Clavicular Hook Plate: A Better Implant Choice for Fixation of Unstable Distal Clavicle Fractures?

Tsai-Hsueh Leu 1, Wei-Pin Ho 1, Poo-Kuang Wong 1, Tai-Yuan Chuang 1, Chin-Chean Wong 1,2*

1 Department of Orthopaedic Surgery, Taipei Medical University, Wan Fang Medical Center, Taipei, Taiwan
2 Graduate Institute of Clinical Medicine, College of Medicine, National Taiwan University, Taipei, Taiwan

KEY WORDS: clavicular hook plate; K-wire and tension band wire; Neer type II distal clavicle fractures

Background: The ideal fixation method for unstable distal clavicle fractures is still controversial. Clavicular hook plates (HPs) are an effective option but the clinical efficacy and advantages/disadvantages of this implant compared with the tension band wire technique in treating this fracture have not been determined.

Methods: A retrospective study was undertaken over a period of 3 years that included 45 patients, who were divided into two groups based on the treatment method. The clavicle HP group included 25 patients and the K-wire and tension band wire (KTBW) group included 20 patients. Radiographic examinations were taken to assess the adequacy of implant fixation and degree of bony union. Clinical results for pain, shoulder function and range of motion were evaluated using Constant–Murley scores.

Results: Two groups of patients were similar in terms of age, sex, injury mechanisms, time to surgery, and time of follow-up. The results showed that the HP group had a significantly higher union rate and lower occurrence of surgical complications (p < 0.001). However, 36% of patients in the HP group developed subacromial shoulder impingement syndrome before implant removal, and their functional scores were poorer than their nonimpinged counterparts.

Conclusions: Although better surgical results and radiological outcome were achieved by using clavicle HP than KTBW in treating unstable distal clavicle fractures, the mechanical hook impingement imposed on the subacromial structures was remarkable and may have lowered the functional scores of patients receiving HP fixation. The result showed that clavicular HP did not offer more clinical advantages than with KTBW in treating unstable distal clavicle fracture.

Copyright © 2012, Taipei Medical University. Published by Elsevier Taiwan LLC. All rights reserved.

1. Introduction

Unstable distal clavicle fractures (Neer type II) are often accompanied with a relatively high risk of nonunion and hence surgical treatment is indicated. The rate of nonunion in these fractures is as high as 22–31%. Although various kinds of fixation methods have been described, no consensus has been reached regarding the best primary treatment for fracture fixation. Fixation techniques include extra-articular or transarticular Kirshner wire, Knowles pin, tension bands, coracoclavicular screws, and clavicular hook plate. Most authors recognize that conventional treatments such as transarticular or extra-articular tension band wire fixation are simple, cost-effective, and easy to apply but carry considerable risks of complications. These complications include uncontrollable pin migration, pin breakage, loss of fixation, and nonunion. In the past few years, clavicle HP has emerged as the implant of choice in treating unstable distal clavicle fracture. Many studies have revealed satisfactory clinical results of using HP as defined by reliable fixation, fast bony union, and few complications. Despite its high rate of fracture union and low occurrence of loss of implant fixation, some authors have raised concerns about the adverse subacromial effects of HP exerted on the neighboring structures causing acromial osteolysis, subacromial shoulder impingement, or even rotator cuff tear.

To date, there have been limited reports comparing the clinical results and patient’s functional outcome of HP fixation and K-wire and tension band wire (KTBW) in treating distal clavicle fractures. Therefore, it is necessary to investigate each type of treatment method separately. In this study, we retrospectively reviewed the clinical outcome of patients receiving either fixation method and analyzed their advantages and problems in detail. Finally, we aimed to establish if clavicular HP is a better implant option for unstable distal clavicle fracture fixation.
2. Patients and methods

