AO clavicular hook plate fixation provides more rigid fixation and good bony union rates for Neer type II distal clavicular fractures. However, the hook may cause rotator cuff tears and subacromial impingement, which adversely affect the clinical results. T-plate fixation is another surgical method of treatment for unstable clavicle fractures, and its clinical efficacy has been demonstrated. The purpose of this study was to compare the clinical outcomes of AO clavicular hook plate and T-plate fixation for Neer type II distal clavicular fractures.

Forty-two patients with Neer type II fractures were divided into 2 groups. The hook plate group comprised 23 patients who underwent hook plate fixation, and the T-plate group comprised 19 patients who underwent distal radius volar locking T-plate fixation. Hook plates were removed 3 to 14 months postoperatively in 15 patients because of shoulder function limitations. All patients were evaluated postoperatively for shoulder pain, activities of daily living, range of motion, strength, and satisfaction according to the University of California, Los Angeles (UCLA) Shoulder rating scale. All fractures in the 2 groups achieved stable fixation and bony union. Both groups yielded similar outcomes with regard to shoulder strength and patient satisfaction ($P = .207$ and $P = .398$, respectively). Significant differences existed between the 2 groups in the mean scores of shoulder pain, activities of daily living, range of motion, and total UCLA score ($P = .001$, $P = .011$, $P = .038$, and $P = .001$, respectively). More patients (74%) in the hook plate group had mild to severe shoulder pain than in the T-plate group (16%). However, shoulder pain was relieved and function improved significantly after removal of the hook plate ($P = .001$).
D

istal clavicle fractures account for approximately 21% of all clavicle fractures. Three types have been demonstrated based on the relationship of the fracture line to the coracoclavicular ligaments and acromioclavicular joint. Neer type I fractures occur between the acromioclavicular joint and the coracoclavicular ligaments. Neer type III fractures are characterized by the extension of the fracture line into the acromioclavicular joint. These 2 types are stable with minimal displacement because the proximal fragment is stabilized by the coracoclavicular ligaments, and they are usually treated with nonsurgical techniques. Neer type II fractures occur more medial to the coracoclavicular ligaments and often result in major displacement because of complete or incomplete rupture of the coracoclavicular ligaments, resulting in higher rates of nonunion ranging from 21% to 44% with nonsurgical management. As a result, surgical treatment has been recommended for Neer type II fractures.

Many surgical procedures have been developed for treatment of Neer type II distal clavicle fractures, including transcromial Kirschner wires and Knowles pins, the Weaver-Dunn procedure, tension band wires, coracoclavicular screw fixation, plate fixation, and arthroscopic treatment. None of these is generally regarded as the gold standard treatment. One popular method of surgical management is AO clavicular hook plate fixation with an extension under the acromion, which provides more rigid fixation and good bony union rates. However, the hook may cause rotator cuff tear and subacromial impingement, which adversely affect the clinical results. T-plate fixation is another surgical method for treatment of unstable clavicle fractures, and published series evaluating its clinical efficacy have demonstrated high union rates, good function, and low complication rates. However, few studies compare the results of hook plate and T-plate fixation for Neer type II distal clavicular fractures. The purpose of the current study was to retrospectively review the clinical outcomes of these 2 techniques.

**MATERIALS AND METHODS**

This study was designed as a retrospective review and was approved by the Ethics Committee of the authors’ hospital. All patients provided written informed consent.

Patients with Neer type II distal clavicle fractures treated in the authors’ hospital between 2007 and 2009 were subjected to the inclusion criteria, which were defined according to a previous study with a slight modification: (1) Neer type II fractures; (2) acute and unilateral fractures; (3) fixation with either an AO hook plate or an AO T-plate; (4) no accompanying injury; (5) normal shoulder function before injury; and (6) at least 12-month follow-up. According to these criteria, 42 patients were included in the study.

