JSES International 8 (2024) 785–790

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Arthroscopic margin convergence of large-sized rotator cuff tears does not lead to better clinical outcome compared with conventional repair

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ARTICLE INFO

Keywords:
Margin convergence
Rotator cuff
Rotator cuff repair
Retear
Shoulder
Large tear

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Background: The margin convergence (MC) technique is used to repair longitudinal-type tears as direct repair of the apex of the longitudinal-type tear from medial to lateral is challenging. Few studies have compared the postoperative clinical outcomes and retear rates of arthroscopic rotator cuff repair (ARCR) using the MC technique with those of conventional ARCR without using the MC technique. Therefore, this study aimed to investigate the efficacy of MC on the clinical outcome and retear rates of patients with large-sized rotator cuff tears. It was hypothesized that ARCR using the MC technique would yield clinical outcome and retear rates similar to those of ARCR without using the MC technique.

Methods: The medical records of consecutive patients who underwent ARCR for large-sized rotator cuff tears were retrospectively evaluated. Forty-four and 35 shoulders were repaired using MC (MC group) and not using MC (non-MC group), respectively. The range of motion (ROM) and the Japanese Orthopaedic Association (JOA) score were assessed preoperatively and after a minimum follow-up period of 12 months postoperatively. Magnetic resonance imaging was performed at least 3 months postoperatively to determine whether the tendons had healed.

Results: The average postoperative follow-up duration was 26.6 months and 24.3 months in the MC and non-MC groups, respectively. The mean ROM and JOA score improved significantly in both groups postoperatively; however, the postoperative range of external rotation and the total JOA score was significantly lower in the MC group. The overall retear rate did not differ significantly between the MC (13/44, 29.5%) and non-MC (7/35, 20.0%) groups, respectively ($P = .332$). No significant differences were observed between the cases with retears in the 2 groups in terms of the postoperative ROM and the total JOA score. In contrast, the postoperative range of external rotation and the total JOA score of the patients with healed tendons in the MC group were significantly poorer than those of the patients with healed tendons in the non-MC group.

Conclusion: ARCR using MC of large-sized longitudinal-type tears does not lead to better postoperative range of external rotation and clinical outcome compared with those of conventional repair.

Arthroscopic rotator cuff repair (ARCR) is commonly performed for the treatment of rotator cuff tears (RCTs), and its complication rate is lower than those of the open or mini-open repair techniques.[18] The torn edge of the tendon is retracted medially in some patients with larger RCTs, which consequently exhibit a narrow and long pattern of tear known as longitudinal-type RCT (eg, U-shaped and L-shaped tears). The traditional repair technique, which reduces the apex of the retracted tendon from the medial to lateral direction, can result in significant strain at the repair site and high rates of retears.[4]

Burkhart et al proposed the use of the margin convergence (MC) technique for treating large-sized longitudinal-type tears in 1996.[2] The MC technique, an initial side-to-side closure technique, can induce a lateral shift of the apex of the retracted tendon, thereby decreasing the gap size and rotator cuff strain.[24] This technique has enabled easy anchor fixation of the edge of the tendon to the bone and may aid in cuff healing. The larger size of the mediolateral tear

The study protocol was approved by the Fukuoka University Institutional Review Board (IRB Approval Number: C21-09-001).

This study was conducted at the Department of Orthopaedic Surgery, Fukuoka University Chikushi Hospital, Chikushino according to approved medical and ethical guidelines.

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https://doi.org/10.1016/j.jseint.2024.02.014

