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Displaced Medial-End Clavicle Fractures Treated with Locking Plate Osteosynthesis

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Background: The purpose of this study was to evaluate clinical efficacy of the medial-end clavicle fractures with a reversed lateral locking clavicle plate.

Material/Methods: Eleven male patients age 28 to 66 years old with medial-end clavicle fractures were included in the present study from October 2014 and October 2017. All the patients received operation of fixed with reversed lateral locking clavicle plates. In the operation, a curved incision approximately 8 to 10 cm in length was made, and after the reduction, the fracture was fixed by a reversed lateral locking clavicle plate. Postoperative follow-up was performed in order to evaluate the efficacy of the treatment. Disabilities of the Arm, Shoulder and Hand (DASH) score was used in evaluation the shoulder function post-operation. The functional assessment was performed by using the DASH score.

Results: No intraoperative complications were found during the operation. All patients' incisions achieved healing after operations. Eleven cases were scored by DASH scoring after the operation; Of these, 9 patients were rated excellent, and 2 patients were rated good. There were no neurovascular injuries, nor were there any hemopneumothorax or internal fixation failures.

Conclusions: The fixation of with reversed lateral locking clavicle plates is effective safe patients with medial-end clavicle fractures.

MeSH Keywords: **Clavicle • Fracture Fixation, Internal • Fractures, Bone**

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Background

According to the epidemiology data of clavicular fractures, fractures of the medial end of the clavicle in adults are the rarest of all clavicular fractures [1]. Only 6% clavicular fractures happened at the medial end of the clavicle [2]. Recently, several studies have reported the poor results achieved from the significantly displaced fracture by conservatively treatment [3,4]. Surgical management is an attractive alternative method for the displaced fractures of the medial end clavicle [5]. However, there was little experience working with this fracture for most orthopedic doctors. In addition, there are vital structures situated under the medial clavicle. Surgery of the medial clavicle remains a challenge for orthopedic doctors [6].

According to the literature, there are no standard surgical procedure for treatment of the displaced medial clavicle fracture. Many surgical approaches have been described, including Kirschner wire, screw, and T-plate fixation. However, the fixation failure rate was high when using the Kirschner wire and screw [1]. Kim et al. reported that with T-plate method, the problems of fragment distraction and screw pull-out were common [7]. Recently, several studies have evaluated the treatment procedure of medial clavicle fracture with locking plate [8]. Tokiyoshi and his colleagues reported the fixation procedure with a locking plate which was generally used in lateral clavicle fractures [9]. However, the effectiveness of locking plates for the medial clavicle fracture is unclear, because few cases have been reported.

In our present work, we described in detail the clinical therapeutic outcomes for the treatment of medial end clavicle

fractures with reversed lateral clavicle anatomic locking plates in order to evaluate its clinical efficacy and safety.

Material and Methods

Patients

Eleven male patients age 28 to 66 years old with medial-end clavicle fractures were included in the present study from October 2014 and October 2017. All the patients received operation of fixed with reversed lateral locking clavicle plates. The general characteristics of the included 11 cases was demonstrated in Table 1.

The work was approved by the ethical committee of Tianjin Hospital and signed informed consent was obtained from each of the included patients. All patients were admitted to the hospital and underwent routine x-rays and computed tomography (CT) examinations. All fractures were affected to be the medial clavicle end. The medial-end clavicle fractures were divided into [10]: A-type fracture is defined as undisplaced fracture, and B-type fracture as displaced fracture according to Edinburgh classification method. Eleven cases had obvious displacements, which were classified as type B; 4 cases were type 1B1 (extra-articular), as shown in Figure 1. Two cases were type BO (intra-articular), shown in Figure 1.

Locking plates

The locking plate used in the present work has several angle screw holes at one end. The diameter of the hole was 2.7-mm and the

Table 1. General characteristics of the included 11 cases.

