


CLINICAL ARTICLE

Clinical Outcomes of Arthroscopy-Assisted Modified Triple Endobutton Plate Fixation in Rockwood Type III Acute Acromioclavicular Joint Dislocation: A Retrospective Study

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Objective: The common triple Endobutton plate (CTEP) fixation is a lengthy procedure that is associated with high failure rates. Therefore, we used arthroscopy to improve the Endobutton fixation method by shortening the duration of surgery and reducing operative complications. This study explored the safety and effectiveness of arthroscopy-assisted modified triple Endobutton plate (MTEP) fixation in Rockwood type III managing acute acromioclavicular joint (ACJ) dislocation.

Methods: This was a retrospective single-center study involving 73 patients with Rockwood type III acute ACJ dislocation treated between January 2016 and January 2021. The 73 patients were classified into three groups, the acromioclavicular hook plate (ACHP) group (22 cases), CTEP group (24 cases) and MTEP group (27 cases), based on the type of surgical treatment they received. Clinical outcome data from the patient records, including the Constant–Murley score (CMS), American Shoulder and Elbow Surgeons score (ASES) and University of California at Los Angeles shoulder rating scale score (UCLA), were retrospectively reviewed. The scores were assessed before surgery and at the third and twelfth month after surgery. The clavicle–coracoid (CC) distance on the affected side was estimated from imaging scans taken before surgery, on the second day after surgery, and within the third and twelfth month after surgery. The student's *t*-test was used to compare normally distributed data for independent samples, while homogeneity of variance test was used to compare normally distributed data among multiple groups. Non-normally distributed data were compared using Mann–Whitney rank-sum tests.

Results: There were no differences in age, gender, body mass index (BMI), dislocated side, trauma etiology, and duration of follow-up among the three groups. There was also no significant difference in the duration of surgery between the ACHP and MTEP groups, although the duration in the two groups was shorter than in the CTEP group ($P < 0.05$). The duration of hospitalization for the MTEP group was significantly shorter than for the CTEP group which was in turn shorter than for the ACHP group (both $P < 0.05$). There was no significant difference in postoperative CMS, ASES, and UCLA scores between the CTEP and MTEP groups but the score for the two groups differed significantly from those of the ACHP group (all P s < 0.05). In addition, there was no significant difference in CC distance among the three groups after surgery ($P > 0.05$).

Conclusion: Arthroscopic reconstruction of the coracoclavicular ligament using MTEP fixation to manage acute Rockwood type III ACJ dislocation is minimally invasive, and is associated with rapid functional recovery, few complications and satisfactory early clinical results.

Key words: Acromioclavicular joint dislocation; Arthroscopy-assisted; Coracoclavicular ligament; Endobutton Plate fixation

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Introduction

Acromioclavicular joint (ACJ) injuries are a common cause of significant shoulder pain and functional impairment in adults and represent a significant proportion (approximately 12%) of shoulder injuries¹. In recent years, the incidence of ACJ injuries has been on the rise annually, possibly due to the increase in the intensity of exercise and changes in habitual lifestyles². The clinical symptoms of ACJ injuries include joint pain, loss of joint functions, and limitations in joint range of motion³. Despite ACJ injuries being a common type of injury and the numerous recent technologies being widely used to treat these injuries, there is still no standard treatment for ACJ dislocation^{4,5}.

In the 1960s, Tossy and colleagues initially classified ACJ injuries as types I, II and III⁶. Subsequently, Rockwood expanded the classification system to include types IV–VI based on radiographic findings⁷. At present, the Rockwood classification system is the most commonly used system among surgeons and is effective for the accurate diagnosis of ACJ injuries^{8,9}. There is a general consensus that Rockwood I and II injuries can be managed using conservative treatment without surgical intervention and that Rockwood IV–VI injuries require surgical treatment. However, the best treatment strategy for Rockwood III injuries remains controversial, with the results of several studies indicating that type III patients treated surgically have better radiological outcomes and comparable functional outcomes in the long term compared with patients treated conservatively. Early surgery leads to significant advantages regarding functional recovery outcomes^{10–12}.

The main objective of surgery for Rockwood type III ACJ dislocation is to achieve anatomical reduction and restore normal ACJ kinematics. Currently, there is no effective treatment for ACJ dislocation. The following three surgical methods are frequently used in clinical practice^{13–20}: (i) acromioclavicular fixation (hook plate); (ii) coracoclavicular fixation; and (iii) ligament reconstruction. A previous study suggested that Endobutton plate fixation yields better outcomes in terms of postoperative shoulder joint complications compared with rigid fixation with a hook plate, and can be used effectively to treat ACJ dislocation. Previous biomechanical and clinical studies have demonstrated that Endobutton plate fixation mimicking the natural anatomic structure can stabilize the ACJ complex^{21,22}. Previously, triple Endobutton plate fixation and double Endobutton plate fixation were found to be efficient methods for the treatment of ACJ dislocations with few complications²³. However, a biomechanical study showed that triple Endobutton plate fixation is more stable during flexion and abduction than double Endobutton plate fixation²⁴.

For many years, the common triple Endobutton plate (CTEP) fixation method has been extensively applied and studied^{15,18,24}. However, it is a technically demanding procedure that requires lengthy operation time and is associated with a high failure rate. Therefore, we improved the Endobutton fixation method to shorten the duration of surgery and reduce operative complications. The arthroscopy-assisted technique is

advantageous because shoulder arthroscopy provides a clearer view of the coracoid process, making it a minimally invasive technique¹⁰.

In the present study, we conducted a retrospective study to compare the efficacy between arthroscopy-assisted Endobutton plate fixation and open hook plate fixation. The aims of this study included the following, (1) highlight the details and key steps involved in arthroscopy-assisted MTEP fixation; (2) evaluate the feasibility and the clinical efficiency of this technique in relation to the traditional fixation method; and (3) describe the precautions that should be followed during arthroscopy-assisted triple Endobutton plate fixation combined with failed surgical cases.