The patients were divided into 2 groups according to the plate used. The hook plate group comprised 23 patients (15 men and 8 women) treated with an AO hook plate. Average patient age in this group was 41.78 ± 11.10 years (range, 21-65 years). Seven injuries were caused by motor vehicle accidents and 16 by a fall from a height. Mean time from injury to surgery was 4.63 ± 2.44 days (range, 2-11 days). The injured side was the right shoulder in 14 patients and the left in 9 patients. Mean operative time was 61.74 ± 4.65 minutes (range, 55-71 minutes). Average follow-up was 22.09 ± 9.30 months (range, 12-48 months) (Table 1).

The T-plate group comprised 19 patients (13 men and 6 women) treated with an AO distal radius volar locking T-plate. Average patient age in this group was 40.47 ± 9.61 years (range, 22-61 years). Five injuries were caused by motor vehicle accidents and 14 by a fall from a height. Mean time from injury to surgery was 4.58 ± 2.34 days (range, 2-10 days), and mean operative time was 60.32 ± 4.82 minutes (range, 55-70 minutes). Average follow-up was 22.42 ± 10.14 months (range, 12-48 months) (Table 1).

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hook Plate Group</th>
<th>T-plate Group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>23</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>No. of M:F</td>
<td>15:08</td>
<td>13:06</td>
<td>&gt;.05</td>
</tr>
<tr>
<td>Mean age (range), y</td>
<td>41.78±11.10 (21-65)</td>
<td>40.47±9.61 (22-61)</td>
<td>.686</td>
</tr>
<tr>
<td>No. of right:left sides</td>
<td>14:09</td>
<td>13:06</td>
<td>&gt;.05</td>
</tr>
<tr>
<td>Mean follow-up (range), mo</td>
<td>22.09±9.30 (12-48)</td>
<td>22.42±10.14 (12-48)</td>
<td>.99</td>
</tr>
<tr>
<td>No. of falling:MVA injuries</td>
<td>16:07</td>
<td>14:05</td>
<td>&gt;.05</td>
</tr>
<tr>
<td>Mean operative time (range), min</td>
<td>61.74±4.65 (55-71)</td>
<td>60.32±4.82 (55-70)</td>
<td>.285</td>
</tr>
<tr>
<td>Mean time from injury to surgery (range), d</td>
<td>4.63±2.44 (2-11)</td>
<td>4.58±2.34 (2-10)</td>
<td>.99</td>
</tr>
</tbody>
</table>

Abbreviations: F, female; M, male; MVA, motor vehicle accident.

### Surgical Technique

**Hook Plate Group**

Surgery was performed under cervical plexus block. A linear incision parallel to the distal clavicle was made. After the fracture was reduced and the subacromial space was confirmed, the hook portion of the plate was inserted under the acromion.
The clavicle portion of the plate was contoured only when required by the shape of a patient’s clavicle to ensure proper fixation onto the clavicle without excessive force. The fixation was then completed with screws. Additional screws or K-wires were used to stabilize the small fragment if necessary.

**T-plate Group**

The skin incision was similar to that used in the hook plate group. After reduction was achieved and maintained, the T-shaped portion and shaft of the distal radius volar locking plate were slightly flattened to fit the configuration of the distal and proximal fragment. Fixation was then completed with locking screws. The position of the screws was checked by fluoroscopy to ensure they did not enter the scapuloclavicular joint. The ruptured coracoclavicular ligaments were not repaired in either group.

**Postoperative Management**

The shoulder was protected with a triangular sling immediately postoperatively and for 6 weeks afterward. Active range of motion exercises of the elbow, wrist, and hand were begun after recovery from anesthesia. Pendulant exercises of the shoulder joint in the arm sling were encouraged if the patient was pain free, and the range of the pendular movement increased gradually but was maintained at less than 45° in the first 2 weeks and up to 90° by 6 weeks. From 6 to 12 weeks, patients were required to remove the sling and exercise the shoulder joint by active motion of more than 90°. Patients were allowed to return to light work if osseous union was evident on radiographs. Strenuous use of the arm was not begun until 6 months postoperatively.

**Clinical Assessment**

All patients had clinical follow-up and radiographs at 4, 8, and 12 weeks, 6 months, 1 year, and then annually thereafter. The clinical results were evaluated using the University of California, Los Angeles (UCLA) Shoulder rating scale. The shoulder function of the hook plate group before and after removing the internal fixation were also analyzed using the UCLA scale. Bony union of the fractures was defined as obliteration of the fracture line and bridging bony callus. To eliminate bias, these tests were administered by an investigator (Y.S.) who had not been involved in the treatment of the patients.

