Treatment for Displaced Medial-End Clavicle Fractures with hook plate: A Retrospective Study

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Research Article

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Abstract

Objective: To retrospectively evaluate the radiological and clinical efficiency of internal fixation using CanSHS-hook plate for treatment of unstable displaced medial-end clavicle fractures.

Methods: From July 2014 to August 2019, 11 patients who underwent open reduction and internal CanSHS-hook plate fixation for medial-end clavicle fractures were included in the present study. There were 9 male and 2 female patients, with the average age of 35.5±11.3 years (aging from 22 to 58 years old). All the patients received routine x-rays and computed tomography examinations to evaluate the fractures before CanSHS-hook plate fixation. During the operation, a standard anterior approach across the sternoclavicular joint to the clavicle was made. After the reduction, the fracture was fixed by CanSHS-hook plate provided by Canwell Corporation under a series of operation procedures. Postoperative follow-up including physical examination and x-ray evaluation was performed in order to evaluate both the radiological and clinical efficiency of the treatment. Exercises were introduced to patients after initial postoperative immobilization. Disabilities of the Arm, Shoulder and Hand (DASH) questionnaires were used to evaluate the shoulder function postoperatively. Complications of any patients were noted to evaluate the disadvantages of the hook plate.

Results: All patients were followed up, with the average follow up period of 14.0±3.3 months (8-20 months). All the 11 cases were unilateral injuries. None of them were pathological fractures or open fractures. No intraoperative complications occurred during the operation. The mean DASH scores were 36.9±17.8, 11.7±5.4, and 7.6±5.0 at 1 month, 3 months postoperatively and the final follow up. There were no neurovascular injuries, mal-union or internal fixation failures. No wound hematoma or infection was obtained during follow up. All the fractures got bony union at the final follow up. The average time of bone union was 13.2±2.7 weeks (10-20 weeks). Postoperative complications included 2 patients complained of implant related discomfort during shoulder motion which disappeared after implant removal, and one delayed union which was healed after electromagnetic stimulation and oral administration of traditional Chinese Medicine. All patients were satisfied with their treatment outcome at the final follow-up.

Conclusions: Although the procedures of planting the CanSHS-hook plate were more complicated than other implants, the fixation of hook plate seemed to be an effective and relatively safe method for patients with medial end clavicle fractures. We recommend this CanSHS-hook plate for tiny and/or comminuted medial end segments because its unique design.

Introduction

Clavicle fractures are common in clinics and the incidence rate is 2.6-12% of all fractures. Allman divided clavicle fractures into three types: the distal clavicle fracture, the middle clavicle fracture, and the medial-end clavicle fracture. The majorities are middle clavicle fractures; however, injuries to the distal or medial fragment also occur: Medial clavicle fracture is the rarest type of all clavicle fractures, accounting for only 2–3% of all clavicle fractures. They commonly occur in middle-aged men as a result of road traffic accident. The high incidence of segmental fractures (9%) and chest trauma (49%) implies an association with high-energy trauma. This is in contrast to the overall demographics of clavicle fractures, which commonly occur in men in their early 30s, with simple fall being the most common mechanism of injury.

Clinical examination often indicates a mal-alignment of the sternoclavicular joint when compared to the contra-lateral side with tenderness to pressure and percussion. Several classification systems are used for this rare injury. According to the classification by AO Foundation, medial-end clavicle fracture is categorized in three types: 15.1 A (extra articular), 15.1 B (intra-articular), and 15.1 C (multi-fragmentary). A Cohort Analysis showed that More than half of them belonged to the extra articular category (n = 11), while 31.6% were part of group 15.1 B and 10.5% were multi-fragmentary fractures. Obviously a correlation existed between the complexity of the fracture and the proportion of operative treatment in these categories: the more complex the fracture, the more the decision for operation was made (15.1 A: 18.2%; 15.1 B: 50%; 15.1 C: 50.0%). According to Edinburgh classification proposed by Robinson, the medial-end clavicle fractures were divided
into: A-type fracture is defined as un-displaced fracture (1A1, extra-articular; 1A2, intra-articular), and B-type fracture as displaced fracture (1B1, extra-articular; 1B2, intra-articular). Throckmorton\textsuperscript{10} refined the classification of medial clavicle fractures, which were divided into five types. Most surgeons preferred Edinburgh classification because it is more convenient and effective.