Methods and Materials

Patient Information

We retrospectively reviewed the charts of patients with acute ACJ dislocation who had undergone arthroscopic fixation or open reduction from January 2016 to January 2021 in our department. Arthroscopic fixation has been applied in clinical practice from July 2017. Before this, acromioclavicular hook plate (ACHP) was routinely performed for the treatment of ACJ dislocation. From August 2017 to March 2019, we mainly used the CTEP for arthroscopic fixation. After April 2019, to reduce surgical complications and shorten the duration of surgery the arthroscopic fixation technique was optimized and the MTEP fixation approach was adopted. All patients who visited our hospital were fully informed of the advantages and disadvantages of conservative treatment and surgical treatment. All patients who underwent surgery gave their written informed consent. The Ethical Committee of Taizhou Hospital of Zhejiang Province approved the study protocol (Ethics approval number: K20220511).

The inclusion criteria were as follows: (i) the patient had been diagnosed with acute Rockwood type III ACJ dislocation (<2 weeks after trauma); (ii) the shoulder was injured on one side; (iii) and the operation was conducted by the same treatment group. The exclusion criteria were as follows: (i) patients with fractures and/or dislocation in other parts of the four extremities or trunk; (ii) patients with vital organ injuries; (iii) patients who underwent operations by different treatment groups; and (iv) patients who were lost to follow-up within 12 months after the surgery. The patients were classified into three groups (ACHP, CTEP and MTEP) based on the type of surgery the patients underwent.

Surgical Techniques

All patients received an infraclavicular block before general anesthesia. Antibiotic prophylaxis using cephalosporin (cefuroxime 1.5 g) was also administered for all patients perioperatively. All affected limbs underwent triangle bandage immobilization for 1 month, and then, rehabilitation was initiated. The patients resumed their daily activities 3 months after surgery and returned to sports half a year later.

Acromioclavicular Hook Plate Fixation

The patients were placed in the beach chair position under general anesthesia, to allow free movement of the affected limb. The skin, superficial fascia and deltoid fascia were successively incised, and the ACJ was exposed. All the patients underwent ACHP fixation after proper reduction of the ACJ. In addition, the ACHP was removed 1 year after surgery in the patients who had excellent clinical results at the 1 year postoperative follow-up.

Common Triple Endobutton Plate Fixation

Step 1. The patients were placed in a lateral recumbent position after general anesthesia.

Step 2. After inspecting the glenohumeral (GH) joint with the posterior and anterior portals using a 4 mm arthroscope

with a 30° visual angle, the shoulder capsule in the rotator interval was opened, and the base of the coracoid exposed using a radiofrequency. Next, the distal clavicle was identified through a 2 cm incision over the clavicle 3 cm from the ACJ. Under C-arm visualization, temporary fixation with a Kirschner wire was used to stabilize the reduced clavicle.

Step 3. After positioning the guide tip under the coracoid base, the conoid ligament tunnel was drilled on top of the clavicle 4 cm from the ACJ and directly in line with the base of the coracoid. At the same time, the trapezoid ligament tunnel was placed on top of the clavicle 2 cm from the ACJ. (Fig. 1A).

Step 4. The first Endobutton plate closed loop was chosen, whose length was similar to that of the conoid ligament tunnel. Then the first and second strands of Ethibond sutures were placed through the first and fourth holes of the