From January 2006 to December 2008, 50 consecutive patients with unstable distal clavicle fractures received surgery at our hospital. There were 45 patients who met the inclusion criteria for the present study (Institutional Review Board Approval No.: 98086; Date: February 11, 2010, approved by Taipei Medical University-Wan Fang Medical Center). The inclusion criteria were: (1) Neer type II fractures; (2) acute fractures without associated injuries; (3) normal shoulder function without previous injury; (4) osteosynthesis with either an AO (Arbeitsgemeinschaft für Osteosynthesefragen, Bettlach, Switzerland) HP or KTBW; or (5) followed up more than 12 months after discharge from hospital. The mean age of the patients was 41.8 years (range: 17–85 years). The average follow-up was 14.5 months (range: 12–25 months). The HP group included 25 patients with a mean age of 41.3 years (range: 17–85 years). Twenty-one injuries (84%) resulted from motorcycle accidents or bicycle falls. The KTBW group included 20 patients with a mean age of 41.3 years (range: 22–66 years). Among these 20 patients, 18 (89%) suffered the injuries from motorcycle accidents or bicycle falls. The clinical and demographic data are shown in Table 1.

In the HP group, the operations were performed by four senior orthopedic surgeons following the method and procedure proposed by the manufacturer.22 The HP used was a modified stainless steel, curved, 3.5-mm dynamic compression plate with a hook-like structure extending from the lateral end. The hook had two different depths (15 mm and 18 mm) to accommodate different thicknesses of the acromion process. Two different plate lengths with six or eight holes were available. The operation was performed with the patients under general anesthesia and in the standard beach-chair position. An incision in line with the clavicle was made and the fracture site as well as the acromioclavicular (AC) joint was identified. The fracture was examined and reduced. The depth of the acromion was determined using a depth gauge. Then, the hook of the plate was passed under the acromion posterior to the AC joint. After the fracture was reduced, the plate was placed along the length of the clavicle and fixed with screws. Taking the fracture pattern into consideration, the plate was bent if it could not precisely fit the contours of the bone. All patients were told to start passive shoulder exercises 2 days postoperatively with the aid of the uninjured arm. Patients were told to use a sling for a period of 1 month, and could start active range of motion (ROM) exercise thereafter. In the KTBW group, 10 patients received transarticular Kirshner wire fixation through the AC joint and 10 patients received extra-articular fixation. An additional cerclage wire tension band was used in 18 patients to obtain more stable fixation. All patients were told to use a sling for the first 4 weeks to protect the operated shoulder. Gentle mobilization was allowed after the pain resolved. No overhead shoulder motion was allowed in the transarticular cases until the implant was removed.

Patients were followed-up every month for the first 6 months and every 3 months thereafter. Anteroposterior shoulder radiographs were used for radiological assessment. Postoperative conditions such as wound infection, surgical revision, loss of implant fixation, shoulder ROM, and radiographic evaluation for bony union were evaluated and documented by the operating surgeon. Clinical union was defined as no tenderness at the fracture site. Bony union was characterized by disappearance of the fracture line on radiographs. In the HP group, all patients had their plates removed at a mean time of 5.8 months (range: 4–8 months). In the KTBW group, the average time to hardware removal was 4.4 months (range: 2–8 months).

At the final visit before removal of the implant, all patients were examined for both active and passive shoulder ROM. The Constant–Murley shoulder score was used for global functional assessment.23 Clinical impression of subacromial shoulder impingement was established by a positive Neer impingement sign.24 Musculoskeletal sonography was arranged for patients who demonstrated positive impingement sign. Student’s t test, Pearson’s χ² test, and Fisher’s exact test were used to compare the two groups. SPSS for Windows version 17.0 (SPSS, Chicago, IL, USA) was used to analyze the data; p < 0.05 was considered significant.

3. Results

Baseline information for patients for age, sex, injury mechanisms, time to surgery, and time of follow-up did not differ significantly from that during follow-up. The results of the clinical and radiological examinations are summarized in Table 2. The surgical outcomes were significantly better in the HP group (p < 0.05). In the HP group, all but one fracture (96%) healed within 6 months. In contrast, four patients in the KTBW did not achieve bony union during follow-up. Furthermore, the number of surgical complications was higher in the KTBW group. In this group, four superficial wound infections related to pin end irritation were identified (20%), which were successfully treated with oral antibiotics. Moreover, four patients experienced loss of implant fixation due to K-wire migration out to the skin. The HP group had two complications related to implant fixation. One patient had screw loosening and another had the hook portion disengaged from the acromion causing partial loss of reduction during follow-up (Figure 1). One patient in the HP group experienced distal clavicle osteolysis (Figure 2).