Medial clavicle fractures require rapid diagnosis and effective treatment to avoid future complications\textsuperscript{7}. However, treatment of such injuries remains a controversial topic in orthopedics. The articulation of the medial clavicle with the manubrium of the sternum forms the sternoclavicular joint and represents the only articular link to the axial skeleton, while the remainder of the pectoral girdle is suspended by the muscles\textsuperscript{11}. The sternoclavicular joint is a saddle-type synovial joint comprising the bulbous medial end of the clavicle and the curved notch of the sternum\textsuperscript{12}. It is the only real joint connecting the upper limb to the axial skeleton incongruous and inherently unstable because the clavicular end is bulbous in shape and the clavicular notch of the sternum is curved. As the deep tissues including the brachial plexus, subclavian vein, axillary vein, and apex pulmonis lies under the medial end of clavicle, conservative treatment is generally used in view of the complex anatomy of the proximal clavicle and the risk of injury to important neurovascular organs. Conservative treatment includes manual reduction, correcting tape, plaster and slings, management of pain, and immobilization of the affected upper extremity for several weeks. However, Shoulder activities can cause sternoclavicular joint (SCJ) passive movement in three planes, including elevation in the coronal plane during shoulder abduction, flexion, and extension, and $45^\circ$ of rotation around the longitudinal axis during arm elevation\textsuperscript{12}. Due to the force at the shoulder girdle, the effect of conservative treatment is not ideal, it usually lead to serious complications, including mal-union, and functional disability. The rate of medial clavicle fracture nonunion after conservative treatment is approximately 8.3\%\textsuperscript{3}. With these unsatisfactory reported outcomes and high nonunion rates following non-operative treatment of displaced medial clavicle fracture, surgical management is an increasing trend for the displaced fractures of the medial end clavicle. Currently, there are no unified recognized standards or specifications for the methods and materials of internal fixation. In addition, there is no fixation material specifically designed for medial-end clavicle fractures. The internal fixation implants reported for medial clavicle fractures include Kirschner wire, steel wire, screws, and various types of steel plates, hook plates, et al. There are no biomechanical data available documenting which of these techniques more adequately restores the normal joint kinematics, and operative treatment is still a challenge for surgeons.

Inspired by this, the present study treated medial clavicle fractures using a method of a special hook plate. Between July 2014 to August 2019, 11 patients with medial end clavicle fractures were treated with such hook plates. The therapeutic effects seemed to be satisfactory. The purpose of the current study was: (i) to explore the therapeutic effect of a special hook plate fixation system for the treatment of displaced medial clavicle fractures; (ii) to explore the advantages and disadvantages of this technique; (iii) to compare the outcomes of this hook plate with those of other studies preliminarily.

**Material and Methods**

**Inclusion and Exclusion Criteria**

**Study Design**

This non-comparative retrospective clinical study was conducted at our hospital from July 2014 to August 2019. It was approved by the ethics committee of our hospital and informed consent was obtained from all the patients.

**Inclusion Criteria**

The inclusion criteria were: (i) patients aged older than 18 years, diagnosed with with unstable displaced medial clavicle fractures that could not be reduced by conservative treatment; (ii) fractures treated with CanSHS-hook plates; (iii) complete clinical data of the patient was obtained and evaluated during different follow-up visits; (vi) outcome evaluation included
radiographic evaluation, extremity function score, and complications; and (v) more than 6 months follow-up to finish the retrospective clinical study.