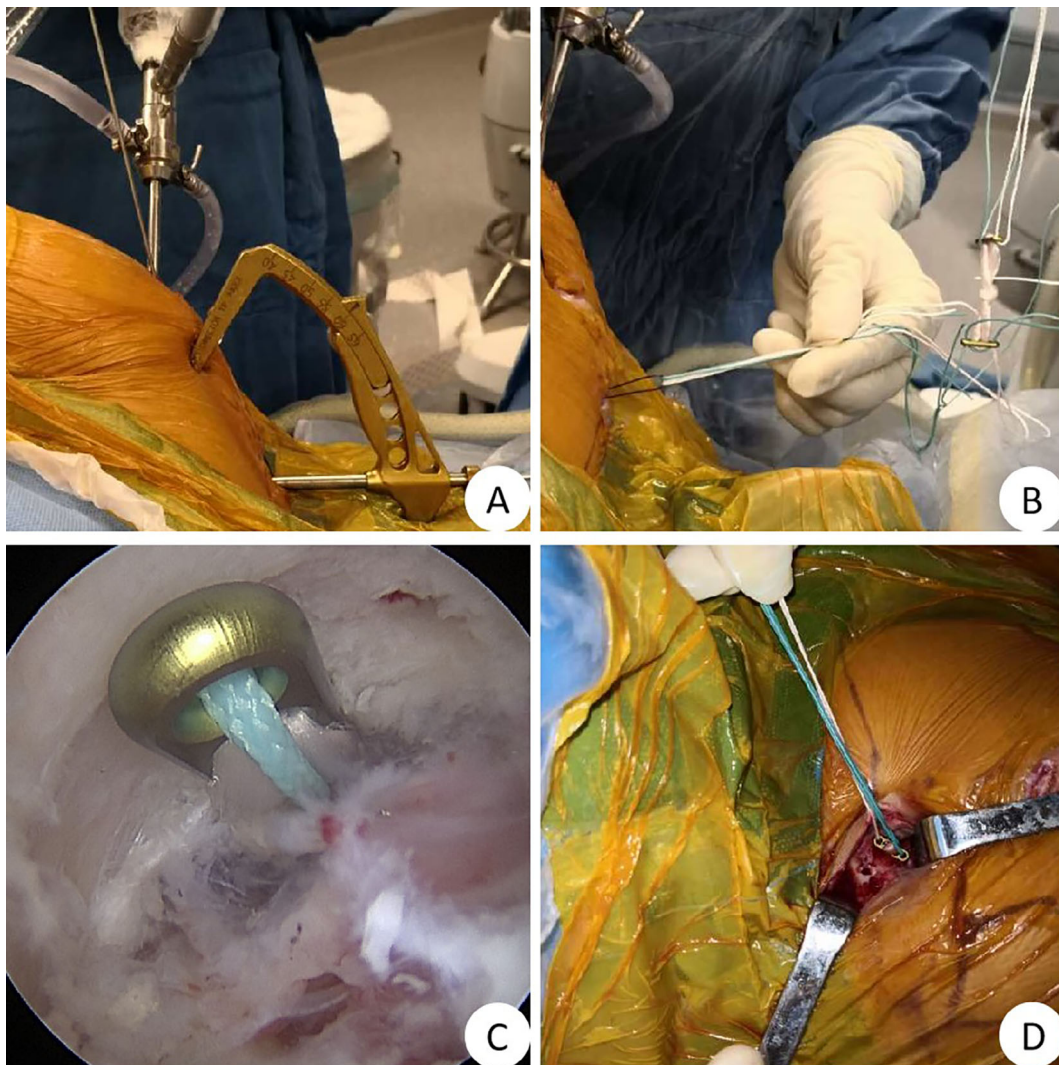


Fig. 1 Surgical procedure of Modified Triple Endobutton Plate (MTEP) Fixation. (A) The guide tip placed under the coracoid base. (B) The modified Endobutton device consisting of two Endobutton closed loops whose lengths summation was similar to that of the conoid ligament tunnel distance. (C) The inferior Endobutton was pulled downward to the base of coracoid. (D) The superior Endobutton was pulled upward on the top of the clavicle

Endobutton. The third strand was placed through the first hole used to reconstruct the trapezoid ligament, and the fourth strand was placed through the closed loop to serve as the dragline wire. The Endobutton and closed loop were inserted first through the conoid ligament tunnel using a smooth cylindrical plunger. After removal of the Kirschner wire, the distal clavicle was pushed downwards until the loop was pulled up using the dragline wire. The second Endobutton plate without loops was placed in the loop above the clavicle and tied by the first and second strands of Ethibond. (Fig 2A).

Step 5. The third strand Ethibond suture was passed through the trapezoid ligament tunnel using the grasper and the guided wire, and was tied on top of the third Endobutton

plate without loops to reconstruct the trapezoid ligament. (Fig 2B).

Modified Triple Endobutton Plate Fixation

MTEP fixation was also divided into five steps, and steps 1, 2, 3, and 5 were similar to those of CTEP fixation. The only difference involved the method used to reconstruct the conoid ligament (step 4). The specific steps and the imaging examination results are as follows.

The modified Endobutton device consisted of two Endobutton closed loops whose summation of lengths was similar to the conoid ligament tunnel distance. To prepare a modified Endobutton device, the first Endobutton's loop was