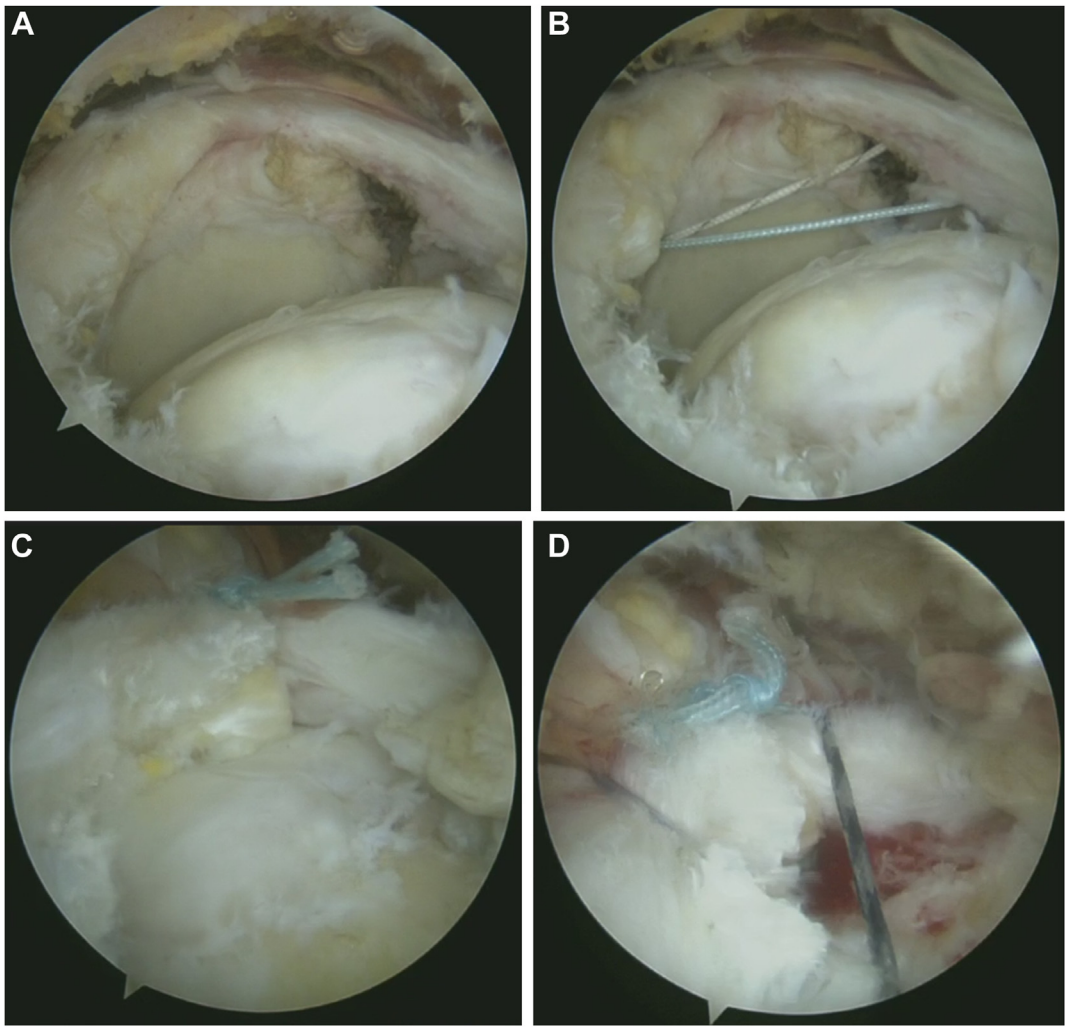

Figure 1 Arthroscopic image of right shoulder viewing from the posterolateral portal. (**A**) Large-sized longitudinal-type rotator cuff tear. (**B**) Two margin convergence sutures were placed through anterior and posterior margins of the rotator cuff. (**C**) Gap size was decreased after the margin convergence technique was performed. (**D**) Knotless suture bridge repair was performed. The suture from the anchor passed the tendon just medial to the horizontal stitch, which was created by the margin convergence for act as a rip-stop.

in longitudinal-type tears is a risk factor for retear;[33] however, the MC technique can reduce the incidence of failure owing to these biomechanical effects.[24] ARCR using the MC technique yields clinical outcomes similar to those of ARCR without using the MC technique;[1,3] however, the differences between the postoperative retear rates of the 2 treatment groups are unclear. Hence, this study aimed to investigate the effect of MC on the clinical outcomes and retear rates of patients with large-sized RCTs. It was hypothesized that ARCR using the MC technique would yield clinical outcomes and retear rates similar to those of ARCR without using the MC technique.

Materials and methods

This single-center, retrospective study was approved by the Institutional Review Board of our institution. All patients with large RCTs of the supraspinatus and/or infraspinatus muscle who underwent ARCR between 2014 and 2020 were eligible for inclusion in this study. A classification system proposed by Cofield et al wherein a tear with a width or length of 3-5 cm was classified as a large-sized tear[7] was used to determine the tear size intraoperatively. Patients with irreparable RCTs, cuff tear arthropathy, fractures or dislocations of the shoulder, a history of undergoing shoulder surgery, a history of inflammatory or neuropathic arthritis, and postoperative follow-up for < 12 months were excluded from the study.