Exclusion Criteria

Patients with the following circumstances were excluded: (i) time from injury to surgery more than 3 weeks; (ii) open or pathologic fractures; (iii) fracture with neurovascular damage; (iv) patient who suffers multiple trauma, including ipsilateral upper extremity fracture, which might affect the postoperative rehabilitation program; and (v) followed for less than 6 months.

General Information

This study involved eleven patients aging from 22 to 58 years old with displaced medial-end clavicle fractures from July 2014 to August 2019. There are 9 males and 2 females. All the patients received open reduction and internal fixation with CanSHS-hook plates (Canwell Co.Ltd., ZheJiang Province, China; http://www.canwell.com.cn/index.html). All patients were admitted to the hospital and underwent routine x-rays and computed tomography (CT) examinations. All eleven cases were unilateral injuries. None of them were pathological fracture or open fracture. The medial-end clavicle fractures were classified according to Edinburgh classification⁶. All eleven cases belong to Edinburgh type B; 4 cases were type 1B1 (extra-articular), while 7 cases were type 1B2 (intra-articular). This study was approved by the ethical committee and signed informed consent was obtained from each of the included patients. These patients were asked to participate in a research examination consisting of Disabilities of the Arm, Shoulder and Hand (DASH) score assessment. The postoperative x-rays were analyzed for the time of union. Data were obtained during clinical and radiographic examinations postoperatively at every follow up.

Operative Technique

Anesthesia and Position

Surgery was performed under general anesthesia in a semi-sitting position by two experienced doctors. Intravenous cefuroxime (1.5 g) was administered to all patients 30 minutes before surgery to prevent wound infection.

Approach and Exposure

A standard anterior approach across the SCJ to the clavicle was used to expose the fracture site and partial sternum.

Reduction and Plating

The fracture was reduced under direct visualization, and the initial reduction was held with Kirschner wires or/and Ethicon sutures. For simple fractures, lag screw was used for fracture segment. For comminuted fractures, Ethicon sutures or steel wires were used. Then, a hole was drilled at the sternum under the protection of guide tool. A proper hook plate was chosen and guided into the hole of the sternum after mold test, and the distal part of the plate was fixed using screws. Fluoroscope was carried to check the reduction and the implants before closure of the wound (Fig. 1; Fig. 2A,B).

Postoperative Management

Postoperatively, blood markers including routine blood test, C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) were routinely tested to reveal the possibilities of infection the day after surgery and 1 week after surgery. The patients were immobilized in a sling for 3 weeks. Passive external rotation was encouraged, and pendulum exercises began at 2 weeks. Progressive physiotherapy including active and passive flexion and uplifting movements started after 3 weeks when the sling was removed. The patients were able to resume their daily activities and work within 3 to 6 months depending on the results of the radiographs.
Follow-up

All the eleven patients were routinely followed up. Postoperative radiological and clinical outcomes including complications were documented and assessed at postoperative months 1, 3, and at the last follow-up. The regular follow-up includes a physical examination, an x-ray evaluation, and the DASH questionnaires. All patients but one received implants removal at about 12 months after the initial operation.

Outcome Measures

Radiographic Evaluation

Plain radiographs were assessed for loss of reduction, implant loosening, migration (which were measured by comparing with the postoperative plain radiographs) and fracture union. Complications including mal-union and nonunion were also evaluated. Radiographic fracture union was defined as evidence of at least three of four healed cortices with external bridging of the callus across the fracture\(^4\), which suggested that fracture got bony healed. Nonunion was defined based on Neer's original description as a "lack of bone bridging for more than 12 months after injury"\(^{13}\), which meant a failure to the treatment. Apparent deformity meant mal-union of fracture, which was result of loss of reduction or poor reduction of fracture.

Disability of the Arm, Shoulder, and Hand Score

The DASH was developed to measure physical disability and symptoms of the upper extremities in people with upper extremity disorders (hand, wrist, elbow, and shoulder). It is a 30-item scale that addresses difficulty in performing various physical activities that require upper extremity function (physical function, 21 items); symptoms of pain, activity-related pain, tingling, weakness, and stiffness (pain symptoms, 5 items); or impact of disability and symptoms on social activities, work, sleep, and psychological well-being (emotional and social function, 4 items). The score ranges from 0 to 100, where 0 = no disability and 100 = most severe disability\(^{14}\).