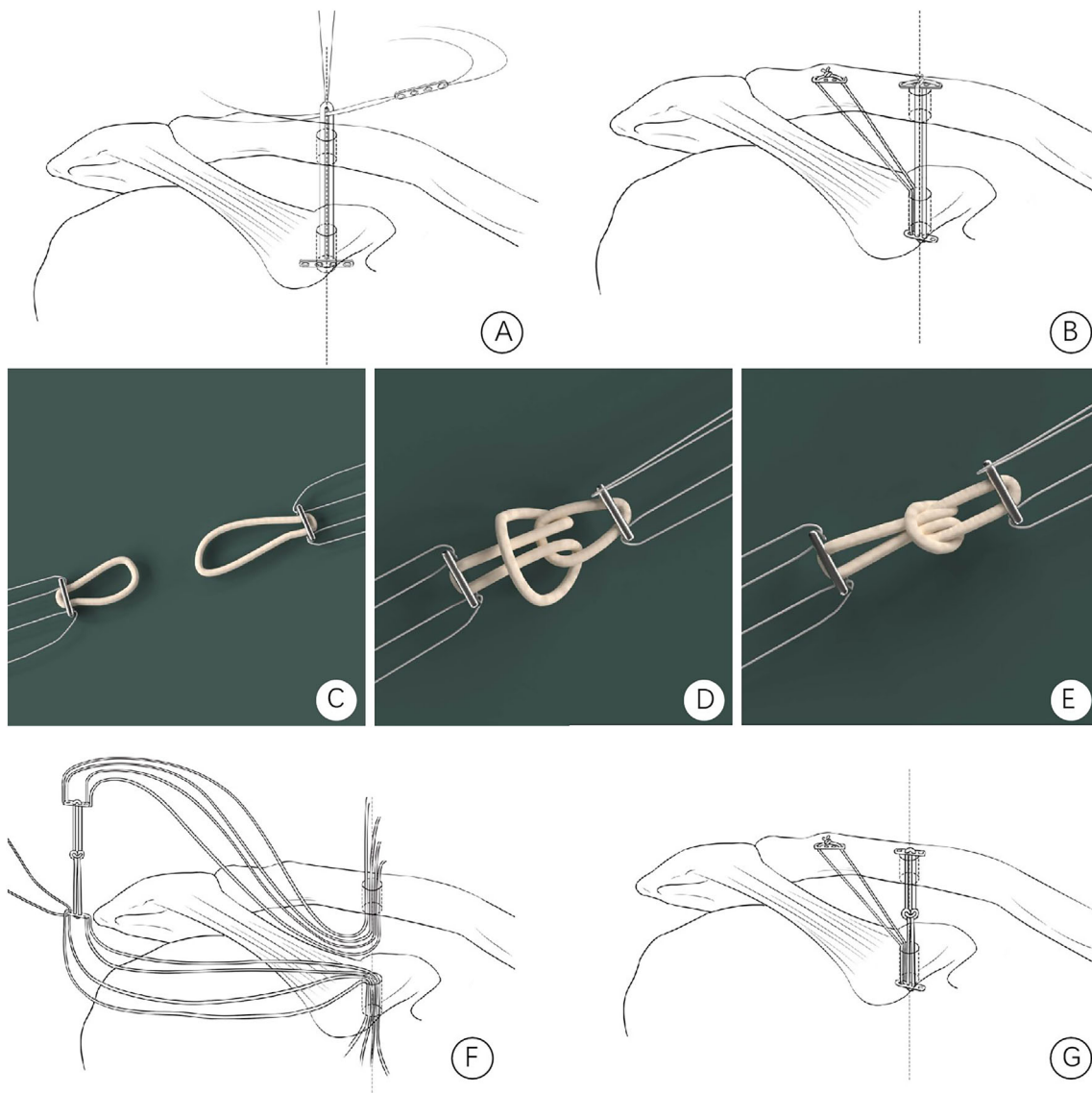


Fig. 2 Illustration of Common Triple Endobutton Plate (CTEP) Fixation and Modified Triple Endobutton Plate (MTEP) Fixation. (A, B) Illustration of Common Triple Endobutton Plate (CTEP). (C–E) The modified Endobutton device consisting of two Endobutton closed loops whose summation of lengths were similar to those of the conoid ligament tunnel distance. (F, G) Modified Triple Endobutton Plate (MTEP) Fixation

initially inserted into the second Endobutton's loop. Next, the first Endobutton was reflected into its own loop which had passed through the second Endobutton's loop. Finally, two Endobuttons were strained from two opposite directions, making a closed-loop slipknot between two Endobuttons, which was the modified Endobutton device. (Fig. 1B and Fig. 2C–E).

In addition, four strands of Ethibond sutures were placed through the first and fourth holes of the inferior and superior Endobutton to serve as the dragline wire. Another Ethibond suture strand was used to reconstruct the trapezoid ligament and was placed through the first hole of the inferior Endobutton. By using the guide wires, the dragline wires were separately inserted through the conoid ligament tunnel of the clavicle and coracoid. (Fig. 2F) After fixation of the inferior Endobutton on the base of the coracoid (Fig. 1C), the Kirschner wire was pulled out, and the distal clavicle was pushed downwards. Subsequently, the superior Endobutton was pulled upwards using a dragline wire and fixed on top of the clavicle (Fig. 1D). In the end, the trapezoid ligament was reconstructed by the third Endobutton (Fig. 2G).

Clinical and Radiographic Assessment

Clinical outcome data from patient records were retrospectively reviewed along with the imaging findings. Data on shoulder function were obtained at the 1-, 3- and 12 month follow-ups, while radiological data were obtained on the second day post-surgery and at the 3- and 12 month follow-ups.

Clinical Assessment

Constant-Murley Score. The Constant-Murley score (CMS) is recommended for the assessment of shoulder function by the European Society for Shoulder and Elbow Surgery (ESSES). It is divided into four modules: pain; daily activities; active range of motion; and strength. Its score ranges from 0 to 100 points, representing worst and best shoulder function, respectively. The minimal clinically important difference (MCID) for CMS (MCID = 3.8) was used as defined by Puzziello *et al.*²⁵

American Shoulder and Elbow Surgeons Rating Scale Score. The American Shoulder and Elbow Surgeons (ASES) rating scale score was developed to provide a standardized method for evaluating shoulder function. This score consists of pain (50 points) and daily shoulder function (50 points). The maximum ASES score is 100 points and a higher score indicates a better shoulder function. The MCID for ASES (MCID = 6.4) was used as defined by Roy *et al.*²⁶

University of California at Los Angeles Shoulder Rating Scale Score. The University of California at Los Angeles (UCLA) shoulder rating scale score is widely used to evaluate shoulder function. This method assigns a score to patients based on five separate domains: pain (10 points); function (10 points); active forward flexion (5 points); strength of forward flexion (5 points); and overall satisfaction (5 points). The maximum UCLA score is 35 points and a higher score

indicates increased shoulder function. The MCID for UCLA (MCID = 3.0) was used as defined by Xu *et al.*²⁷

Radiographic Assessment

Clavicle-Coracoid Distance. The clavicle-coracoid (CC) distance is the distance between the clavicle inferior surface and the coracoid superior surface. It is a critical radiographic measurement tool for assessing reduction of the ACJ, and was calculated using the standard anteroposterior scans of the ACJ taken preoperatively and postoperatively.

Statistical Analysis

Statistical analysis was performed using SPSS software (IBM SPSS 23.0, SPSS Inc., Chicago, IL, USA). Pearson's chi-square or Fisher's exact test were used to compare the sex, affected side, cause of injury, and dislocation type across the three groups. The Kolmogorov-Smirnov test was used to determine the distribution of continuous variables. Normally distributed data were presented as mean and standard deviation (SD), while non-normally distributed data were expressed as Median and interquartile range (IQR). The student's *t*-test was used to compare normally distributed data for independent samples, while homogeneity of variance test was used to compare normally distributed measurements for multiple groups. Non-normally distributed data were compared using Mann-Whitney rank-sum tests. The statistical significance level was set to be 0.05.

Results

Analysis of the Demographic Characteristics

Based on the medical records, 145 patients were initially recruited, but 36 patients were excluded because of vital organ injury, 22 patients were excluded because of fractures in other parts of the body and 13 patients declined to participate. The 74 patients who met the inclusion criteria were then