Surgical technique

All surgical procedures were performed by the senior author. The patients were placed in the beach chair position with an interscalene block after the induction of general anesthesia. A standard posterior portal was created to facilitate the initial evaluation of the glenohumeral joint pathology. Excess bursal tissue was removed after the creation of the posterolateral portal for the evaluation of the subacromial space to confirm the shape of the posterosuperior RCT. Tendon mobilization, including the release of the coracohumeral ligament and the glenohumeral capsule, was performed if the mobility of the rotator cuff was insufficient. Excessive tension may be observed at the apex of the tear during tendon reduction in patients with longitudinal type of RCTs that exhibited the long and narrow pattern with increased mediolateral length (Fig. 1*A*). The surgeon performed MC using No. 2 FiberWire sutures (Arthrex, Naples, FL, USA) if the edge of the tendon could not be reached from the medial to the lateral aspect to cover the original footprint (Fig. 1 *B* and *C*). The number of sutures required

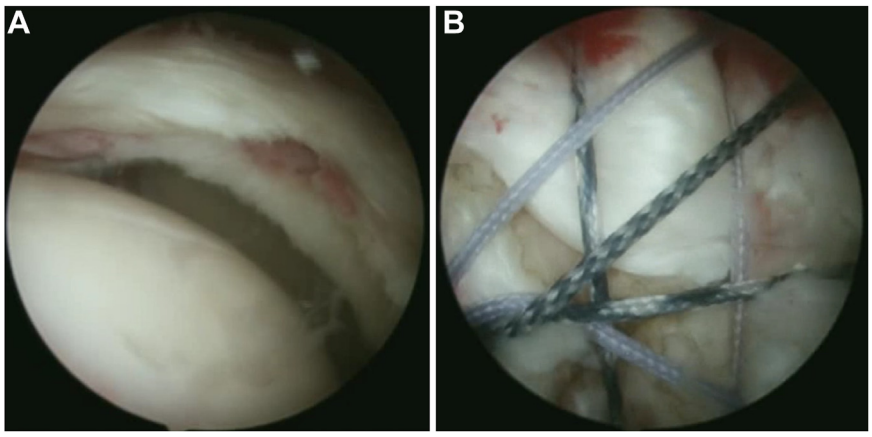

Figure 2 Arthroscopic image of the left shoulder from the posterolateral portal. (**A**) Large-sized rotator cuff tear classified as the wide pattern with increased anterior to posterior length. (**B**) Conventional knotless suture bridge repair was performed.

was determined based on the mediolateral distance of the RCT. The single-row technique or knotless suture bridge technique was performed after MC was completed (Fig. 1*D*). The suture from the anchor passed the tendon medial to the horizontal stitch created by MC acted as a rip-stop. The conventional single-row technique or knotless suture bridge technique without using MC was performed if the apex of the retracted tendon could be reduced to the footprint (Fig. 2 *A* and *B*).

Débridement or single-row repair was performed in cases with subscapularis tendon partial-thickness tears limited to the superior one-third of the subscapularis muscle, whereas single-row repair was performed in cases with complete tearing of more than the superior one-third of the subscapularis tendon.

The postoperative rehabilitation protocols were similar for both treatment groups. A sling with an abduction pillow was used for 6 weeks postoperatively. Passive and active range of motion (ROM) exercises were commenced 4 and 6 weeks postoperatively, respectively.

Clinical functional evaluation

The Japanese Orthopaedic Association (JOA) score was determined preoperatively and at the last follow-up visit for the clinical functional evaluations.[15] The JOA score < 83 points after surgery was unsatisfactory.[16] The active ROM for forward flexion, abduction, external rotation, and internal rotation were measured preoperatively and at the last follow-up visit. The degree of internal rotation was evaluated at the highest vertebral level that the tip of the thumb could reach. The first to 12th thoracic vertebrae were referred to as 1 to 12, the first to fifth lumbar vertebrae were referred to as 13 to 17, the sacrum was referred to as 18, and the buttock was referred to as 19.[14]

