Residual coracoclavicular separation after plate fixation for distal clavicle fractures: comparison between fracture patterns

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Background: Plate fixation is an established treatment for Neer type II and V distal clavicle fractures; however, residual coracoclavicular (C-C) separation after osteosynthesis for unstable distal clavicle fractures has rarely been discussed. This study aimed to reveal the extent of postoperative C-C separation after plate fixation for distal clavicle fractures and to evaluate the relationship between residual C-C separation and the risk of postoperative complications.

Methods: We retrospectively reviewed 60 patients with a displaced distal clavicle fracture that was treated with a Scorpion plate without C-C reconstruction and successfully united. Distal clavicle fractures were divided as per the Neer classification into type IIA (12 patients), IIB (36 patients), and V (12 patients) groups. The modified C-C distance ratio at the time of injury and after bone union, and the postoperative complications (plate-related pain, delayed union, infection, and contracture) were compared among the three groups.

Results: The mean postoperative modified C-C distance ratio was 115.0% ± 12.0%; this ratio was significantly larger in the type IIB and V groups than in the type IIA group (P = 0.021 and P = 0.006, respectively). However, there was no significant difference in the frequency of postoperative complications among the three groups.

Conclusions: Our study demonstrated that a certain degree of C-C separation remained after plate fixation for Neer type II and V distal clavicle fractures, even when bone union was achieved. The postoperative residual C-C separation was greater for the type IIB and V groups than for the type IIA group; however, this difference may not affect postoperative complications.

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Keywords: Distal clavicle fracture, Plate, Scorpion plate, Outcome, Coracoclavicular ligament, Coracoclavicular distance, Complication, Neer classification

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Distal clavicle fractures have a high rate of nonunion after nonoperative treatment owing to the progression of dislocation caused by the two opposing forces of trapezius traction and the weight of the upper extremity.²²,²₅,²₆ In general, fractures classified as types II and V using the Neer classification²⁰,²⁶ are thought to be unstable and are usually indicated for surgery.² Neer type IIA fractures have intact coracoclavicular (C-C) ligaments, including the conoid and trapezoid ligaments, whereas type IIB fractures are associated with rupture of the conoid ligament and type V fractures have a comminuted fracture pattern (Fig. 1). Therefore, Neer type IIB and V fractures are considered more unstable than a type IIA fracture.

Plate fixation has recently become an established surgical treatment for distal clavicle fractures and yields satisfactory outcomes.⁸,⁹,₁₃,₁₈ However, even with stable plate fixation, C-C separation can remain postoperatively because of the functional loss of the integrity of the C-C ligament and may affect the likelihood of postoperative complications. Although there have been studies that focused on the presence or absence of bone union, residual C-C separation after osteosynthesis for an unstable distal clavicle fracture has rarely been discussed.

This study aimed to determine the extent of postoperative C-C separation after plate fixation without C-C reconstruction for Neer type IIA, IIB, and V distal clavicle fractures and to evaluate the relationship between residual C-C separation and the risk of postoperative complications.

This study was approved by the National Hospital Organization Tokyo Medical Center Independent Ethics Committee (No. R19-037). * Corresponding author: Ryogo Furuhata, MD, Department of Orthopaedic Surgery, National Hospital Organization Tokyo Medical Centre, 2-5-1 Higashigaoka, Meguro-ku, Tokyo 152-8902, Japan. E-mail address: ryogo4kenbisha@gmail.com (R. Furuhata).
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Materials and methods

This study was approved by the independent ethics committee of the authors’ affiliated institution.

Patient selection

We retrospectively reviewed patients with Neer type II and V distal clavicle fractures that were treated with a plate without C-C reconstruction and successfully united. We included patients with acute distal clavicle fractures within 3 weeks of injury. We excluded patients with inadequate follow-up, which was defined as the inability to continue follow-up until radiographically confirmed fracture union was observed and cases in which follow-up was not feasible for at least 1 year after surgery. To accurately evaluate C-C separation after bone union in this study, we reviewed our cases with distal clavicle fracture in which bone union could be directly confirmed at the time of plate removal. Therefore, we excluded patients who did not undergo plate removal.

During the study period, 74 patients underwent osteosynthesis using the plate alone. Seven patients were excluded owing to inadequate follow-up. Bone union was obtained in all patients within 1.5 years postoperatively. Seven patients did not undergo implant removal and were excluded in this study. As a result, 60 patients (50 men, 10 women) who met the inclusion criterion were enrolled in the study. The mean patient age at the time of implant removal was 42.8 ± 13.0 (range, 14–72) years. The injury was on the right in 38 patients and on the left in 22 patients. Osteosynthesis was performed for the distal clavicle fracture 8.1 ± 4.2 (range, 1–19) days after the date of injury, and the implant was removed 12.8 ± 4.5 (range, 4.3–29.3) months after osteosynthesis. A total of 12 patients had a type IIA fracture, 36 had a type IIB fracture, and 12 had a type V fracture. There was no significant difference in age, sex, side injured (left/right), time from injury to surgery, or time to implant removal between the three types of fracture (Table 1).

