Comparison of Dynamic and Locked Compression Plates for Treating Midshaft Clavicle Fractures

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abstract

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The purpose of this study was to compare the parameters of perioperative course and cost-effectiveness for patients with midshaft clavicle fractures treated by dynamic compression plates or locked compression plates.

This retrospective, case-controlled study involved 54 patients with midshaft clavicle fractures who received dynamic compression plates (n=21) or locked compression plates (n=33) between January 2002 and December 2008. Indications for surgery included displacement or shortening >2 cm, comminuted fractures, and skin tenting. Patients with previous malunion, nonunion, multiple injuries of the shoulder girdle, or open fractures were excluded. Preoperative demographics showed no statistically significant differences between the 2 groups. Eighteen patients with dynamic compression plates and 28 patients with locked compression plates with postoperative follow-up >1 year were included for comparison. Statistical analyses for operative time, blood loss, complication rate, hospital stay, and union rate demonstrated no statistically significant difference between the 2 groups. The only statistically significant difference was a higher rate of plate removal requests in the dynamic compression plate group. Considering medical expenditure, locked compression plates cost 6 times more than dynamic compression plates in the authors’ institution (US $600 vs $100, respectively).

Other than more plate removal requests in the dynamic compression plate group and greater expense in the locked compression plate group, dynamic compression plates and locked compression plates achieved satisfactory operative outcomes in treating midshaft clavicle fractures, with no statistically significant difference between perioperative course and eventual fracture union observed between the 2 groups.

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Figure: Preoperative anteroposterior radiograph showing an AO/OTA 06-B1 right clavicle fracture (A). Postoperative anteroposterior radiograph after open reduction and internal fixation with a 3.5-mm locked compression plate (B).
Recent studies have shown better functional outcomes in patients with displaced midshaft clavicle fractures treated with operative fixation than with nonoperative methods.\(^1\)\(^-\)\(^3\) Considerable malunion may develop with nonoperative treatment and requires operative correction and fixation for residual functional deficit.\(^2\)\(^-\)\(^3\) Plate fixation systems and intramedullary fixation are commonly used. Intramedullary fixation is considered less invasive than plate fixation. However, plate fixation is superior to intramedullary fixation in achieving and maintaining anatomic reduction, although it may cause more periosteum stripping and cosmetic problems.

Locked compression plates became popular when biomechanical studies demonstrated better stability provided by locked compression plates than with nonlocked plates.\(^4\)\(^-\)\(^6\) However, several studies reported that nonlocked plates, such as reconstruction plates and dynamic compression plates, achieved satisfactory results with few complications.\(^7\)\(^-\)\(^8\) The authors of the current study tested the null hypothesis that locked compression plates provided better clinical results than dynamic compression plates for treating midshaft clavicle fractures. The study was conducted to compare the parameters of perioperative course and surgical outcome between locked compression plates and dynamic compression plates in treating midshaft clavicle fractures.

**Materials and Methods**

This retrospective, case-controlled study of 54 patients with acute midshaft clavicle fractures between January 2002 and December 2008 received approval from the Institutional Review Board of Kaohsiung Veterans General Hospital (VGHKS99-CT6-05). Fracture pattern was classified according to the AO/OTA classification system. Indications for surgery included displacement or shortening >2 cm, comminuted fractures, and skin tenting. For patients who met the criteria, the advantages and disadvantages of the 2 plates were explained, and the patients decided which fixation device they preferred. Consequently, 21 patients received AO/ASIF 3.5-mm dynamic compression plates (Synthes, Solothurn, Switzerland), and 33 patients received AO/ASIF 3.5-mm locked compression plates (Synthes). Two senior surgeons (Y.-W.T., S.-W.Y.) specializing in fracture management performed all surgeries. Patients with previous malunion, nonunion, multiple injuries of the shoulder girdle, or open fractures were excluded, as were those with postoperative follow-up <1 year. Therefore, 18 patients from the dynamic compression plate group and 28 patients from the locked compression plate group were included in the study. Preoperative demographics are shown in Table 1.

All surgeries were performed under general anesthesia. The patient was placed in the beach-chair position with a sand bag under the scapula. Through a superior incision, the fractures were reduced as anatomically as possible with minimal stripping of the periosteum. The locked compression plates were contoured to fit the anatomical curve of the clavicle. The dynamic compression plates were applied without bending. Plate fixation was performed with at least 6 cortical purchases on each side of fracture site regardless of the plate used, except in 2 patients receiving locked compression plates. Postoperative protection by an arm sling was advised for 2 weeks postoperatively to reduce surgical wound discomfort. However, pendulum exercises of the injured limb were allowed. Regular follow-up occurred at 6-week intervals. Fracture union was determined by adequate callus formation bridging across the fracture site on plain radiographs.