Statistical Analysis

Statistical analysis was performed using SPSS software (version 17.0, SPSS Inc., Chicago, IL, USA). Differences of DASH scores between the different follow up time points were analyzed by one-way ANOVA. A \(P\)-value of < 0.05 was considered statistically significant.

Results

General Data

11 patients (average age, 35.5 ± 11.3 years) with medial clavicle fractures were included in our retrospective study. The general characteristics of the 11 cases were demonstrated in Table 1. All the 11 patients suffered from a high-trauma fracture\(^{15}\). 9 patients had vehicular trauma, 2 patients had a fall from height. The mean time of bone union was 13.2 ± 2.7 weeks (10–20 weeks).
<table>
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<tr>
<th>Case</th>
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<th>Mechanism of injury</th>
<th>Edinburgh Classification</th>
<th>Complications</th>
<th>DASH Score (last follow-up)</th>
<th>Follow-up period(months)</th>
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</table>

**Radiographic Evaluation**

At follow-up, each patient was qualified for the final evaluation. Each fracture had solid radiographic evidence of fracture union. Nonunion, mal-union or loss of reduction were not observed, and no screws or plates were broken. The average clinical follow-up times were 14.0 ± 3.3 months (8–20 months) (Fig. 2C,D; Fig. 3).

**Disability of the Arm, Shoulder, and Hand Score**

The mean DASH scores were 36.9 ± 17.8, 11.7 ± 5.4 and 7.6 ± 5.0 at 1 month, 3 months postoperatively, and the final follow up, respectively, showing significant improvement ($P<0.05$).

**Complications**

2 patients complained of implant-related discomfort during shoulder motion, and another patient experienced delayed union of the fracture. Electromagnetic stimulation and oral administration of traditional Chinese Medicine were used until the bony union was achieved. No superficial wound infection appeared. The mean time of implants removal was 14.5 ± 2.8 months (12–20 months) except 1 patient who received removal surgery at about 8 months by the last follow up.

**Discussion**

**Epidemiology and Anatomy**

Medial-end clavicle fractures take place more frequently than traditionally considered. Throckmorton and Kuhn\textsuperscript{10} reported a higher incidence (9.3%) of medial-end clavicle fractures, and 22% of fractures of the medial clavicle were seen only on...
CT scans in their case series which covered a 5-year period. Traditionally, these fractures have been managed conservatively, even when significantly displaced\(^\text{16}\). However, recent studies have shown that conservative treatment of displaced medial clavicle fractures is associated with an 8% rate of symptomatic nonunion\(^\text{17}\), which is a serious failure and a challenge for surgeons\(^\text{18}\). The SCJ is a synovial joint that connects the upper extremity with the axial skeleton and contributes to range of motion during humeral elevation as well as glenohumeral and scapulothoracic motion\(^\text{19,20}\). Fracture of the medial clavicle means rupture of the SCJ and disabilities of the glenohumeral and scapulothoracic motion.

**Current Treatment Status**

Some recent studies have recommended open reduction and internal fixation for displaced or comminuted medial clavicle fractures to prevent nonunion and dysfunction, especially in young or physically active individuals\(^\text{4,21,22}\). The traditional indications for surgical repair were only open fractures, neurovascular involvement, or a threat to the integrity of the overlying skin, even in the presence of significant displacement\(^\text{15}\). Various implants have been used for open reduction internal fixation of medial clavicle fracture and achieved relatively satisfied results. These implants include T plate\(^\text{23}\), reversed distal clavicle locking plate\(^\text{24}\), Recon plate\(^\text{9}\), Hook plate\(^\text{11}\), 3.5/2.7-mm locking compression plate\(^\text{25}\) and L-shape distal radius plate\(^\text{26}\). Although these materials for internal fixation were reported to be efficient, the small sample size and no control study in these clinical reports did not provide enough evidence. Nevertheless, in most instances, the type of plate selected was aimed at obtaining stable fixation in medial fragments. However, in some instance, if the medial fragments are too small and/or too comminuted, it is not efficient to use these kinds of plates. Moreover, a low profile 2.4-mm plate may not be strong enough to resist torsional and bending forces on clavicle whilst healing occurs\(^\text{27}\).