Radiological evaluation

Each patient underwent magnetic resonance imaging (MRI) preoperatively and more than 3 months postoperatively. The mediolateral length and anteroposterior width were evaluated on oblique coronal and sagittal fat-suppressed T2-weighted images using the method described by Davidson et al.[8] The postoperative cuff integrity was assessed using the Sugaya classification system, wherein types IV and V were considered retears.[31] The Cho classification system was used to evaluate the retear patterns categorized as detachment of the tendon insertion from the footprint or failure at the musculotendinous junction.[6] The Fuchs modification of the classification system proposed by Goutallier et al[10,11] was used to assess the preoperative fatty infiltration of the rotator cuff muscle. The global fatty degeneration index was calculated subsequently as the average stage for 3 muscles: the subscapularis, supraspinatus, and infraspinatus muscles.

Statistical analysis

All statistical analyses were performed using SPSS for Windows, version 29 (IBM Corp., Armonk, NY, USA). The results are presented as mean (standard deviation) or percentage. The Shapiro-Wilk test was performed to confirm whether the data were normally distributed. Unpaired *t*-test or Mann-Whitney U test was performed to compare continuous variables, whereas the chi-square test was performed to compare categorical variables. Paired *t*-test or the Wilcoxon signed-rank test was performed to compare the preoperative and postoperative ROM and the clinical outcome. A P value of $< .05$ was considered statistically significant.

Results

A total of 102 patients (104 shoulders) with large-sized RCTs underwent ARCR during the study period. Among these 104 shoulders (102 patients), 44 shoulders (43 patients) and 35 shoulders (34 patients) were included in the MC and non-MC groups, respectively, after the application of the exclusion criteria (Fig. 3). Table I presents the demographic characteristics of the patients. No significant differences were observed between the 2 groups in terms of the baseline characteristics except for the mediolateral tear size measured on the preoperative magnetic resonance images, proportion of traumatic event, and subscapularis tendon tear. No significant differences were observed between the 2 groups preoperatively in terms of clinical outcomes, including active ROM or any JOA score factor (Table II). Both groups exhibited significant improvements from the preoperative assessment; however, the postoperative range of external rotation, JOA ROM score, and total JOA score were significantly lower in the MC group than those in the non-MC group (Table II). The overall retear rate did not differ significantly between the MC (13/44, 29.5%) and non-MC (7/35, 20.0%) groups ($P = .332$). Similarly, the distribution of the retear patterns did not differ significantly between the groups ($P = .848$) (Table III). No significant differences were observed between the patients with retears in the 2 groups in terms of the postoperative range of external rotation and JOA score; however, the patients with healed tendons in the MC group had