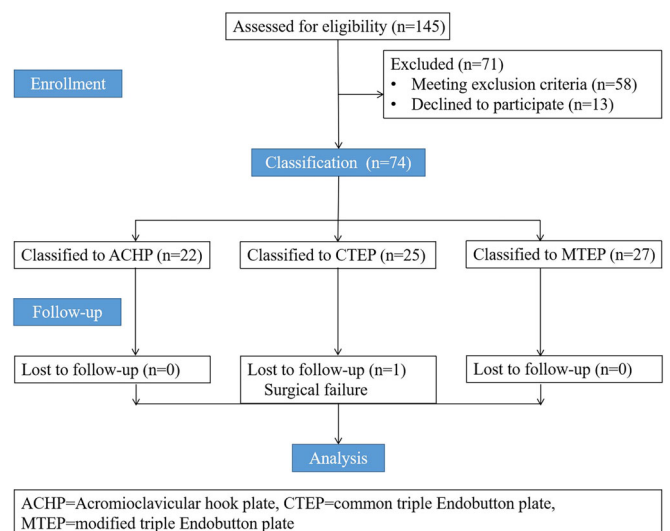


Fig. 3 A flow chart showing patient selection process

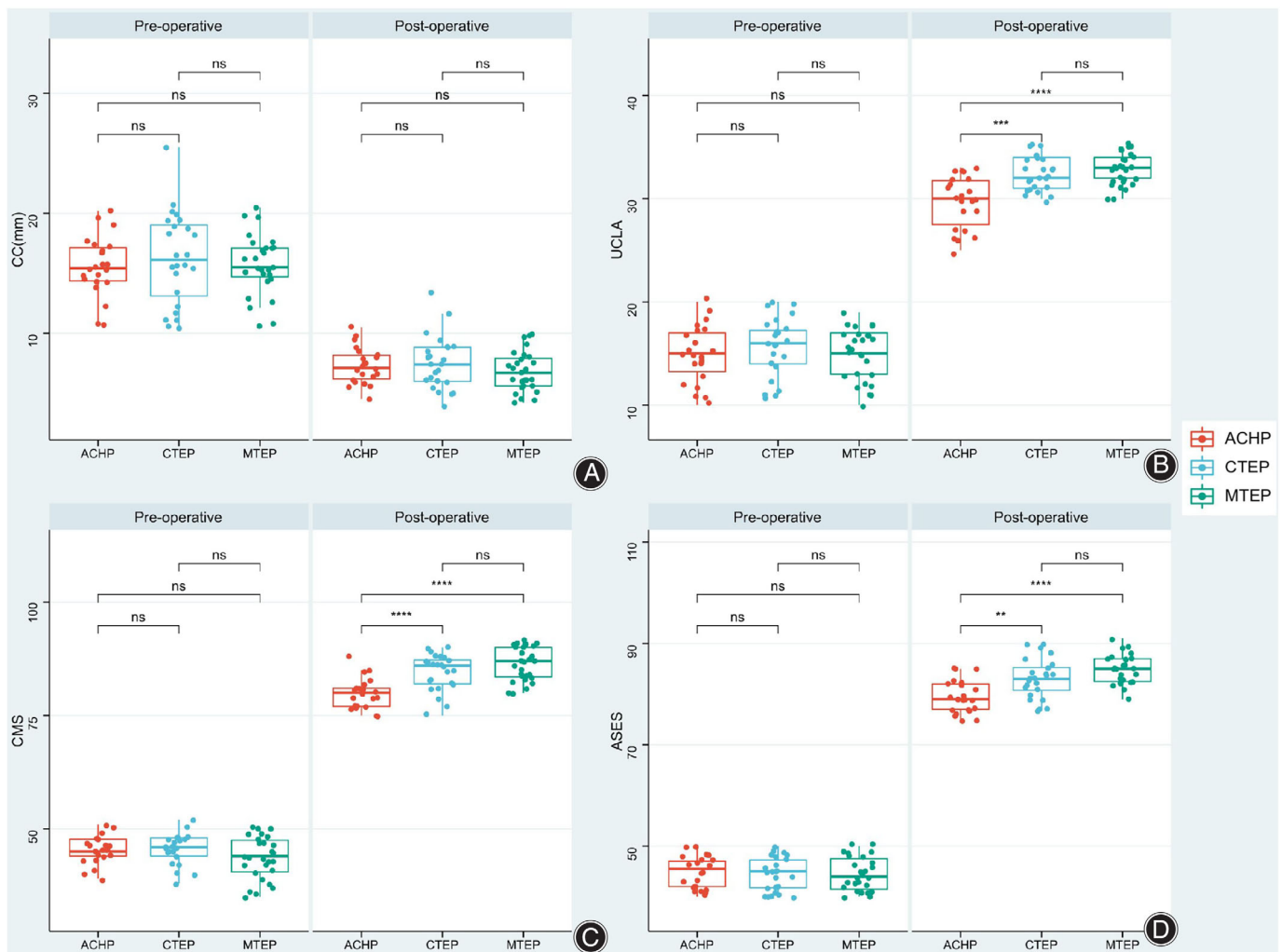


Fig. 4 Comparison of clinical and radiographic assessment index. (A) Comparison of CC before and 12-month after surgery among the three groups. (B) Comparison of UCLA before and 12-month after surgery among the three groups. (C) Comparison of CMS before and 12-month after surgery among the three groups. (D) Comparison of ASES before and 12-month after surgery among three groups. ns: no significant difference; *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$; ****: $P < 0.0001$. ACHP, Acromioclavicular hook plate; ASES, American Shoulder and Elbow Surgeons score; CC, clavicle-coracoid distance; CMS, Constant-Murley score; CTEP, common triple Endobutton plate; MTEP, modified triple Endobutton plate; UCLA, University of California at Los Angeles shoulder rating scale score

classified into three groups based on the type of surgery carried out: ACHP group (22 cases); CTEP group (25 cases); and MTEP group (27 cases). However, one patient was lost to follow-up due to failed surgery in the CTEP group, bringing the final number of cases in this group to 24. A flow chart of the patient inclusion process is shown in Fig. 3. There were no differences in age, gender, body mass index (BMI), dislocated side, and trauma etiology among the three groups. Baseline characteristics of the patients are shown in Table 1.

Comparison of Hospitalization Period, Duration of Surgery and Follow-Up

No differences in follow-up time were found among the three groups (both P s > 0.05). There was no significant difference in

the duration of surgery between the ACHP and MTEP groups ($P > 0.05$), but the duration of the CTEP group was significantly longer than that of the other groups ($P < 0.05$). The hospitalization period of the MTEP group was significantly shorter than for the CTEP groups which was in turn shorter than the ACHP group (both P s < 0.05) (Table 2).