**Experience for Delayed Union**

Delayed union of the fracture was observed in one case. This patient was carefully followed up and several measurements were taken to prevent non union. Routine blood test, CRP, and ESR were performed monthly to exclude infection until bony union was achieved. Electromagnetic stimulation and oral administration of traditional Chinese Medicine were used to promote bone union. Currently, non union of the clavicle is still a troublesome problem, so careful attention should be paid in treatment of these kinds of injuries. Giuseppe Rollo’s study\(^\text{17}\) showed 22/71 infected clavicle non union while 49 atrophic or oligoatrophic, which suggested full preparation of initial surgeries could avoid complex procedures for non union cases.

**Comments on CanSHS-hook plate**

According to the literatures, there are no standard surgical procedures for treatment of the displaced medial clavicle fracture. Furthermore, there is no fixation material specifically designed for medialend clavicle fractures. In the present study, the CanSHS-hook plates we used in our series of patients was specially designed for SCJ dislocation and medial clavicle fracture. Through about average 14.0 months follow up, the radiological and clinical results seemed to be satisfactory. Compared with locking plate, the CanSHS-hook plate has advantages for tiny and/or comminuted medial end segments because no screws need to be planted in this area. The traditional hook plate has poor ability to resist distortion and it is easy to penetrate through the sternum. Besides, the hook penetrating through the sternum will damage the internal organs. The CanSHS-hook plate we used has an anatomical shape and special designs to prevent such disadvantages.

**Conclusion**

Although the operation procedures were more complicated, the present study showed that fixation using the CanSHS-hook plate for medialend clavicle fractures can provide enough stability for bony union and achieve reliable clinical effects. Our study has several disadvantages, the sample size was small and this is no control study. Therefore, the results only
provide a reference for the treatment. We believe an ideal fixation implant for medial clavicle fracture is yet to be developed.

**Declarations**

**Acknowledgements**

None.

**Ethics approval and consent to participate**

The study was performed in accordance with the ethical standards of the Declaration of Helsinki of 1964. Consent to participate in the study was obtained from all the patients.

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**Availability of data and materials**

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary material. All data and materials were in full compliance with the journal's policy.

**Authors’ contributions**

HX and XKG designed the study. SHG operated on the patients and HX performed the postoperative follow-up. CSC collected and analyzed the data and XKG prepared the manuscript. All authors read and approved the final manuscript.

**Consent for publication**

Since this is a retrospective study, no consent is needed from patients. All authors consent to the publication of this manuscript.

**Competing interests**

The authors declare that they have no competing interests.

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**References**


**Figures**

![Fig1A.jpg](image1)
![Fig1B.jpg](image2)
![Fig1C.jpg](image3)
![Fig1D.jpg](image4)

**Figure 1**

(A) Using a lag screw to maintain fracture reduction. (B) After initial fixation with a lag screw, a hole is drilled in the midline of the sternum under protection. (C) The proximal end of CanSHS-hook plate was pulled through the hole of sternum. (D) The fracture is reduced and fixed using a CanSHS-hook plate.
Figure 2

A 24-year-old young man. (A) Preoperative CT image of fracture. (B) The view of the hook plate during operation. (C) The fractures were reduced and fixed with hook plate and screws. (D) Fractures got union.
Figure 3

A 40-year-old man. (A, B) Preoperative CT images of fracture. (C) The fractures were reduced and fixed with hook plate and screws. (D) Fractures got union at 12 months postoperatively.