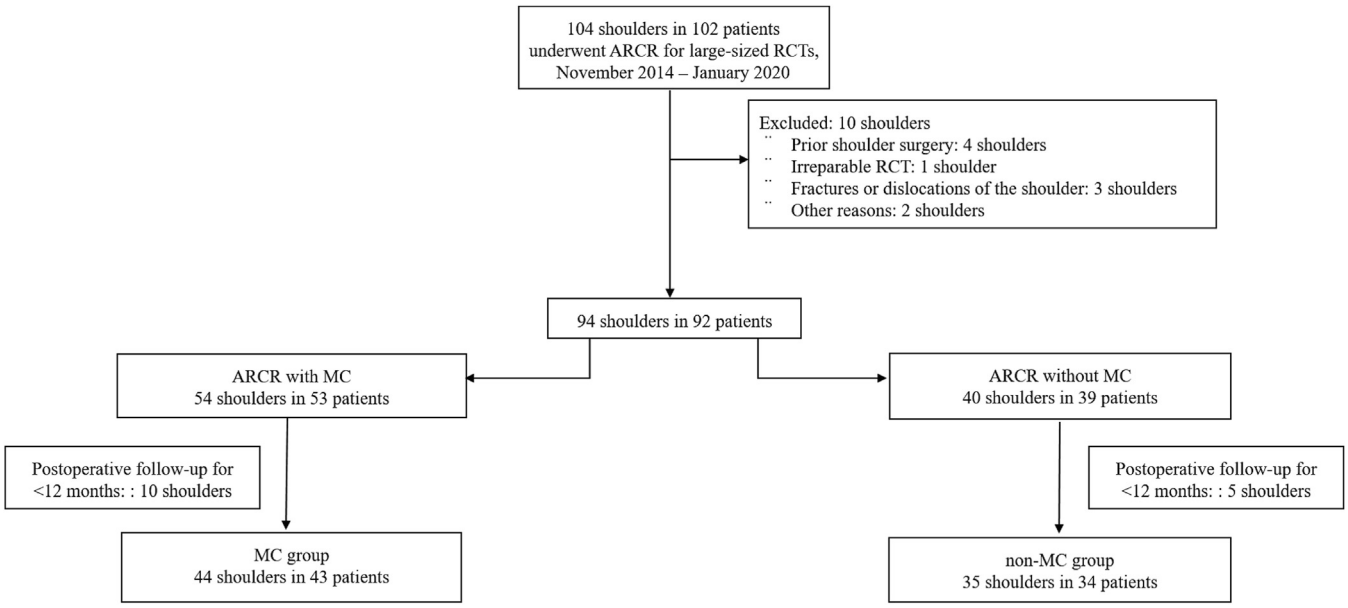

Figure 3 Flowchart of patient selection. *ARCR*, arthroscopic rotator cuff repair; *RCT*, rotator cuff tear; *MC*, margin convergence.

Table I
Demographic characteristics of the patients.

Variable	MC (+) (n = 44)	MC (−) (n = 35)	*P* value
Age (yr)	69.0 ± 8.1	65.7 ± 9.8	.252
BMI	24.5 ± 2.7	24.2 ± 3.2	.644
Sex			
Male	27	20	
Female	17	15	.704
Arm dominance, yes:no	31:13	25:10	.925
Traumatic event, yes:no	20:24	5:30	.003
Diabetes, yes:no	5:39	1:34	.156
Smoking, yes:no	6:38	8:27	.286
Repair method			
Suture bridge:single row	43:1	34:1	.870
Subscapularis tendon tear, yes:no	11:33	17:18	.030
Tear size (MRI), mm			
ML	33.4 ± 7.1	29.8 ± 7.5	.032
AP	24.0 ± 9.3	24.2 ± 8.0	.940
GFDI	1.67 ± 0.49	1.50 ± 0.45	.114
Imaging follow-up, mo (MRI)	14.1 ± 11.6	15.1 ± 10.9	.765
Follow-up, mo	26.6 ± 11.9	24.3 ± 9.7	.435

Data are presented as mean ± standard deviation.
MC, margin convergence; *MRI*, Magnetic resonance imaging; *BMI*, body mass index; *ML*, mediolateral; *AP*, anteroposterior; *GFDI*, Global fatty degeneration index.

significantly poorer postoperative range of external rotation, JOA ROM score, and total JOA score than those of the patients with healed tendons in the non-MC group (Table IV). The proportion of unsatisfactory outcomes among the patients with retears did not differ significantly between the MC (2/13, 15.4%) and non-MC (2/7, 28.6%) groups, respectively ($P = .482$).

Discussion

The mean ROM and all items of the JOA score exhibited significant improvement postoperatively in both groups; however, the postoperative range of external rotation, JOA ROM score, and total JOA score in the MC group were significantly lower in the present study. The overall retear rate did not differ significantly between the MC (29.5%) and non-MC (20.0%) groups, thereby disproving our hypothesis that ARCR using MC would lead to clinical outcomes and retear rates similar to those of ARCR without using MC. The postoperative range of external rotation, JOA ROM score, and total JOA score of the patients with healed tendons in the MC group were significantly poorer than those of the patients with healed tendons in the non-MC group.