Comparison of Clinical and Radiographic Assessment Index

There were no differences in the clinical shoulder function data (CMS, UCLA, ASES) or CC distance among the three groups (both P s > 0.05) before surgery. However, there was significant improvement in shoulder function and CC distance at 12 months post-surgery compared with preoperatively

TABLE 1 The demographic characteristics of the studied patients

Demographic characteristics	ACHP (n = 22)	CTEP (n = 24)	MTEP (n = 27)	F value	χ^2	P value
Age, years (mean \pm SD)	55.14 \pm 11.01	52.08 \pm 12.19	51.89 \pm 10.59	0.605		>0.05
Gender, n (%)					2.05	>0.05
Male	16 (73)	13 (54)	15 (56)			
Female	6 (27)	11 (46)	12 (44)			
BMI (mean \pm SD)	24.75 \pm 2.64	25.09 \pm 2.93	24.75 \pm 2.61	0.125		>0.05
Dislocated side, n (%)					0.424	>0.05
Left	9 (41)	12 (50)	13 (48)			
Right	13 (59)	12 (50)	14 (52)			
Trauma etiology, n (%)					3.71	>0.05
Motobike accident	6 (27)	6 (25)	11 (41)			
Traffic accident	8 (36)	9 (38)	9 (33)			
Fall	5 (23)	8 (33)	5 (19)			
Sport trauma	3 (14)	1 (4)	2 (7)			

ACHP, acromioclavicular hook plate; BMI, body mass index; CTEP, common triple Endobutton plate; MTEP, modified triple Endobutton plate; SD, standard deviation.

TABLE 2 Comparison of hospitalization period, operation time and follow-up among three groups

Characteristics	ACHP (n = 22)	CTEP (n = 24)	MTEP (n = 27)
Hospitalization period, days (IQR)	14 (8–15)	9 (7.25–12) ^{a,c}	6 (4–11) ^{a,b}
Operation time, minutes (mean \pm SD)	40.77 \pm 12.28	50.67 \pm 8.66 ^{a,c}	39.93 \pm 8.50 ^b
Follow-up, months (IQR)	12 (12–13)	12 (12–13)	12 (12–13)

ACHP, Acromioclavicular hook plate; CTEP, common triple Endobutton plate; IQR: interquartile range; MTEP, modified triple Endobutton plate; SD: standard deviation.; ^aVersus ACHP, $P < 0.05$.; ^bVersus CTEP, $P < 0.05$.; ^cVersus MTEP, $P < 0.05$.

($P < 0.05$). Moreover, the final data on shoulder function for the MTEP and CTEP groups were better than those of the ACHP group ($P < 0.05$), but there was no significant difference between the MTEP and CTEP groups ($P > 0.05$). In addition, there was no significant difference in CC distance among the three groups after surgery ($P > 0.05$). Comparison of preoperative and postoperative clinical and radiographic assessment indices among the three groups are shown in Fig. 4 and 5.

The differences in clinical outcomes observed in our study between ACHP and CTEP patients were 2.7, 4.7 and 3.6 for the UCLA, CMS and ASES scores, respectively. The differences in clinical outcomes between ACHP and MTEP patients were 3.1, 6.4 and 5.4 for the UCLA, CMS and ASES scores, respectively. None of the ASES differences exceeded the MCID, but both of the CMS differences exceeded the MCID. Moreover, we observed that differences in the UCLA score between ACHP and MTEP exceeded the differences in the MCID score, but the difference between ACHP and CTEP did not (Table 3).

Complications

A 39 year-old female with type III ACJ dislocation underwent CTEP fixation. Coracoid Endobutton plate loosening was seen at the end of the third postoperative month. The

patient presented with low-intensity pain (VAS: 3/10) when abducting the affected upper extremity. This patient was lost to follow-up because she visited another hospital and was excluded from the study (Fig. 6).

Discussion

This retrospective single-center study is the first to compare ACHP fixation, CTEP fixation and MTEP fixation for acute Rockwood type III ACJ dislocation. Briefly, two well-established surgeries were compared. It was found that patients who underwent CTEP fixation showed better shoulder function compared with those who underwent ACHP fixation. Based on literature and biomechanical studies, we then modified CTEP fixation (MTEP fixation) to shorten the duration of surgery and improve ACJ stability. Our results demonstrated that MTEP fixation was associated with better shoulder function compared with ACHP fixation, and shorter surgery time and less complications compared with CTEP fixation.

Theoretical Advantages and Key Steps of MTEP Fixation

The technique has simple operation and allows early mobilization. The ACHP fixation is commonly used for rigid trans-articular fixation²⁸. However, at long-term follow-ups, the hook has been shown to exhibit physical impingement,

