Can Only Fix Sternoclavicular Joint to Treat Bipolar Clavicle Injury?

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Research article

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Abstract

Background: Owing to the rarity of bipolar clavicle injury, treatment remains controversial. The purpose of this study is to report treatment of bipolar clavicle injury with internal plate fixation.

Methods: We present our experience of clavicle hook plating for sternoclavicular joint dislocation and anatomical plating for distal clavicle fracture for the treatment of three consecutive bipolar clavicle injuries with different injury patterns. At follow up, radiographs were assessed for joint congruity, fracture union, and implant failure. Clinical evaluation included Disability of the Arm, Shoulder, and Hand (DASH), Constant and Murley Score, Visual Analog Scale (VAS), and complications.

Results: All patients had a minimum follow-up of six months. Each fracture had solid union, and each dislocation showed no sign of recurrent dislocation, the mean shoulder forward flexion was 153.3°±10.4°, the mean DASH score was 13.9±9.2 points. The mean Constant and Murley score was 82.3±12.3 points, and the mean VAS score was 2.2±2.0 point. No complications were encountered, and each patient was highly satisfied with their treatments.

Conclusion: Our experience of using internal plating for bipolar clavicle injury is positive, as it allows early mobilization and resulted in good joint function. Also, only sternoclavicular joint fixation might be sufficient for some part of bipolar clavicle injury, acromioclavicular joint fixation is not necessary unless residual instability existence.

Background

Although acromioclavicular (AC) joint dislocations and distal clavicle fractures are common, sternoclavicular (SC) joint injury and fractures of the medial clavicle are rare. In 1831, Porral [1] firstly reported a case with simultaneous dislocation or subluxation of both ends of the clavicle, Beckman [2] reported a 16th case in 1924, and it was not until 1982 that more cases were reported [3], this injury is also named as “floating clavicle”. Nowadays, the term bipolar clavicle injury or floating clavicle is often referred to any combinations of dislocation and fracture at both ends of the clavicle [4].

Bipolar injury of the clavicle is rare and often caused by high-energy trauma, although road-traffic and sports injuries have increased the frequency of clavicle injury, most reports have been based on single cases, only a few of published English studies presented multiple cases [4-8]. Thus, treatment of this injury remains limited. Both surgical and conservative treatment strategy had been successful reported by different researchers, however, this is no consensus in literature regarding the best management for bipolar clavicle injury. The purpose of this study is to report three cases with different injury patterns who were successful treated by a clavicle hook plate (Balser plate) fixation, to explore the advantages and disadvantages of the technique and to review recently published literature.

Materials And Methods

Subjects

After obtaining Institutional Board Review approval, the authors retrospectively analyzed patients with bipolar clavicle injury seen from December 2017 to March 2020 in Hong Hui Hospital, Xi’an Jiaotong University School of Medicine (Xi’an, China). This study was approved by the Ethics Committee of Hong Hui Hospital, and each patient agreed to publish their images and individual clinical details with written informed consent. During this period, the authors treated 4 patients with bipolar injury of the clavicle. The surgical indications were dislocations or fractures that could not be reduced by conservative treatment and/or appeared prone to recurrence after conservative treatment. Among these patients, one patient with both AC and SC joint dislocation was treated conservatively, and the remain three cases underwent internal clavicle hook plate fixation. Thus, the three cases with surgical treatment met the following inclusions: bipolar clavicle injuries were treated by clavicle hook plate fixation with a ≥6-month follow-up (Table 1). Patients with bipolar clavicle injuries treated by conservative treatment or patients with only one single clavicle end injury were excluded from this study.

Surgical technique

After administration general anestheisa, the patient was placed in a semi-sitting beach chair position on the operating table. An oblique incision was made over the medial clavicle and sternum. After soft tissue flaps were retracted, the displacement of medial clavicle and the torn surrounding ligaments were examined. All fibrous tissue from the medial aspect of the clavicle (case 1 and case 3) and fracture fragments (case 2) were debrided. After SC joint and/or fracture reduction was achieved, a 1.5-mm Kirschner wire was used for temporary fixation. A space posterior aspect of the superior manubrium was then bluntly created with extreme care by using a curved hemostatic forceps [9,10]. Then, the hook of the plate was inserted into the space posterior to the manubrium, the other end of the hook plate was fixed on the anterior part of the medial clavicle (Figure 1). Torn ligaments were repaired by using nonabsorbable suture (case 2). For case 1 and case 2, intraoperative image showed accurate reduction of AC joint, we treated these two cases acromioclavicular joint conservatively. For case 3, after fixation of sternoclavicular joint, an incision was made over the lateral aspect of the clavicle to reveal the lateral end of clavicle, after debridement of fibrous tissue, the fracture fragments were reduced and fixed by a locking plate. Finally, the surgical wounds were closed in layers.

