kraeutler MJ, Schuette HB, et al. Early versus delayed motion after rotator cuff repair: a systematic review of overlapping meta-analyses. Am J Sports Med. 2017;45(12):2911–5.
27. Iwashita S, Hashiguchi H, Okubo A, Yoneda M, Takai S. Characteristics of the patients with delaminated rotator cuff tear. SICOT J. 2018;4:28.
28. Kim YS, Jin HK, Lee HJ, et al. Is it safe to Inject corticosteroids into the glenohumeral joint after arthroscopic rotator cuff repair?. Am J Sports Med. 2019;47(7):1694–700.
29. Lin CY, Huang SC, Tzou SJ et al. A positive correlation between Steroid injections and cuff tendon tears: a Cohort study using a clinical database. Int J Environ Res Public Health. 2022;19(8).
30. Kim SC, Kim IS, Shin SS, et al. Clinical and structural outcome of intra-articular steroid injection for early stiffness after arthroscopic rotator cuff repair. Int Orthop. 2022;46(3):563–71.
31. Ueda Y, Sugaya H, Takahashi N, et al. Rotator cuff lesions in patients with stiff shoulders: a prospective analysis of 379 shoulders. J bone Joint Surg Am. 2015;97(15):1233–7.
32. Liu X, Yang G, Xie W, et al. Research trends and emerging treatment in frozen shoulder research: a bibliometric analysis and meta-analysis. Asian J Surg. 2024.
33. Millar NL, Meakins A, Struyf F, et al. Frozen shoulder. Nat Rev Dis Primers. 2022;8(1):59.
34. Lim WSR, Lie DTT, Mitra AK, et al. What is the optimal surgical intervention for patients with frozen shoulder and a concomitant partial-thickness rotator cuff tear? JSES Int. 2021;5(1):93–7.
35. Cadet ER, Hsu JW, Levine WN, et al. The relationship between greater tuberosity osteopenia and the chronicity of rotator cuff tears. J Shoulder Elbow Surg. 2008;17(1):73–7.
36. Bennett WF. Arthroscopic repair of massive rotator cuff tears: a prospective cohort with 2- to 4-year follow-up. Arthroscopy: J Arthroscopic Relat Surg. 2003;19(4):380–90.
37. Kirkley A, Griffin S, Dainty K. Scoring systems for the functional assessment of the shoulder. Arthroscopy: J Arthroscopic Relat Surg. 2003;19(10):1109–20.
38. Millett PJ, Warth RJ, Dornan GJ, et al. Clinical and structural outcomes after arthroscopic single-row versus double-row rotator cuff repair: a systematic review and meta-analysis of level I randomized clinical trials. J Shoulder Elbow Surg. 2014;23(4):586–97.
39. Plachel F, Siegert P, Rüttershoff K, et al. Long-term results of arthroscopic rotator cuff repair: a follow-up study comparing single-row versus double-row fixation techniques. Am J Sports Med. 2020;48(7):1568–74.

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