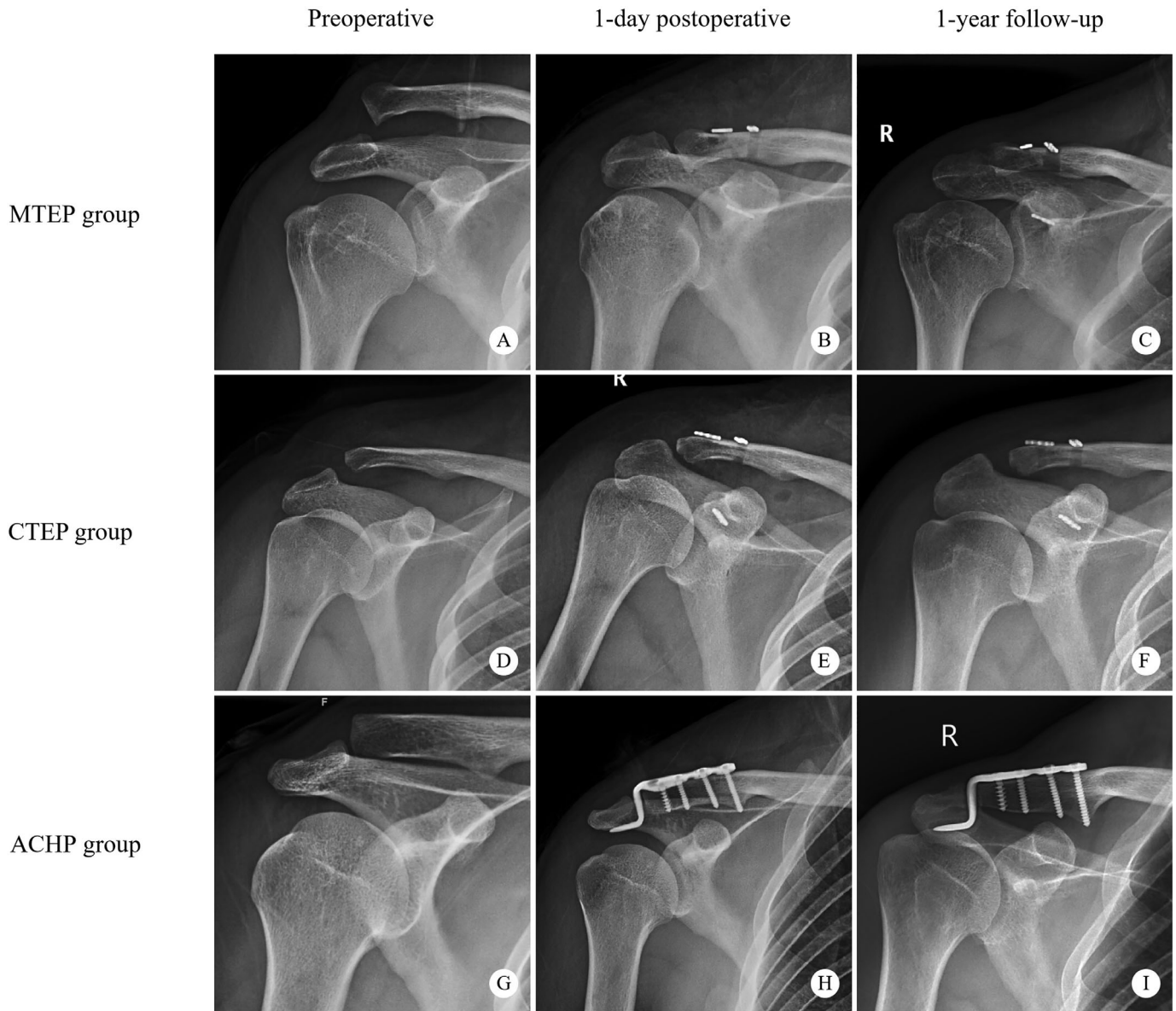


Fig. 5 The radiography of injured shoulders in Three groups showing a satisfactory operation outcome. (A, B,C) MTEP group; (D, E, F) CTEP group; (G, H, I) ACHP group; (A, D, G) preoperative; (B, E, H) 1-day postoperative; (C, F, I) 1-year follow-up. ACHP, Acromioclavicular hook plate; CTEP, common triple Endobutton plate; MTEP, modified triple Endobutton plate

which may cause sub acromial erosion, rotator cuff lesions, and poor shoulder joint functional scores^{29,30}. Thus, to prevent the adverse effects associated with ACHP on ligamentous healing, a second ACHP removal operation is often performed 8–12 months after the first surgery²⁹.

Due to the various complications associated with ACHP, there has been an increase in the use of nonrigid techniques, such as anatomical reconstructions of the coracoclavicular ligaments using Endobutton plates and fiber sutures. The coracoclavicular ligaments, including the conoid and trapezoid ligaments, play an important role in maintaining the stability

and function of ACJ¹⁴. In 2004, a biomechanical study demonstrated the effectiveness and efficiency of anatomical reconstructions of coracoclavicular ligaments from a theoretical perspective³¹. Initially, a single Endobutton and fiber suture were used to construct the conoid ligament, but this method has been associated with issues such as knot slippage, suture breakage and button migration leading to high failure rates²². Therefore, anatomical conoid ligament reconstruction performed using the double Endobutton plate method has gradually replaced the single Endobutton plate method in clinical and biomechanical studies¹⁷. Lim reported a novel method

TABLE 3 Mean differences of the clinical outcomes among the three fixation

Clinical outcomes	Mean	SD	Mean difference (95% CI)	MCID
UCLA				3.0
ACHP	29.7	2.6	Ref.	
CTEP	32.4	1.6	2.7 (1.1–4.3)	
MTEP	32.8	1.5	3.1 (1.5–4.7)	
CMS				3.8
ACHP	79.9	3.4	Ref.	
CTEP	84.6	4.0	4.7 (2.0–7.4)	
MTEP	86.3	3.7	6.4 (3.8–8.9)	
ASES				6.4
ACHP	79.5	3.2	Ref.	
CTEP	83.1	3.9	3.6 (1.0–6.2)	
MTEP	84.9	2.8	5.3 (3.1–7.5)	

ACHP, acromioclavicular hook plate; CI, confidence interval; CTEP, common triple Endobutton plate; MCID, minimal clinically important difference; MTEP, modified triple Endobutton plate; SD, standard deviation.

based on the double Endobutton plate method using an additional Endobutton plate mimicking the trapezoidal ligament³². Although previous studies have demonstrated promising results for double or triple Endobutton plate fixation, the results of the latest biomechanical study conducted in 2020 showed that the trapezoid ligament may prevent distal clavicle posterior dislocation during flexion of the GH joint. Therefore, the absence of a trapezoid ligament may increase the failure rate of surgery²⁴. This biomechanical study provides a theoretical rationale for triple Endobutton plate fixation.

Moreover, recent technological advances in shoulder arthroscopy have enabled orthopedic surgeons to achieve better visualization of the coracoid base through a minimally invasive method instead of partial deltoid detachment and extensive soft tissue dissection^{16,17}. Therefore, arthroscopy-

assisted surgery was chosen to reduce surgical bleeding and meet patients' aesthetic expectations.