Surgical methods

At our institution, we performed osteosynthesis using Scorpion plates (Aimedic, Tokyo, Japan) from April 2007 to March 2012 and Scorpion Neo plates (Aimedic) from April 2012 to December 2019 for Neer type II and V distal clavicle fractures. These plates, which are anatomic nonlocking plates that do not straddle the acromioclavicular joint and fix the distal bone fragments using screws and plate arms in an anteroposterior direction (Fig. 2), have been reported to achieve satisfactory clinical outcomes for type II and V distal clavicle fractures.28–30 For comminuted type IIB and almost all type V fractures, cerclage suturing of the distal bone fragment to a plate with nonabsorbable sutures was added to plate fixation.

Postoperative rehabilitation and implant removal

Postoperatively, the affected arm was kept in a sling for 1–3 weeks depending on the postsurgical strength of fixation. Pendulum exercise was started on the day after surgery, and active range-of-motion exercise was allowed from 1 week after surgery. When bone union was observed after surgery, the plate was removed in accordance with the preference of the patient. Approximately one quarter of patients who underwent plate fixation for distal clavicle fractures were reported to have requested implant removal due to plate irritation.4 In addition, the scorpion plates used in this study were non-locking plates and thus may become loose over time, resulting in symptoms of plate irritation. Therefore, we recommend implant removal routinely at our institution.

Evaluation

The clinical outcomes included the modified C-C distance ratio,28 frequency of postoperative complications (plate-related pain, delayed union, contracture, and infection), and postoperative range of shoulder anterior elevation. A single examiner evaluated the outcomes using plain radiographs and clinical notes. We divided the fractures into three Neer classification groups (type IIA, IIB, and V groups) based on simple radiographs and intraoperative findings and compared the outcomes among these three groups.

The conventional C-C distance (the vertical distance between the upper border of the coracoid process and the inferior cortex of the clavicle)16,30,28 does not increase in a type V distal clavicle fracture, where comminuted inferior fragments are attached to the C-C ligaments and not dislocated upward.28 Therefore, the conventional C-C distance cannot reflect the functional loss of integrity of C-C ligands of type V fractures. Because this study included not only type II but also type V distal clavicle fractures, we opted to use a modified C-C distance, defined as the vertical distance between the upper border of the coracoid process and the upper border of

**Figure 1** Neer classification of distal clavicle fractures. The scheme shows Neer type IIA (A), IIB (B), and V (C) fractures.
The mean preoperative modified C-C distance was 29.8 ± 5.9 mm, and the ratio was 157.2% ± 32.2% (compared with the unaffected side). Comparing the three study groups, the preoperative modified C-C distance ratio was highest for the Neer type V group (8.3%) in the type V group; however, the difference was not significant ($P = .369$). The mean modified C-C distance at the time of plate removal was 21.9 ± 2.6 mm, and the ratio was 115.0% ± 12.0%. Although the postoperative modified C-C distance ratio improved significantly in each group in comparison with the preoperative ratio ($P < .001$), the C-C interval was found to be wider than that on the contralateral side. The modified C-C distance ratio at the time of plate removal was significantly greater in the type IIB and V groups than in the type IIA group ($P = .021$ and $P = .006$, respectively). There was no significant difference in the modified C-C distance ratio at the time of plate removal between the type IIB and V groups ($P = .465$) (Table II).

The postoperative complication rates were comparable among the three groups (Neer types IIA, IIB, and V) (Table III). Plate-related pain was observed in one patient (8.3%) in the type IIA group, one (2.8%) in the type IIB group, and one (8.3%) in the type V group. All patients with delayed union were observed nonoperatively, and bone union was finally obtained at the final follow-up. The mean postoperative ranges of anterior elevation of Neer type IIA, IIB, and V fractures were $166 ± 26°$ (range, 90–180°), $168 ± 21°$ (range, 80–180°), and $171 ± 20°$ (range, 110–180°), respectively; however, there were no significant differences among the three groups ($P = .869$). Postoperative shoulder contracture was observed in one patient in the type IIB group; this patient showed no improvement after removal of the implant and subsequently underwent arthroscopic capsulotomy.

**Discussion**

In this study, we made two important clinical observations. First, the C-C separation remained after plate fixation for Neer type IIB and V fractures even when the fracture successfully united. Second, although the C-C separation remained in type IIB and V fractures after surgery, it did not have a significant effect on the postoperative complication rate.
First, the results of this study indicated that C-C separation improved significantly after plate fixation in all three distal fracture groups; however, C-C separation remained in the type IIB and V groups. Given that two components of the C-C ligaments control vertical translation,6,10,23 the C-C distance is used as an indicator of the extent of C-C ligament injury in a distal clavicle fracture,6,30,29 and an increased C-C distance suggests disruption of this ligament.24 Previous reports have shown that the preoperative C-C distance is significantly greater in type IIB fractures than in type IIA fractures.16 Although no significant difference was observed, similar trends were evident in this study. Moreover, we found that the preoperative modified C-C distance was significantly greater in the type V group than in the type IIA group, which can be explained by the proximal and distal bone fragments not being continuous with the C-C ligaments in the type V group. After plate fixation, the modified C-C distance remained greater in the type IIB and V groups in this study. The conoid ligament is ruptured in a displaced type IIB fracture but is attached to the distal fragment in a type IIA fracture. Even with successful bone union, the functional loss of integrity of the conoid ligament is thought to remain and result in C-C separation. Lee et al16 found that the C-C distance after hook plate fixation tended to be greater for type IIB fractures than for type IIA fractures but that the difference was not significant. This discrepancy may be partly accounted for by the fact that a plate that does not straddle the acromioclavicular joint was used in the present study, whereas a hook plate was used in the previous study.16 For type V distal clavicle fractures, it is important to perform fixation of not only the proximal and distal fragments but also the inferior bone fragments that are attached to the