Postoperative management

Following surgery, the patient’s affected shoulder was placed in a sling for 4 weeks. Then, gentle Godman’s pendulum exercises were started under a physical therapist supervision, active strengthening exercise began 3 months, and patients were permitted to return to their regular activity at 6 months postoperatively.
Patients were followed at 1, 2, 3 and 6 months postoperatively, then taken once half-year. X-rays contained the whole length of clavicle including both sternoclavicular and acromioclavicular joint. Fracture union was defined as evidence of at least three of four healed cortices across the fracture site [11]. Clinical evaluation included Disability of the Arm, Shoulder, and Hand (DASH), Constant and Murley Score for shoulder function, and Visual Analog Scale (VAS) for pain [12]. In addition, intraoperative and postoperative complications were also recorded.

Results
The study cohort comprised three patients with three different injury patterns: a 54-year-old female (patient 1) presented with dislocations of both AC and SC joints, a 26-year-old male (patient 2) presented with fracture-dislocation of the SC joint associated with AC subluxation, and a 58-year-old female (patient 3) presented SC dislocation associated with distal clavicle fracture. Specifically, all three patients had an anterior SC dislocation, patient 1 and patient 2 had a Type Ⅰ acromioclavicular joint dislocation according to Rockwood classification [13], patient 2 had a type 1B2 medial clavicle fracture according to Edinburgh classification [14], patient 3 had a type Ⅰ distal clavicle fracture according to Neer's classification [15]. Injury mechanism contained one fall form height, one crashing, and one car accident. Two patients had injury on the left side and 1 had injury on the right. All patients had closed injuries without damage to neurovascular or mediastinal structures. Two patients were associated with multiple injuries (patient 2 and patient 3).

All patients were initially treated by closed reduction. However, recurrence instability was present in each patient and therefore necessitated surgical fixation. Each SC injury was fixation by clavicle hook plate, AC dislocation in patient 1 and patient 2 were treated conservatively, and immediate postoperative plain radiography confirmed correct hook plate placement and accurate reduced AC. More, distal clavicle fracture in patient 3 was fixed by anatomic locking plate.

With a at least of six months follow-up, each patient was qualified for the final evaluation. At the last follow, each fracture had solid union, and each dislocation showed no sign of recurrent instability, the mean shoulder forward flexion was 153.3±10.4°, the mean DASH score was 13.9±9.2 points. The mean Constant and Murley joint function score was 82.3±12.3 points, with 1 excellent cases and 2 good cases. And, the mean VAS score was 2.2±2.0 point. Although patient 1 and patient 3 had mild shoulder limitation, each patient was able to resume preinjury daily activity and satisfied with their treatments. Complications like important structures rupture, infection, hardware failure, or vital organ injury did not happen.

Discussion
Bipolar dislocation of the clavicle is rare, and surgeon's treatment experience is limited, both diagnosis and surgery are challenging for surgeon. As this injury is frequently one part of polytrauma (brain trauma, rib fracture, hemothorax, pneumothorax, scapula fracture, or chest injury) [4], bipolar clavicle injury is usually initially missed or delayed diagnosed on plain radiography because the only indication of an abnormality may be slight widening of the AC joint [16,17]. CT scanning with three-dimensional reconstructions is most valuable to get an early diagnosis, to evaluate the precise displacement of each end of clavicle, and to make a preoperative planning [5,18]. The authors recommend that whenever one end of pathology clavicle is suspected, the whole length of clavicle including both sternoclavicular and acromioclavicular joint should be examined, in such cases, CT scan would be necessary.

The mechanism of bipolar clavicle injury is still not well-known; this injury is frequently a result of high-energy trauma, like a deforming force on the lateral aspect of the shoulder or a driving force squeezing the shoulders together combined with trunk torsion [8,10]. Two hypotheses have been advocated. One theory suggests two dislocations occur simultaneously, the trauma force on the shoulder is initially transformed into the elastic energy to the clavicle [19]. When the external force disappears, the clavicle relaxes and returns to its normal shape, the energy continues to conduct on both sides of the clavicle, causing each clavicle end ligaments damage and subsequent dislocation of the acromioclavicular joint and sternoclavicular joint [7,19]. And the another one proposes that an initial dislocation of the sternoclavicular joint followed by subsequent dislocation of the acromioclavicular joint [20].