Case	Age (years)	Side	Mechanism of injury	Edinburgh classification	Complication	Follow-up period (months)
1	38	R	Motorcycle	1B1	Ipsilateral lateral clavicular fracture	18
2	33	R	Car accident	1A1	Right rib fracture	22
3	58	R	High fall	1B1	NO	21
4	66	R	Bicycle	1B2	NO	11
5	51	R	Direct collision	1B1	NO	21
6	28	L	Car accident	1B2	NO	18
7	37	R	Direct collision	1A2	Right rib fracture	14
8	42	R	Bicycle	B1	NO	12
9	34	L	Car accident	1B1	NO	15
10	57	R	Bicycle	1B1	NO	11
11	44	L	Car accident	1B1	NO	16

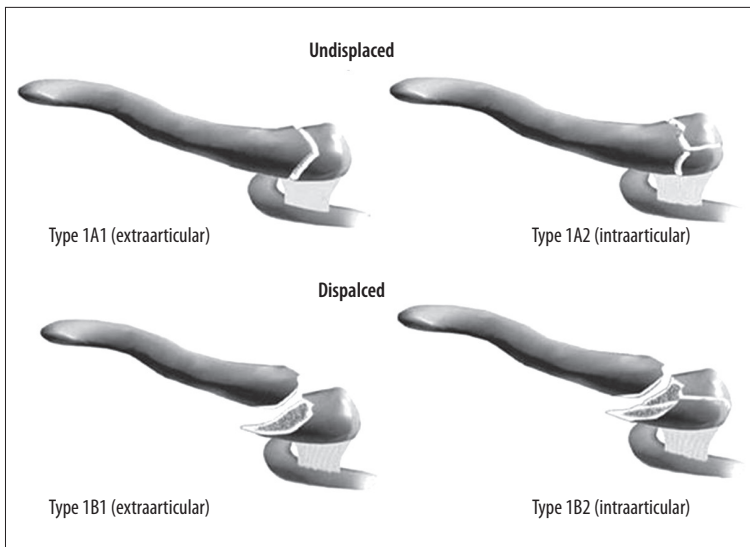


Figure 1. Edinburgh classification of medial-end clavicle fractures.

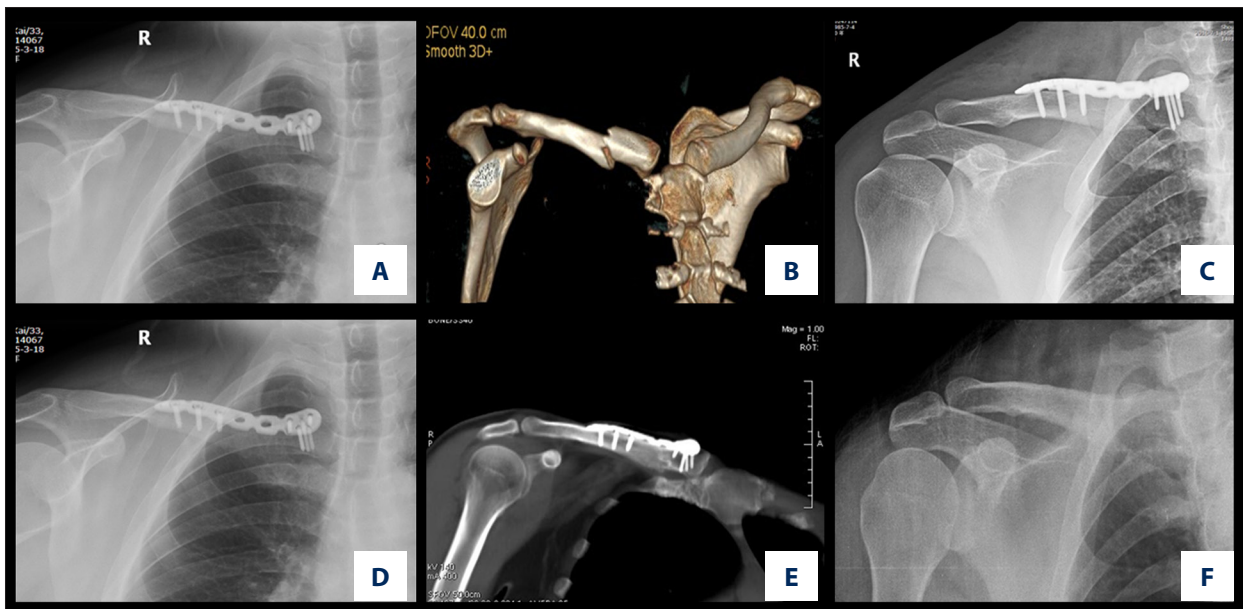


Figure 2. A 33-year-old male was diagnosed of a medial clavicle fracture. (A) X-ray of the clavicle after operation. (B) Computed tomography image of the medial clavicle fracture. (C) X-ray after treatment by locking plate. (D, E) The fracture healed after 1-year post operation. (F) The fixation was removed.

locking screws can path through in order to fix the fragments. The other side of the plate was fixed with 3.5-mm locking screws.