However, considering the possibility of knot loosening with CTEP fixation, which can lead to fixation failure, we modified the conoid ligament reconstruction method regarding CTEP to simplify and shorten the fixation process period which eventually yields stable fixation outcomes. The strength of the loop provided by Pfizer was more than 40% that of body ligaments³³. MTEP fixation can make a completely closed loop between two Endobutton plates, making the conoid ligament reconstruction result more solid and shortening the resetting and knotting time.

Feasibility and Clinical Efficiency of the Technique Compared with Traditional Fixation

Although MTEP fixation had better outcome compared with ACHP, and shorter hospitalization period and operation time compared with CTEP and ACHP, statistical significance does not necessarily mean clinical relevance. Incorporation of patient-reported outcomes during evaluating a therapeutic decision lead to MCID outcomes. Given that no study has reported MCID of ACJ dislocation, three studies defining MCID for arthroscopic surgical therapy of patients with shoulder pathologies were explored^{25–27}. By comparing MCID, the differences of ASES and CMS presented the exact opposite result. This may be due to the differences in validity, reliability and sensitivity of different scales. The CMS is currently the most commonly reported outcome measure, followed by the ASES score³⁴. A meta-analysis of type III ACJ dislocation found that the CMS was the most commonly used score at 63% in the 22 studies included³⁵. The validity and reliability of several shoulder outcome scores, including that of the CMS and ASES scores has been examined for multiple shoulder pathologies³⁶. However, the ASES score system was predominantly used for degenerative

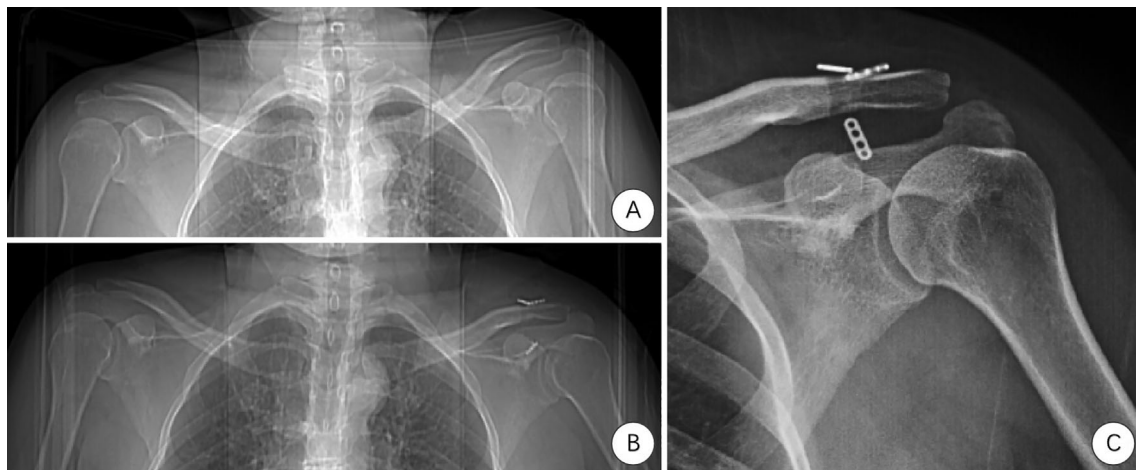


Fig. 6 A 39 year female patient who developed an injury due to a car accident. (A) The X-ray film of both shoulders showing left acute ACJ dislocation (type III). (B) The x-ray film of both shoulders taken on the second day after surgery indicating good ACJ reconstruction results. (C) Coracoid Endobutton plate loosening seen at the end of the third postoperative month

shoulder disorders, and rotator cuff repairs. Therefore, for acute ACJ dislocation, we inferred that the CMS score showed higher clinical relevance compared with the ASES score. Otherwise, we observed that the difference in UCLA between ACHP and MTEP was higher compared with that for MCID, but the difference in UCLA between ACHP and CTEP did not. This finding further demonstrated that MTEP fixation had better clinical effects compared with CTEP fixation.

Precautions for Arthroscopy-Assisted Triple Endobutton Plate Fixation

Finally, considering the failure rates following CTEP fixation and the difficulties associated with the MTEP fixation process, the following challenges need to be considered. First, before establishing the coracoid tunnel, the guide must be pointed at the midway of the coracoid base; if necessary, C-arm visualization can be used. Otherwise, any departure from this position may lead to Endobutton plate loosening, as was the case in our study. Then, when establishing the coracoid tunnel, the surgeons should find a clear operative visual field under arthroscopy to prevent brachial plexus and axillary artery injuries.

Strengths and Limitations

This study has several strengths and limitations. The main strength is that, based on biomechanical and anatomical principles, we have improved the CTEP fixation technology, thereby simplifying the reduction and fixation processes, improving convenience and shortens the operation, with stable outcomes. The second strength is that we have compared the clinical outcomes with MCID scores, and found that differences in the UCLA score between ACHP and MTEP exceeded the differences in the MCID score, but the difference between ACHP and CTEP did not. This further

demonstrates the effectiveness of the MTEP fixation technique. The major limitations of this study include the sample size and follow-up duration. These two shortcomings made it difficult to explore differences among the three treatments and the potential complications of the operation, such as sub acromial traumatic osteoarthritis, or surgical failure. Therefore, there is a need for prospective controlled studies to validate the present findings.

Conclusions

In conclusion, this study shows that the three surgical methods are effective and relatively safe. Traditional ACHP fixation, although simple, always yields worse shoulder function compared with MTEP and CTEP fixation in Rockwood type III ACJ dislocation patients. Although CTEP is widely used in clinical practice, its use is associated with several complications, such as knot slippage, suture breakage, and button migration. In theory, MTEP fixation overcomes these shortcomings and shortens the operation time. In brief, MTEP, an improved version of CTEP, simplifies the reduction and fixation processes, improves convenience and shortens the operation, with stable outcomes.

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Author Contributions

Hantao Jiang and Jingling Tong contributed to the conception of the study; Liping Shen performed the data analyses and wrote the manuscript; Gang Jin helped perform the analysis with constructive discussions; Rangteng Zhu performed the retrospective study.

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