Four different patterns of bipolar injury of the clavicle had been reported: (1) dislocation of both ends of the clavicle, (2) dislocation of the sternoclavicular joint with distal clavicle end fracture, (3) dislocation of the acromioclavicular joint with medial clavicle end fracture, and (4) segmental fracture of the clavicle [21]. For most floating clavicle, the medial end displaced anteriorly while the lateral end displaced superiorly or posteriorly (Rockwood type III or IV). Eni-Oloto and Hobbs [7] reported a case of inferior displacement of lateral end and superior displacement of the medial end. And, only a few of bipolar clavicle injury with posterior SC joint dislocation have been found [4,8,22,23]. Posterior SC joint dislocations and medial clavicle fractures are life-threatening injuries because of their potential to cause damage to retrosternal structures. In this study, we encountered 3 different injury patterns, and where we treated an extremely rare case of acromioclavicular joint dislocation combined with medial clavicle end fracture-dislocation (Figure 1), to the best of our knowledge, in the past few of years, only Lee et al. [21] had reported one such case.

Owing to the rarity and limited experience of this injury, treatment remains controversial and challenging. In the early stage, most authors treated their patients nonoperatively with satisfactory results [2,3,7,20,24]. However, most patients sustained deformity/residual pain or instability [20]. Sanders et al. [25] reported a group of six cases with both ends dislocations, all patients treated with conservative methods initially, 4 cases required additional surgical intervention because of continuing pain, and finally got good results after AC joint reconstructions. Also, Lee et al. [21] found superior results in patients treated with surgical treatment. Thus, a consensus towards the fact that younger and active patients should be treated with surgical treatment, due to unacceptable pain, deformity, and shoulder function limitation if the anatomical reduction cannot be restored [4,10,21].

When bipolar clavicle injury is treated operatively, surgical approach to the acromioclavicular dislocation and lateral end fracture is well-described and standard procedure. Surgical options vary from internal fixation (Hook plate, Kirschner, pin) to ligaments reconstruction (such as Weaver-Dunn, coracoclavicular reconstruction) [13]. However, there is no consensus on the standard treatment strategy for SC joint injury. Surgical treatment is challenging due to the proximity between SC joint and important retrosternal structures (trachea, esophagus, brachiocephalic veins, brachiocephalic artery, and brachialplexus). Many operative procedures have been described for surgical treatments, and each had its own merits and drawbacks, such as pins, Kirschner wires, T-plate fixation, medial clavicle resection, and ligament reconstruction [9,12,26]. Our previous study had showed clavicle hook plate to be a very feasible option.
for displaced medial clavicle fracture and SC joint dislocation with several advantages, such as minimal risk of damage to retrosternal structures, dynamic fixation without damage to SC joint cartilage surface, and improved fixation stability for comminuted medial clavicle fracture [9]. In this study, we fixed each SC joint injuries with hook plate. Meanwhile, in a report of two cases of bipolar clavicle injury, Schemitsch et al. [10] fixed SC joint with clavicle hook plate, at the follow up, both patients got good outcomes. Our treatment outcome was consistent with theirs.

More, controversy still exists about the management sequence of bipolar clavicle injury. Schemitsch et al.[10] recommended initially fixed the more displaced end. Whereas, in a study containing 6 operative cases and 5 conservative cases, Lee et al.[21] fixed AC injuries with a hook plate firstly, and then open reduction and anterior SC ligament repair was performed after failed closed reduction of the medial end of the clavicle. Yurdakul et al.[27] and Thyagarajan et al.[22] fixed the sternoclavicular joint firstly in their reports. The authors experience was consistent with the above two studies, in this present study, once the SC joint was stabilized, the AC dislocation was found to be reducible passively, the reasons might be that the sternoclavicular joint is much more incongruous because the clavicular end is bulbous in shape and the clavicular notch of the sternum is curved. Thus, the authors presume that SC fixation is sufficient for some part of bipolar clavicle injury, especially for cases with AC dislocation, and AC fixation is not necessary unless residual instability existence.

In this study, the authors noted that a patient (Figure 2) who preoperatively presented SC dislocation associated with distal clavicle fracture sustained a slight acromioclavicular joint dislocation after a hook plating in SC joint and an anatomic plate osteosynthesis in distal clavicle, the reasons might be an inaccurate reduction of distal clavicle due to chronic injury or a hook plating under large stress. Meanwhile, the authors admit limitations of this study, such as small size of samples, lack of a control group, and short time of follow-up period. However, considering the rarity of bipolar clavicle injury, the limitations did not influence the results.