**Statistical Analysis**

Mann-Whitney U test was used to determine the statistical significance of the differences in measurement data between the 2 groups. Chi-square test was used for enumeration data of the preoperative demographics between the 2 groups. A P value less than .05 was considered significant.

**RESULTS**

**Analysis of the Common Clinical Data**

Table 1 shows that the constituent ratios of sex, injured side, and mechanisms of injury are consistent between the hook plate and T-plate groups, with no significant differences between them (P > .05). Furthermore, no significant differences existed in average age (P = .686), follow-up time (P = .990), operative time (P = .285), and time from injury to surgery (P = .990).

**Shoulder Pain**

At final follow-up, 6 (26%) patients in the hook plate group had no pain, 12 (52%) had mild pain, 4 (18%) had moderate pain, and 1 (4%) had severe pain. The pain in the shoulder affected sleep when lying on the injured side. Sixteen (84%) patients in the T-plate group had no pain, and 3 (16%) had mild pain when undertaking strenuous activities with no effect on sleep. Average pain scores for the hook plate and T-plate groups according to the UCLA Shoulder rating score were 8.09 ± 1.38 and 9.68 ± 0.75, respectively (Table 2), demonstrating a significant difference (P = .001). Fifteen patients in the hook plate group with bony union underwent plate removal because of shoulder pain at a mean of 10 months (range, 3-14 months) and were followed for 3 to 6 months. In these patients, shoulder pain scores (9.60 ± 0.80) increased dramatically compared with scores (7.47 ± 0.88) before plate removal (P = .0001, Figure 1A), and became almost equal to the scores (9.68 ± 0.75) of the T-plate group (P = .812) (Figure 1B).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hook Plate Group</th>
<th>T-plate Group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCLA rating score</td>
<td>30.91 ± 3.55 (24-35)</td>
<td>34.11 ± 2.18 (29-35)</td>
<td>.001</td>
</tr>
<tr>
<td>Pain</td>
<td>8.09 ± 1.38 (6-10)</td>
<td>9.68 ± 0.75 (8-10)</td>
<td>.001</td>
</tr>
<tr>
<td>Activities of daily living</td>
<td>8.61 ± 1.50 (6-10)</td>
<td>9.68 ± 0.75 (8-10)</td>
<td>.011</td>
</tr>
<tr>
<td>Range of motion</td>
<td>4.61 ± 0.48 (4-5)</td>
<td>4.89 ± 0.33 (4-5)</td>
<td>.038</td>
</tr>
<tr>
<td>Strength of forward flexion</td>
<td>4.74 ± 0.44 (4-5)</td>
<td>4.89 ± 0.32 (4-5)</td>
<td>.207</td>
</tr>
<tr>
<td>Patient satisfaction</td>
<td>4.87 ± 0.34 (4-5)</td>
<td>4.95 ± 0.23 (4-5)</td>
<td>.398</td>
</tr>
<tr>
<td>Union time, wk</td>
<td>8.75 ± 2.55 (6-13)</td>
<td>8.06 ± 1.52 (6-11)</td>
<td>.528</td>
</tr>
<tr>
<td>No. of infections</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: UCLA, University of California, Los Angeles.
Mean activities of daily living scores according to the UCLA Shoulder rating scale were $8.61 \pm 1.50$ for the hook plate group and $9.68 \pm 0.75$ for the T-plate group (Table 2). The scores were significantly different between the 2 groups ($P < .01$). In the hook plate group, 11 (48%) patients were able to perform all normal activities of daily living, 8 (35%) had moderate activity restrictions, and 4 (17%) had relatively severe restrictions. In the T-plate group, 16 (84%) patients could perform all normal activities of daily living and 3 (16%) had slight restrictions. In the hook plate group, mean activities of daily living scores after plate removal ($9.73 \pm 0.68$) were higher than those before plate removal ($8.40 \pm 1.50$) ($P = .001$) (Figure 1A). No differences existed in the scores between the hook plate group after plate removal ($9.73 \pm 0.68$) and the T-plate group ($9.68 \pm 0.75$) ($P = .847$) (Figure 1B).