**Table II**

|                      | Type IIA (n = 12) | Type IIB (n = 36) | Type V (n = 12) | P value |
|----------------------|------------------|------------------|-----------------|---------|
| Modified C-C distance ratio before plate fixation (%) | 142.9 ± 23.1     | 157.4 ± 32.1     | 176.2 ± 35.0*   | .045    |
| Modified C-C distance ratio at plate removal (%)   | 105.9 ± 5.7      | 116.8 ± 12.3*    | 121.6 ± 13.7*   | .006    |

C-C, coracoclavicular.

* P < .05 (vs. modified C-C distance ratio for Neer type IIA).

**Table III**

|                      | Type IIA (n = 12, %) | Type IIB (n = 36, %) | Type V (n = 12) | P value |
|----------------------|----------------------|----------------------|-----------------|---------|
| Plate-related pain   | 1 (8.3)              | 4 (11.1)             | 2 (16.7)        | .81     |
| Delayed union        | 1 (8.3)              | 1 (2.8)              | 1 (8.3)         | .63     |
| Infection            | 1 (8.3)              | 0 (0)                | 0 (0)           | .13     |
| Contracture          | 0 (0)                | 1 (2.8)              | 0 (0)           | .71     |
conoid ligament and trapezoid ligament; however, it is often difficult to achieve accurate anatomical reduction of inferior bone fragments with plate fixation alone. This may have contributed to the residual modified C-C distance in the type V group.

Second, although postoperative C-C separation persisted in type IIB and V distal clavicle fractures, this did not affect the postoperative complication rates. While the severity of the associated disruption of the C-C and acromioclavicular ligaments has been reported to contribute to nonunion of distal clavicle fractures,12 other studies have reported that an increased C-C distance does not significantly affect shoulder function or bone union postoperatively.20,21 Previous studies comparing the clinical outcomes as per the Neer classification found no significant difference in the functional outcomes for shouldlers or the complication rates between type IIA and IIB fractures.20,31 The results of the present study are comparable with those reports.16,30,29,31 In recent years, there have been an increasing number of reports on the addition of C-C ligament augmentation using a suture anchor or suture button to plate fixation for unstable distal clavicle fractures.5,27,33,34 While it had been reported that the addition of C-C ligament augmentation provided better functional outcomes,2,33 a report indicated comparable outcomes after plate fixation with and without C-C ligament augmentation,27 therefore the benefit of using additional C-C ligament augmentation compared with plate fixation alone is controversial. In addition, there are concerns about complications owing to the addition of C-C ligament augmentation, such as clavicale fracture5,7,14,15 and coracoid process fracture3,17,35 at the suture hole and brachial plexus injury.32 The results of this study suggest that the degree of residual C-C separation observed in this study (up to approximately 120% of that on the unaffected side) after plate fixation for Neer type IIB or V distal clavicle fractures does not significantly affect short-term clinical findings, which may not actively support the necessity of adding C-C augmentation to plate fixation for Neer type IIB and V fractures with functional loss of the integrity of C-C ligaments. Further studies are needed to clarify the association of residual C-C separation and long-term clinical outcome.

This relatively large-scale study obtained data from 60 patients in whom the same implant was used, whereas most previous studies on the surgical outcomes of distal clavicle fractures had a sample size of 50 or less. This can be considered a major limitation of this study. However, our study also has three major limitations. First, it had a retrospective design, which meant that the results may have been affected by residual confounding factors owing to biases arising from the differences in factors not measured in the three study groups. For example, the radiographic assessment was made at the time of plate removal, which was not uniform among the cases. Second, a questionnaire survey was not included, so it was not possible to determine additional objective functional outcomes. Third, all patients included in the study underwent implant removal. We could have evaluated the fractures with successful bone union directly confirmed during plate removal, but this may have resulted in a degree of selection bias. In addition, 7 of 74 (9.5%) patients were excluded in this study owing to inadequate follow-up, which may have resulted in a selection bias.

Conclusions

The results of our study demonstrated that a certain degree of C-C separation remained after plate fixation for Neer type II and V distal clavicle fractures, even when bone union was achieved. The postoperative residual C-C separation was greater for the type IIB and V groups than for the type IIA group; however, this difference may not affect postoperative complications.

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