In the KTBW group, the mean score for the injured shoulder was 86.9 points (range: 80–96 points). In the HP group, the mean score for the affected shoulder using the Constant–Murley scoring system was 85.7 points (range: 64–97 points). The difference between both groups was insignificant. Nine patients in the HP group who developed subacromial shoulder impingement (with positive Neer’s sign) scored <80 points. All of them reported implant-related symptoms during shoulder mobilization including pain, a scraping feeling, or ROM limitation caused by impingement.

### Table 1

<table>
<thead>
<tr>
<th>Clinical outcomes</th>
<th>HP (n = 25)</th>
<th>KTBW (n = 20)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union rate</td>
<td>24/25 (96)</td>
<td>16/20 (80)</td>
<td>0.084</td>
</tr>
<tr>
<td>Surgical revision</td>
<td>0/25 (0)</td>
<td>2/18 (11.1)</td>
<td>0.199</td>
</tr>
<tr>
<td>Wound infection</td>
<td>0/25 (0)</td>
<td>4/20 (20)</td>
<td>0.035</td>
</tr>
<tr>
<td>Distal clavicle osteolysis</td>
<td>1/25 (4)</td>
<td>0/20 (0)</td>
<td>0.258</td>
</tr>
<tr>
<td>Coracoclavicular widening</td>
<td>0/25 (0)</td>
<td>6/20 (30)</td>
<td>0.034</td>
</tr>
<tr>
<td>Loss of implant fixation</td>
<td>2/25 (8)</td>
<td>4/20 (20)</td>
<td>0.041</td>
</tr>
<tr>
<td>Hardware removal</td>
<td>25/25 (100)</td>
<td>20/20 (100)</td>
<td>1.0</td>
</tr>
<tr>
<td>Symptomatic hardware</td>
<td>4/25 (16)</td>
<td>9/20 (45)</td>
<td>0.049</td>
</tr>
<tr>
<td>Shoulder impingement</td>
<td>9/25 (36)</td>
<td>1/20 (5)</td>
<td>0.03</td>
</tr>
<tr>
<td>Functional score (mean ± SD)</td>
<td>85.7 ± 9.2</td>
<td>86.94 ± 4.36</td>
<td>0.56</td>
</tr>
</tbody>
</table>

HP = hook plate; KTBW = K wire and tension band wire; SD = standard deviation.

### Table 2

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>HP (n = 25)</th>
<th>KTBW (n = 20)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (y)</td>
<td>41.3 ± 18.2</td>
<td>41.3 ± 13.5</td>
<td>0.953</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>13/12</td>
<td>10/10</td>
<td>0.531</td>
</tr>
<tr>
<td>Fall from a height, n (%)</td>
<td>4 (16)</td>
<td>2 (1)</td>
<td>0.645</td>
</tr>
<tr>
<td>Bicycle/motorcycle accident, n (%)</td>
<td>21 (8)</td>
<td>18 (89)</td>
<td>0.740</td>
</tr>
<tr>
<td>Mean time to surgery (d)</td>
<td>1.5 ± 1.1</td>
<td>1.9 ± 1.7</td>
<td>0.428</td>
</tr>
<tr>
<td>Time to implant removal (mo)</td>
<td>5.8 ± 0.7</td>
<td>4.4 ± 1.6</td>
<td>0.001</td>
</tr>
<tr>
<td>Average follow-up (mo)</td>
<td>13.3 ± 4.4</td>
<td>14.4 ± 3.2</td>
<td>0.098</td>
</tr>
</tbody>
</table>

Data represent the mean ± standard deviation. F = female; HP = hook plate; KTBW = K wire and tension band wire; M = male.
The clinical impingement was further confirmed by musculoskeletal sonography with respect to abnormal proximal migration of humeral head during shoulder forward elevation or abduction (Figure 3). In all these patients, the impingement problems gradually resolved within 8 weeks of hardware removal.

4. Discussion

Distal clavicle fractures account for 10–26% of all clavicle fractures and are most common among middle-aged men.1,2 The majority of the injuries are caused by traffic accidents and accidental falls. Several studies have recommended open reduction and internal fixation in Neer type II fractures of the distal clavicle due to their high tendency of nonunion.1 However, the standard treatment of these fractures remains controversial. There are various methods of operative treatment. One of the widely used methods is transarticular or extra-articular KTBW. Good results are reported by various authors using these methods.4,14 Neer and Krüger-Franke et al have reported very good outcome in patients operated upon with this technique, with few complications.1,25 Kao et al have used extra-articular tension band wire to fix the displaced fracture without penetrating the AC joint.4 In their series, 11 of the 12 patients (92%) obtained a bony union with a range of painless motion after an average of 4 months. Although tension band wire fixation has good functional results and high union rate, an important disadvantage of using pins and K wires in shoulder surgery is the risk of migration.