Range of Motion

Ten (44%) patients in the hook plate group and 2 (10.5%) patients in the T-plate group had less than $120^\circ$ of active forward elevation. Average scores for active forward motion were $4.61 \pm 0.48$ in the hook plate group and $4.89 \pm 0.33$ in the T-plate group at final follow-up (Table 2). Significant differences existed between the groups ($P = .038$). After plate removal, mean range of motion (ROM) scores increased from $4.53 \pm 0.50$ to $4.87 \pm 0.34$ ($P = .019$) (Figure 1A) and reached levels similar to those in the T-plate group ($4.89 \pm 0.33$) ($P = .808$) (Figure 1B).

Strength of Motion and Patient Satisfaction

No significant differences existed in the mean scores for strength ($P = .207$) or patient satisfaction ($P = .398$) between the 2 groups, although 6 (18%) patients in the hook plate group and 2 (11%) patients in the T-plate group had grade 4 muscle strength (Table 2). After plate removal in the hook plate group, motive shoulder strength was slightly improved, but no significant differences existed in scores before and after plate removal (Figure 1A).

Total UCLA Scores

Mean total UCLA scores of the hook plate and T-plate groups ($30.91 \pm 3.55$ and $34.11 \pm 2.18$, respectively) showed a significant difference at final follow-up ($P = .001$) (Table 2). Total UCLA scores in the hook plate group after plate removal ($34.40 \pm 1.54$) were significantly higher than those before plate removal ($30.27 \pm 2.91$) ($P = .0001$) (Figure 2A). No differences existed in UCLA scores between the hook plate group and the T-plate group after plate removal ($P = .664$) (Figure 2B). In the hook plate group, according to the UCLA rating system, 5 (22%) patients had an excellent result (34-35 points), 13 (57%) had a good result (29-33 points), and 5 (21%) had a fair result (less than 29 points). In the T-plate group, 17 (89%) patients had an excellent result and 2 (11%) had a good result. After plate removal in the hook plate group, 14 (93%) patients had excellent results, and 5 (21%) had good results.
an excellent result and 1 (7%) had a good result. Figures 3 and 4 show typical cases.

Complications

No intraoperative complications occurred. According to clinical and radiographic results, all patients achieved bony union by 8.75±2.55 weeks postoperatively (range, 6-13 weeks) in the hook plate group and 8.06±1.52 weeks postoperatively (range, 6-11 weeks) in the T-plate group (P=.528) (Table 2). Other possible complications, such as plate breakage, internal fixation loosening, osteoarthritis of the acromioclavicular joint, and pin migration, did not occur. Superficial infection was identified in 1 patient in the hook plate group 10 days postoperatively but was cured with 1 week of treatment with oral antibiotics and local dressing changes at the incision site. No complications occurred in the T-plate group.

DISCUSSION

Plate fixation systems are increasingly used for the treatment of distal clavicle fractures. The AO clavicular hook plate anatomically fits the acromion and clavicle, with the lateral hook passing below the acromion posterior to the acromioclavicular joint and the shaft fixing to the superior surface of the clavicle. This subacromial hook provides distal leverage that allows the portion of the plate that is fixed to the clavicle to act as a depressor, bringing the medial fracture fragment down to facilitate bony union and early postoperative mobilization.28-30 The AO T-shaped distal radius volar locking plate, which was initially designed to fix distal radius fractures, is a good fit to the configuration of the distal clavicle, and stable fixation of the fracture can be completed by the use of multiple, divergent locking screws in the distal fragment. Although the results of this AO plate system in the current study were excellent with few complications, no study has reported a comparison of the clinical results of the AO hook plate and the T-plate for fixation of distal clavicular fractures.