The decision to perform MC first in the case of patients with large-sized longitudinal RCTs remains controversial. Burkhart et al recommended performing MC first to decrease the length of the tear and the rotator cuff strain.[2] In contrast, Mochizuki et al recommended performing anatomic repair, such as reducing the mobile posterior leaflet anterolaterally toward the anterior margin of the greater tuberosity, rather than MC in their anatomical study.[29] Park et al reduced the mobile leaflet first during the repair of large-sized longitudinal-type tears without using MC and reported that its clinical outcomes and retear rates were similar to those of large-sized mobile RCTs.[30] The postoperative range of external rotation, JOA ROM score, and total JOA score were significantly lower in the MC group than those in the non-MC group, especially in the case of patients with healed tendons, in the present study. Reducing the mobile posterior leaflet anterolaterally toward the anterior margin of the greater tuberosity is difficult due to the loss of mobility if MC is performed first. This might diminish the moment arm in external rotation and decrease the range of external rotation, which decreases the JOA ROM score. Consequently, the total JOA score was also lower in the MC group. The decreased range of external rotation may also be attributed to the postoperative shoulder stiffness. The biomechanical study by Mihata et al revealed that anterior MC during the superior capsule reconstruction induced shoulder stiffness by closing the rotator interval.[26,27] A recent systematic review reported that anterior MC in superior capsule reconstruction may result in lesser improvement in the range of external rotation.[32] Inui et al reported no significant improvement in the range of external rotation postoperatively in patients who underwent rotator cuff repair using MC.[17] Hence, the rotator interval may become tighter in the process of performing MC, which would lead to lesser improvement in the range of external rotation compared with non-MC group.

Table II
Preoperative and postoperative clinical outcomes.

Variable	MC (+) (n = 44)	MC (−) (n = 35)	*P* value
Forward flexion			
Preoperatively	114.2 ± 42.1	106.4 ± 48.8	.634
Last follow-up	150.6 ± 13.3	150.3 ± 13.2	.814
Abduction			
Preoperatively	108.8 ± 42.2	106.0 ± 48.3	.870
Last follow-up	154.1 ± 15.3	155.1 ± 16.7	.771
External rotation			
Preoperatively	37.5 ± 20.3	41.7 ± 21.2	.313
Last follow-up	45.7 ± 21.2	54.5 ± 14.6	.045
Internal rotation			
Preoperatively	13.1 ± 3.4	11.8 ± 3.6	.130
Last follow-up	12.1 ± 3.1	11.4 ± 2.5	.131
JOA score (Max. 100)			
Preoperatively	60.7 ± 11.5	61.2 ± 12.1	.969
Last follow-up	91.2 ± 8.4	94.0 ± 7.1	.038
Pain (Max. 30)			
Preoperatively	9.2 ± 3.4	9.9 ± 4.6	.738
Last follow-up	27.3 ± 4.2	27.6 ± 4.3	.584
Function (Max. 20)			
Preoperatively	12.2 ± 4.7	11.9 ± 4.4	.855
Last follow-up	19.3 ± 2.1	19.3 ± 2.0	.984
Range of motion (Max. 30)			
Preoperatively	20.9 ± 6.5	21.0 ± 6.4	.847
Last follow-up	24.8 ± 3.9	27.4 ± 3.1	.003

Data are presented as mean ± standard deviation.
MC, margin convergence; *JOA*, Japanese Orthopaedic Association.

Table III
Overall retear rates and patterns.

Variable	MC (+) (n = 44)	MC (−) (n = 35)	*P* value
Sugaya type I-III	31 (70.5)	28 (80.0)	
Sugaya type IV, V	13 (29.5)	7 (20.0)	.332
Retear pattern			
Retear at the tendon insertion	5 (38.5)	3 (42.9)	
Retear at the musculotendinous junction	8 (61.5)	4 (57.1)	.848

Data are presented as n (%).
MC, margin convergence.

Table IV
Postoperative clinical outcomes based on the presence of retears.

Healed variable	MC (+) (n = 31)	MC (−) (n = 28)	*P* value
Forward flexion	150.2 ± 13.9	148.8 ± 12.7	.735
Abduction	153.2 ± 14.6	152.9 ± 16.1	.872
External rotation	46.9 ± 17.6	56.1 ± 15.0	.041
Internal rotation	11.9 ± 3.1	11.5 ± 2.6	.402
JOA score (Max. 100)	91.7 ± 8.7	94.9 ± 6.6	.033
Pain (Max. 30)	27.4 ± 4.3	28.2 ± 3.7	.309
Function (Max. 20)	19.4 ± 2.2	19.4 ± 2.1	.827
Range of motion (Max. 30)	25.0 ± 3.6	27.4 ± 3.1	.009
Retear variable	**MC (+) (n = 13)**	**MC (−) (n = 7)**	***P* value**
Forward flexion	151.5 ± 12.0	156.4 ± 14.1	.588
Abduction	156.2 ± 17.2	164.3 ± 16.9	.351
External rotation	42.7 ± 28.7	48.3 ± 11.8	.588
Internal rotation	12.7 ± 3.3	11.3 ± 2.3	.135
JOA score (Max. 100)	90.1 ± 7.8	90.6 ± 8.5	.757
Pain (Max. 30)	26.9 ± 4.4	25.0 ± 5.8	.485
Function (Max. 20)	18.9 ± 1.8	18.6 ± 1.7	.643
Range of motion (Max. 30)	24.5 ± 4.6	27.3 ± 3.0	.211

Data are presented as mean ± standard deviation.
MC, margin convergence; *JOA*, Japanese Orthopaedic Association.