Surgical procedures

Operation was performed under intubation anesthesia or unilateral cervical plexus anesthesia. Patients were in the supine position with the shoulder slightly high. The fracture of clavicle was gently exposed without dissecting the periosteum. The fracture was anatomically reduced fixed temporarily. All fractures were fixed by the lateral clavicle plate (Figure 2). And the medial fragment was then fixed by a 2.7-mm locking

screws; the other side of the plate was fixed with a 3.5-mm locking screw. The medial fragment was drilled and fixed with locking screw through the unilateral cortex. In the patient with ipsilateral medial and lateral clavicle fracture, the medial clavicle fracture was fixed with the reversed lateral locking clavicle plate; the lateral end clavicle fracture was fixed with hook fracture (Figure 3). The wound was sutured layer by layer.

Postoperative management

Postoperatively, the patients were immobilized in a sling for 3 weeks. Progressive physiotherapy was started after 3 weeks and



Figure 3. A 66-year-old male had a medial clavicle fracture. (A) X-ray of the clavicle before surgery. (B) Computed tomography image of the medial clavicle fracture. (C) X-ray after operation by locking plate.

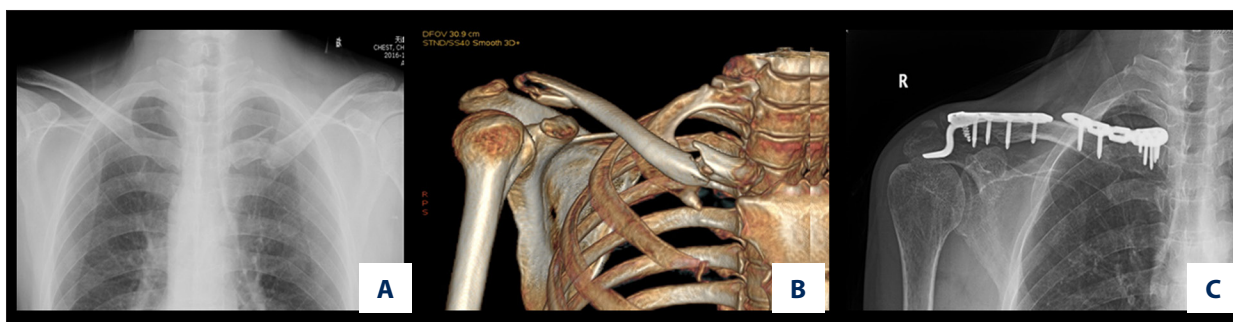


Figure 4. A 38-year-old male had ipsilateral medial clavicle fracture and lateral clavicle fracture. (A) X-ray of the clavicle before surgery. (B) Computed tomography image of the right shoulder girdle showing displaced medial fracture and lateral fracture of the clavicle. (C) The medial clavicle fracture was fixed with reversed lateral locking clavicle plate, and the clavicle fracture was fixed with a hook plate.

included active and passive flexion and uplifting movements. Within 2 months of surgery, the patients achieved a full range of motion of the shoulder. The patients were able to resume their daily activities and work within 4 months after surgery.

Follow-ups

All the cases received regular follow-up including a physical examination, an x-ray evaluation, and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. During the follow up, the range of motion of the shoulder and any complications were recorded.

Results

Intraoperation findings

The operations could be finished within 2 hours. No intraoperative complications, such as neurological, vascular, or tracheal damages were observed in the included 11 cases. The patients didn't receive any blood transfusions during the operation. And postoperative complications such as infection and early

displacement didn't occur after fixation. Postoperative x-ray and CT examinations showed excellent placement of the internal fixation in all 11 patients (Figure 4).

Long-term follow ups results

All the 11 patients were followed up after surgery. No patient showed fracture instability in imaging or on physical examination. The shoulder joint activity was slightly limited in 1 patient, and the limited range was less than 15 degrees. One patient felt mild pain in the sternoclavicular joint during shoulder movement. Two patients felt plate irritation, and selected to have their hardware removed at 10 and 15 months after their initial operation respectively. According to DASH scoring, the mean DASH score was 8.0 (range, 0 to 13); 9 patients were scored as excellent and 2 patient were scored as good. All patients were satisfied with the results of surgery. All patients achieved previous activity levels, and 9 patients returned to their previous occupation.