The current study compared functional scores of the 2 groups according to the UCLA Shoulder rating scale. The results showed that the T-plate group exhibited improvement in activities of daily living, shoulder pain, and ROM, which resulted in a higher rate of excellent and good results compared with the hook plate group. According to the composition of the UCLA scores, all patients in both groups were satisfied with the surgical results. However, the activities of daily living and ROM scores differed significantly between the 2 groups and were in accordance with the pain scores. Furthermore, after plate removal, shoulder function in the hook plate group improved markedly due to pain relief, and total UCLA scores and the rate of excellent and good results increased and almost reached the level of the T-plate group. Therefore, pain during shoulder movement could largely account for the relatively lower rate of function recovery in the hook plate group.

In the hook plate group, 74% of patients had mild to severe pain in the shoulder that affected their sleep when lying on the injured side and influenced shoulder function when lifting the arm more than 90°. These symptomatic complications may be caused by higher stress at the undersurface of the acromion and impingement of the subacromial structures. ElMaraghy et al31 performed subacromial morphometric assessment of the clavicle hook plate and reported that implantation of the subacromial hook resulted in subacromial bursal penetration in almost all specimens. In addition, the size of the subacromial space is limited under nor-
mal circumstances. Compromising this space with bursal inflammation due to the presence of the subacromial hook could further narrow the distance between the supraspinatus tendon and the subacromial arch, which leads to rotator cuff impingement.\textsuperscript{1,3} Furthermore, the subacromial hook is free to move with the rotation and elevation of the clavicle; at 90° of arm elevation, clavicle backward rotation is less than 5° and clavicle elevation is approximately 6° in the scapular and sagittal planes; by 150° of arm elevation, mean backward clavicle rotation increases to 27°, whereas clavicle elevation increases to 21°.\textsuperscript{3,5} These observations suggest that this type of hook contact predisposes subacromial structures and the undersurface of the acromion to inflammation and impingement, leading to shoulder pain and function limitation.

Whether to remove the hook plate after bony union remains controversial. Some authors have recommended that the plate not be removed.\textsuperscript{29} Others have suggested that the plate should be removed routinely 3 to 5 months postoperatively to avoid complications.\textsuperscript{16-18} According to the current results of 15 patients in the hook plate group, mean total UCLA scores after plate removal were significantly increased. Pain scores, activities of daily living scores, and ROM scores all improved markedly and almost reached those of the normal shoulder joint. Therefore, the hook plate should be removed once bony union is achieved.

Studies have reported excellent results of distal clavicle fractures treated with a T-shaped distal radius volar locking plate, with few complications.\textsuperscript{15,22-24} In the current study, patients in the T-plate group also demonstrated excellent function and high union rates with no complications. Few patients had obvious clinical symptoms that adversely affected their activities of daily living throughout the follow-up period. The activities of daily living score in the T-plate group was higher than that in the hook plate group before plate removal because the T-plate, unlike the hook plate, avoids the need to interfere with the scapuloclavicular joint, and therefore does not lead to iatrogenic subacromial impingement or rotator cuff damage, so that the function of the shoulder joint is less compromised.

Disruption of the coracoclavicular ligament from the medial clavicular fragment results in displacement of the medial fragment. In the current study, without repair of the coracoclavicular ligament, acceptable bony union was achieved and no instability of the acromioclavicular joint occurred after plate removal. This result also supports the conclusion reported by Jin et al\textsuperscript{14} that solid union of the fracture can guarantee stability of the clavicle and it is not necessary to repair the coracoclavicular ligament in the treatment of distal clavicle fractures.

The current study had 2 limitations. It was a retrospective study and not randomized; therefore, selection bias may have existed. Also, the series was not large.

**CONCLUSION**

AO hook plate fixation and T-shaped distal radius volar locking plate fixation are effective surgical procedures for treatment of Neer type II distal clavicle fractures. However, significant ROM and function limitation arising from shoulder pain occurred in the hook plate group, although patients were satisfied with the technique. Use of T-plate fixation without disturbance to the acromioclavicular joint, subacromial space, and rotator cuff led to a higher incidence of good and excellent clinical results compared with those treated by hook plate fixation, which was not removed. Therefore, the T-plate provides an alternative method for internal fixation of distal clavicle fractures, but further prospective research is needed involving larger case numbers.

**REFERENCES**