Chi-square test and Student’s t test were used to compare categorical and continuous variables, respectively, between the 2 groups. Statistical significance was set at \(P<.05\).

**Results**

After excluding patients who met the exclusion criteria, 18 (85.7%) of 21 patients in the dynamic compression plate group and 28 (84.8%) of 33 patients in the locked compression plate group with an average follow-up of 19.9 and 18.1 months, respectively, were included for comparison. No statistically significant differences existed between the groups.

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**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>DCP Group</th>
<th>LCP Group</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>18</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>No. of men/women</td>
<td>15/3</td>
<td>17/11</td>
<td>.104</td>
</tr>
<tr>
<td>Mean patient age (range), y</td>
<td>37.4 (16-80)</td>
<td>45.0 (15-71)</td>
<td>.105</td>
</tr>
<tr>
<td>No. of combined injuries* (%)</td>
<td>7 (38.9)</td>
<td>12 (42.9)</td>
<td>.790</td>
</tr>
<tr>
<td>Average time from injury to surgery, d</td>
<td>4.5</td>
<td>3.1</td>
<td>.446</td>
</tr>
<tr>
<td>AO/OTA classification, no. (%)</td>
<td></td>
<td></td>
<td>.349</td>
</tr>
<tr>
<td>06-A</td>
<td>10 (55.6)</td>
<td>12 (42.9)</td>
<td></td>
</tr>
<tr>
<td>06-B</td>
<td>4 (22.2)</td>
<td>12 (42.9)</td>
<td></td>
</tr>
<tr>
<td>06-C</td>
<td>4 (22.2)</td>
<td>4 (14.3)</td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: DCP, dynamic compression plate; LCP, locked compression plate.*

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Intracranial hemorrhage, hemothorax, multiple rib fractures, long bone fractures.
with respect to age, sex, fracture pattern, and other demographic characteristics (Table 1). The percentage of complex fractures, such as AO/OTA 06-B and -C, was similar between the 2 groups (44.4% in the dynamic compression plate group and 57.2% in the locked compression plate group). Average time from injury to surgery was 4.5 days in the dynamic compression plate group and 3.1 days in the locked compression plate group.

Because Kaohsiung Veterans General Hospital is a tertiary medical center, a high rate of combined injuries was noted in both groups (38.9% in the dynamic compression plate group and 42.9% in the locked compression plate group), including intracranial hemorrhage, hemothorax, pneumothorax, multiple rib fractures, and long-bone fractures. Because hospital stays varied depending on patient concomitant injuries, they could not be compared. However, if patients with associated injuries were excluded, average hospital stay was 3.8 days in the dynamic compression plate group and 4.4 days in the locked compression plate groups ($P=.325$). Other than hospital stay, no statistically significant differences existed in operative time ($P=.7$, Student’s $t$ test) or blood loss ($P=.07$, Student’s $t$ test) (Table 2). However, more blood loss was noted in the dynamic compression plate group than in the locked compression plate group (84.5 vs 41.2 mL, respectively). No neurovascular injuries, wound infections, or other immediate complications requiring further surgical intervention occurred in either group.

Cumulative union rate was 94.4% in the dynamic compression plate group and 96.4% in the locked compression plate group by 24 weeks postoperatively (Table 3). No broken or deformed plates occurred during follow-up. However, screw loosening without loss of reduction was observed in 3 patients in the dynamic compression plate group and 1 patient in the locked compression plate group ($P=.298$). The fractures united in these 4 patients by final follow-up. In addition, 1 patient in the locked compression plate group developed loss of reduction with complete backout of distal screws 4 months postoperatively. One patient in the dynamic compression plate group experienced delayed union because the fracture union could not be confirmed on radiographs until 10 months postoperatively. Among the patients with solid fracture union, 12 in the dynamic compression plate group and 8 in the locked compression plate group requested implant removal. Requests for plate removal occurred significantly more often ($P=.011$, Student’s $t$ test) in the dynamic compression plate group (66.7%) than in the locked compression plate group (28.6%).

**DISCUSSION**

Although conservative treatment remains an option for treating midshaft clavicle fractures, satisfactory functional outcomes with early pain relief justify operative treatment of displaced midshaft clavicle fractures. Screw fixation and intramedullary fixation were reported to achieve comparable clinical outcomes, including functional recovery and return to normal activities of daily living. Intramedullary fixation prevents extensive soft tissue stripping and cosmetic problems. A titanium elastic nail may be placed with a small incision by an experienced surgeon. However, this demanding procedure may cause some complications, including shortening and rotation in comminuted clavicle fractures.