Conclusion

Internal plating was proven to be a safe and effective treatment for bipolar clavicle injury, and only sternoclavicular joint fixation might be sufficient for some part of bipolar clavicle injury. However, this treatment calls for a well-trained surgeon to avoid damaging to retrosternal structures and fixing under large stress.

Abbreviations

AC joint: acromioclavicular joint
SC joint: sternoclavicular joint
DASH, Disability of the Arm, Shoulder, and Hand
VAS, visual Analog Scale

Declarations

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgements
Not applicable.

Authors Contributions
Jun Zhang conceived and designed the study. Dongxu Feng wrote the manuscript and collected the relevant data. Yong Liu, Zijun Li, Jie Huang, Mei Fan, Xiaomin Kang collected the relevant data and performed the statistical analyses. All the authors interpreted the data and contributed to preparation of the manuscript.

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Ethical Approval Ethics approval and consent to participate
This study was approved by the Ethics Committee of Hong Hui Hospital. Written informed consent was obtained from all patients prior to participate in the study.

Consent for publication
Informed consent was acquired of every patient to publish their individual clinical details and accompanying images.

Competing Interests
The authors declare that they have no competing interests.
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Tables

Table1 Patients data.
| Case | Age (years) | Sex | Side | Mechanism | Associated injury | Medial injury | Lateral injury | Time to surgery (days) | treatment | Follow up (months) | VAS | Shoulder function (fl°) |
|------|-------------|-----|------|-----------|------------------|---------------|----------------|-----------------------|-----------|-------------------|-----|------------------------|
| 1    | 54          | F   | R    | Fall      | None             | Anterior dislocation | Type II dislocation | 4                     | SC: Hook plate | 13                | 4   | 150*                  |
|      |             |     |      |           |                  |                |                |                       | AC: neglect       |                   |     |                       |
| 2    | 26          | M   | L    | Crashing  | Tooth fracture   | Fracture-anterior dislocation | Type II dislocation | 8                     | SC: Hook plate | 8                 | 0   | 165*                  |
|      |             |     |      |           |                  |                |                |                       | AC: neglect       |                   |     |                       |
| 3    | 58          | F   | L    | Car accident | Chest injury, brain injury | Anterior dislocation | Type II fracture | 147                   | SC: Hook plate | 11                | 2   | 145°                  |
|      |             |     |      |           |                  |                |                |                       | AC: plate         |                   |     |                       |

Medial clavicle fracture, based on Edinburgh classification. Distal clavicle fracture, based on Neer classification. Acromioclavicular joint dislocation, based on Rockwood classification. VAS, visual analog scale; DASH score, disability of the arm, shoulder and hand; AC, acromioclavicular joint; SC, sternoclavicular joint; F, female; M, male; L, left; R, right.

**Figures**

**Figure 1**

In patient 2 (26-year-old man), the preoperative posteroanterior (A, B) radiographs show a dislocated left sternoclavicular joint and a slight widening left acromioclavicular joint. A computed tomography scan (C) shows intraarticular medial clavicle fracture and impingement of the skin by the medial clavicle. 3D CT reconstruction from above (D) shows fracture-anterior dislocation of the sternoclavicular joint and sub-dislocation of the acromioclavicular joint. Intraoperative photograph (E) reveals the dislocated medial clavicle end. An immediate postoperative radiograph (F) shows anatomical reduction of both sternoclavicular joint and acromioclavicular joint as well as satisfactory position of hook plate. At 8 months follow up, the patient shows congruency of both sternoclavicular joint and acromioclavicular joint in radiography image (G) and got full shoulder mobility (H).
A 58-year-old woman (patient 3) was injured in a car accident, after repair of the life-threatening injury, she came to our institute for surgical intervention because of intolerable pain in her shoulder. An anterior view (A) shows anterior dislocation of the left sternoclavicular joint. The (B) preoperative X-ray and (C) CT scan show a left anterior dislocation of the sternoclavicular joint (SCJ) and an ipsilateral Neer type III distal clavicle fracture. A postoperative radiograph (D) shows the reconstructed clavicle with a hook plating in SCJ and a plate osteosynthesis in distal clavicle. Radiographs 11 months postoperatively shows the normal alignment of the SCJ, solid union of distal clavicle and a slight persistent acromioclavicular joint dislocation. (F, G) Although she had a slight pain and function limitation in her shoulder joint, she was satisfied with the treatment.