In our series, K-wire fixation with an additional tension band wire was used in most cases and achieved satisfactory stability. In 16 patients, full radiological healing and full return of function were obtained quickly after K-wire removal 2–4 weeks postoperatively (Figure 4). However, three cases had loss of reduction due to pin migration and resulted in nonunion. However, the functional score was regarded as good and no further surgery was necessary. We think that it is important to make the K wire have bicortical bony purchase to decrease the risk of pin migration during shoulder motion, and consider that pin migration can actually be avoided. All patients should be immobilized for 1 month in a sling followed by restriction of shoulder flexion and abduction to 90° until the K wire is removed after consolidation has been confirmed.

In the present study, the functional shoulder score showed no difference between the HP and KTBW groups. However, from a biomechanical viewpoint, the HP can provide more resistance to the deforming force of the shoulder musculature than KTBW.26 Moreover, rotational movement of the AC joint during shoulder abduction and flexion remains unaffected. Direct and functional postoperative aftercare in patients receiving HP fixation is possible without marked restriction in shoulder ROM. The HP group was thus expected to have significantly better functional scores and greater ability to return to their previous level of activity. Unfortunately, we found a high occurrence of subacromial shoulder impingement syndrome in the HP group. Nine patients (36%) complained of a subjective feeling of mechanical impingement while trying to lift their shoulder above their head. Moreover, they were unable to elevate or abduct the arm over 90°. Nine patients who developed impingement symptoms also had poorer constant scores and less clinical satisfaction.

Other investigators have also described subacromial shoulder impingement and have related this problem to plate placement in the subacromial space. Meda et al used clavicular HP in 31 patients and six (19%) developed signs of impingement.13 Monsaert et al treated 10 patients with clavicular HP and two of them required plate removal secondary to pain and decreased ROM in shoulder abduction and forward flexion.27 El Maraghy et al have provided cadaveric evidence that the position of the hook portion of the

![Figure 1](Figure 1.png) A 56 year-old man with left distal clavicle fracture was treated with clavicular hook plate. (A) Radiography at the immediate postoperative period showed good fracture reduction. (B) X-ray at 4 weeks showed the hook portion of the plate was disengaged from the acromion causing partial loss of reduction.

![Figure 2](Figure 2.png) A 44 year-old man with right distal clavicle fracture was treated with clavicular hook plate. (A) Radiography at the immediate postoperative period showed good fracture reduction and fixation. (B) Immediate X-ray after implant removal showed distal clavicle osteolysis.
implant can predispose anatomic structures to the postoperative complication of subacromial impingement. To the best of our knowledge, the only solution is removal of the implant after bony consolidation has taken place. In all our patients, the impingement problems disappeared and they experienced symptomatic resolution within 8 weeks of plate removal. Another point of interest is that shoulder impingement was more often encountered in our older patients. We suggest that the age of the patients has to be taken into account when the decision is made how to treat this type of fracture.

In conclusion, both surgical methods (HP and KTBW) for treatment of unstable distal clavicle fractures could achieve satisfactory results. There were no differences in functional scores among the two groups of patients. Although the union rate was high (96%) and surgical complication rate was low in the HP group, an unacceptable high percentage of impingement problems (36%) renders HP a potentially harmful device to the surrounding subacromial structures. In our opinion, the advantages of more rigid fixation and unrestricted early mobilization do not outweigh the disadvantages of the impingement problems. Therefore, we acknowledge that

Figure 3 Dynamic musculoskeletal sonography of a 36 year-old man who developed shoulder impingement syndrome after receiving hook plate fixation of a left distal clavicle fracture. At 90° forward elevation, abnormal superior translation of the humeral head with regard to the acromion obstructing its passage beneath the acromion was noted. AC = acromion; HH = humeral head; SSP = supraspinatus tendon.
References