The overall retear rate did not differ significantly between the MC (29.5%) and non-MC (20.0%) groups in the present study, although a larger mediolateral tear size in the MC group was one of the risk factors for retears.[33] Hatta et al reported that performing multiple-suture MC prior to footprint repair diminishes the stress on the repair site by lateralizing the free margin of longitudinal-type RCT.[12] Thus, the MC technique can be performed in cases wherein the longitudinal-type RCT that cannot be repaired using the conventional technique.

The postoperative JOA pain and function scores for both repair methods were similar in the present study. The treatment of larger RCTs is technically demanding despite the advances in surgical techniques.[13] Larger tear size may be associated with poorer postoperative shoulder function[21] and lesser improvement of pain.[9] The MC technique may be an efficient technique as the postoperative JOA pain and function scores of the 2 techniques were equivalent despite the larger size of mediolateral tear in the MC group.

The proportion of RCTs caused by a traumatic event and the mediolateral size of the tear were significantly higher in the MC group. In contrast, the proportion of patients with subscapularis tendon tear was significantly higher in the non-MC group. The torn edge of the tendon tends to retract rapidly due to the preserved elasticity of the musculotendinous unit if the tendon is ruptured due to a traumatic event.[20] This could explain the larger mediolateral size of the tear in the MC group. A larger width and length of the posterosuperior tear have been associated with subscapularis tendon tear in atraumatic RCTs.[25] Most patients in the non-MC group had atraumatic RCTs (30/35, 85.7%). Moreover, only patients with large-sized RCTs were included in this study. These characteristics may reflect the difference in the proportion of the subscapularis tendon tear between the MC and non-MC groups in the present study.

The present study has some limitations. First, the minimum postoperative follow-up period of 12 months was relatively short. Although a follow-up period of 24 months is more appropriate, most patients achieved functional recovery within 6 months postoperatively. The recovery proceeded until 12 months postoperatively when it reached a plateau.[5,23] Second, the timing of postoperative MRI examinations for evaluating the structural outcome was not consistent. A previous study reported that most retears occurred within the first 3 postoperative months.[28] All patients underwent MRI more than 3 months postoperatively in the present study. Thus, it is unlikely that retears would occur after the MRI examination was performed. Third, the proportion of the detailed patterns of longitudinal RCTs was not described in this study, as it was difficult to distinguish the original tear pattern in the chronic stage despite the slight discrepancies in appearance between U-shaped and L-shaped tears.[30] Hence, only large longitudinal tears repaired using MC and large-sized tears repaired without using MC were categorized in this study. Fourth, cases with subscapularis tear combined with the posterosuperior RCT were not excluded. Previous studies have demonstrated that the postoperative clinical outcomes of patients who underwent isolated repair of posterosuperior tears were comparable with those of the patients who underwent repair of combined subscapularis tear.[19,22] Thus, these combined subscapularis tears were less likely to influence the postoperative clinical outcome. Fifth, the number of patients was small and power analysis was not performed to ascertain whether the study numbers could support these findings. Sixth, the larger size of the mediolateral tear in the MC group may have influenced the postoperative ROM and clinical outcome. Because the MC technique is usually selected for repairing longitudinal-type tears, the size of the mediolateral tear in the MC group was larger than that of those in the non-MC group in our study.

Conclusion

ARCR using MC of large-sized longitudinal-type tears does not lead to better postoperative range of external rotation and clinical outcome compared with those of conventional repair.

Acknowledgments

The authors express their deep thanks to Dr. Hisatomi Arima, Professor in the Department of Preventive Medicine and Public Health, Faculty of Medicine, Fukuoka University, for his valuable guidance in the statistical analysis of the data.

The authors would like to thank Editage (www.editage.jp) for English language editing.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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