Plate fixation has been used to effectively treat displaced midshaft clavicle fractures. Nonlocked reconstruction plates became less popular for fixation of midshaft clavicle fractures due to lower stiffness and a higher rate of malunion. Although locked plates provide better angular stability than conventional dynamic compression plates by threaded fixation of screws on the plate, conventional dynamic
Compression plates also provide adequate stability for fixation of midshaft clavicle fractures. Limited-contact dynamic compression plates are another option with the advantage of preserving blood supply to the periosteum. However, the limited-contact dynamic compression plate was not included in the current study due to inadequate experience resulting from the limitations of national health insurance.

Comparative clinical studies of dynamic compression plates and locked compression plates are limited. The current study was designed to evaluate the clinical outcomes of displaced midshaft clavicle fractures that were operated with these 2 plates. With comparable demographic data between the 2 groups (Table 1), no statistically significant difference was found in operative time, blood loss, complication rate, hospital stay, and eventual union rate between the groups. The cumulative union rate was comparable between the groups by 24 weeks postoperatively (P=.747). Therefore, the null hypothesis of this study—that locked compression plates provided better clinical outcomes than dynamic compression plates for treating midshaft clavicle fractures—should be rejected.

The only statistically significant difference between the 2 groups was a higher plate removal rate in the dynamic compression plate group (66.7%) than in the locked compression plate group (28.6%) (P=.011). During follow-up, 12 patients in the dynamic compression plate group and 8 patients in the locked compression plate group requested plate removal. Among these patients, 4 in the dynamic compression plate group and 2 in the locked compression plate group requested plate removal due to prominent screw heads with no obvious discomfort. Other patients requested plate removal because they did not want foreign implants retained in their bodies. It was somewhat difficult to apply the dynamic compression plates to fit the curve of the clavicle due to its noncontourable design. To purchase 2 cortices for each screw, the position of the dynamic compression plates must be adjusted carefully. Nonetheless, skin irritation over both ends of the plate was sometimes inevitable. In contrast, the locked compression plates could fit the anatomical curve of the clavicle due to its noncontourable design. Therefore, less skin irritation and fewer plate removal requests resulted in those patients using locked compression plates.

Although locked compression plates provided better stability in compression...
and torsion than did dynamic compression plates, 2 cases of screw pullout occurred in the locked compression plate group (Figures 1, 2). The common shortcoming in these 2 cases was inadequate screw purchase. Brouwer et al.\(^4\) reported 4 cases of failed locked plates in midshaft clavicle fractures and suggested that perfectly parallel screws resulted in axial failure. Bending strength and angular stability strength by the locked screw on the plate may not be achieved unless the construct is fixed without violation of biomechanical principles. In the locked compression plate group in the current study, 2 patients with inadequate screw purchase developed early screw pullout before fracture union. One of the 2 patients sustained an AO/OTA 06-B3 clavicle fracture in a motor vehicle collision (Figure 2). He received radiotherapy over the cervical region for hypopharyngeal carcinoma approximately 1 month postoperatively. Fracture reduction failed without callus formation by 4 months postoperatively. Radiotherapy may have had a negative effect on bone union.

Regarding medical expense, AO/ASIF 3.5-mm locked compression plates cost 6 times more than AO/ASIF 3.5-mm dynamic compression plates in the authors’ institution (US $600 vs $100). Despite the higher expense of the locked compression plate, no statistically significant differences were found in operative time, blood loss, hospital stay, complication rate, and union rate between the dynamic compression plate group and the locked compression plate group. The current study provides an objective reference for the cost-effectiveness of dynamic compression plates and locked compression plates in treating midshaft clavicle fractures.

The current study had several limitations. Regarding methodology, a comprehensive discussion on the limited-contact dynamic compression plate and titanium elastic nail by a less invasive approach was not included, although the intent was to compare the cost-effectiveness of fixation devices for operative treatment of midshaft clavicle fractures; there was not enough experience using the 2 devices due to the limitations of national health insurance. With respect to the studied patients, the severity of associated injury was not concordant between the 2 groups for a statistical comparison on hospital stay, despite the occurrence rate of concomitant injuries being similar. In addition, a discussion on the position of plate placement that may influence fixation stability\(^4,5,25,26\) was not included because a reasonable grouping of patients for comparison could not be made in this study design.

**CONCLUSION**

For operative treatment of midshaft clavicle fractures, fixation by dynamic compression plates or locked compression plates results in satisfactory outcomes. Based on comparable preoperative demographics in the 2 groups, a comparison of perioperative course and eventual fracture union disclosed no statistically significant difference between the groups, other than more requests for plate removal in the dynamic compression plate group.

**REFERENCES**

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