Discussion

Medial-end clavicle fractures are rare, only 2% to 6% of all clavicle fractures are in the medial section [10–12]. However, Throckmorton and Kuhn reported a higher incidence (9.3%) of medial-end clavicle fractures in their series, which covered a 5-year period [11].

Many investigators have reported that CT scans can be useful to the diagnosis of the medial clavicle fracture. Throckmorton and Kuhn [11] reported that 22% of fractures of the medial clavicle were seen only on CT scans in their case series. CT scans can also determine the amount of displacement, which is helpful for determining the treatment. In our study, all 11 cases received CT scan before treatment.

Conservative treatments have been reported to have excellent outcomes for most patients with an immobilizing sling or brace [13]. Historically, few fractures, even significantly displaced fractures, are openly reduced and fixed due to the risk of injuring important structures that are in close proximity to the medial third of the clavicle, including neurovascular and airway structures. However, recent studies have shown that conservative treatment of displaced medial clavicular fractures is associated with an 8% rate of symptomatic nonunion [14]. Robinson et al. [14] reported that the nonunion rate of displaced medial-lateral fracture patients (14.3%) was higher than that of non-displaced fracture patients (6.3%) at 24 weeks. It is widely accepted that the operation should be performed for displaced medial-end clavicle fractures.

Kim et al. [7] reported the surgical treatment of displaced medial clavicular fractures with a small T-shaped plate. To prevent fragment distraction and screw pullout between the medial fragment of the clavicle and the T-shaped plate, several tension band sutures were fixed between the steel plate hole and sternoclavicular ligament with No. 2 braided non-absorbable suture. Gill et al. reported excellent postoperative outcomes using a modified hook plate in treatment of a medial clavicle fracture [15]. However, because of fixation passed the sternoclavicular joint, the plate had to be removed for shoulder motion at 3 months postoperatively. The plate could also not provide effective fixation for the fracture for more fragments.

Locking plates serve a role in angle stability. These plates have been reported as having advantages over standard compression plates. Oe et al found that T-shaped locking plates provide more rigid fixation because at least 3 locking screws can be placed in medial bone fragments [16].

It is considerably more difficult to treat a shorter medial clavicle fragment or a comminuted fracture. Sanchez et al. described

treatment of medial comminuted clavicle fractures via sternoclavicular joint reconstruction using a 5-mm tibialis anterior allograft; this is the same method of dislocation used for the sternoclavicular joint. Because of nearby neurovascular structures, the investigators suggested the vascular surgeon should be on standby during the operation, given there were the high potential for complications [17].

In our present work, the medial clavicle fractures were fixed with lateral clavicle plates that were reversed. The same method has been reported in the literature. Wang et al. reported a case of 1 patient having an extra-articular fracture of medial clavicle was fixed with an inverted distal clavicle locking plate and had a satisfying outcome in 2015 [18]. Bakir et al. used a lateral clavicular plate to fix partial inter-articular fractures in 2017 [19]. We found that reliable fixation can be attained using a lateral clavicular plate in shorter medial fragment or comminuted fractures. The medial fragment was fixed with at least by 3 locking screws, for there were many small fragment-locking holes in the medial of the plate. Because of the locking mechanism, the fracture can be fixed uncortically. The fracture of all 11 patients with the application of lateral clavicle plates achieved rigid fixation. No intraoperative complications, such as neurological, vascular, or tracheal damages, were found by allowing unicortical locking screws in the medial clavicle fracture in our patients. All patients were satisfied with the results of surgery. All patients had previous activity levels, and 9 patients returned to their previous occupation.

However, the plate should be contoured to fit the anatomy of the medial end fracture prior to insertion. There were still mild symptoms of plate irritation in 2 cases, that required their hardware removed. One patient felt mild pain in the sternoclavicular joint during shoulder movement. We found the plate partially beyond the sternoclavicular joint. So that the sternoclavicular ligament should remain intact the plate should not influence the sternoclavicular joint.

Conclusions

Although limited by the small sample size, our study showed that early fixation and displacement of clavicular fracture can lead to anatomical reconstruction of the clavicle with fewer complications. However, contouring and placement of the plate, and protection of the sternoclavicular joint, are very critical in the fixation of medial clavicle fractures with reversed lateral clavicle plates.

Conflict of interest

None.

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