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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 ($P = .021$ and $P = .006$, 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.

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 classification[20,19] 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).

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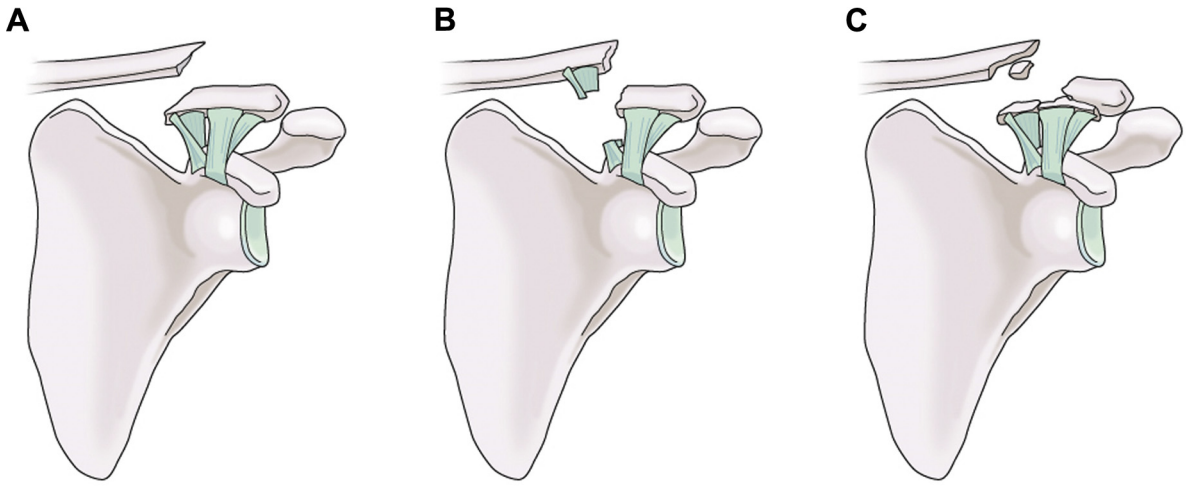

Figure 1 Neer classification of distal clavicle fractures. The scheme shows Neer type IIA (**A**), IIB (**B**), and V (**C**) fractures.

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 I).

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.[11] 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)[16,30,29] 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

Table I
Patient demographic and clinical characteristics.

	Type IIA (n = 12)	Type IIB (n = 36)	Type V (n = 12)	*P* value
Age, yr	40.9 ± 12.2	43.9 ± 14.3	44.3 ± 9.8	.82
Sex, male/female	12/0	28/8	10/2	.20
Side of injury, right/left	8/4	20/16	10/2	.22
Time from injury to surgery, d	8.9 ± 4.2	7.9 ± 4.6	7.9 ± 2.6	.75
Time to plate removal, mo	13.1 ± 5.8	12.7 ± 4.3	12.8 ± 3.4	.96

Figure 2 A photos of the Scorpion Neo plate.

the clavicle based on a previous report.[28] The modified C-C distance was measured on plain radiographic images of both clavicles taken simultaneously in the standing position. We calculated the modified C-C distance ratio by obtaining the percentage of the C-C distance compared with the unaffected side at the time of injury (Fig. 3) and just before plate removal (Fig. 4) because radiographs of both clavicles had been obtained routinely before osteosynthesis and plate removal at our institution. Plate-related pain was evaluated from the medical records of patient complaints just before plate removal. We defined delayed bone union as a lack of bone union for more than 12 months after the injury.[21] We defined postoperative shoulder contracture as the passive range of elevation less than 90°.

Statistical analysis

All statistical analyses were conducted using SPSS software (version 26.0; IBM, Armonk, NY, USA). We used the chi-squared test to compare proportions of variables (including sex, side injured, plate-related pain, delayed union, contracture, and infection). The mean values of continuous variables (including age at time of surgery, time from injury to surgery, time to implant removal, modified C-C distance ratio, and range of motion) were compared using one-way analysis of variance; if significant differences were found, we applied Tukey's *t*-test. We used a paired *t*-test to compare modified C-C distance ratios between the time of surgery and the time of implant removal in each group. For the testing of all hypotheses, a two-sided α-threshold of 0.05 was considered statistically significant.

Results

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 and significantly greater than that for the type IIA group ($P = .035$). The preoperative modified C-C distance ratio was greater in the type IIB group than in the type IIA 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, four (11.4%) in the type IIB group, and two (16.7%) in the type V group; however, the pain resolved after removal of the plate in all these cases. Delayed bone union at 1 year 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.

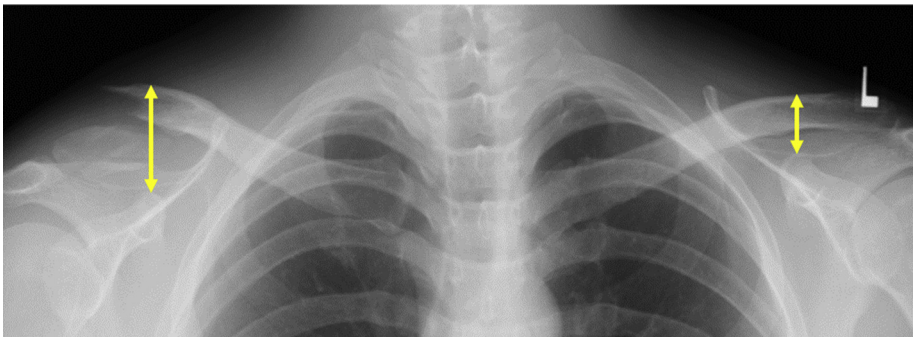

Figure 3 Measurement of the modified coracoclavicular (C-C) distance at the time of injury. The modified C-C distance is measured as the perpendicular distance between the top of the coracoid process and the upper border of the clavicle (*arrow lines*).

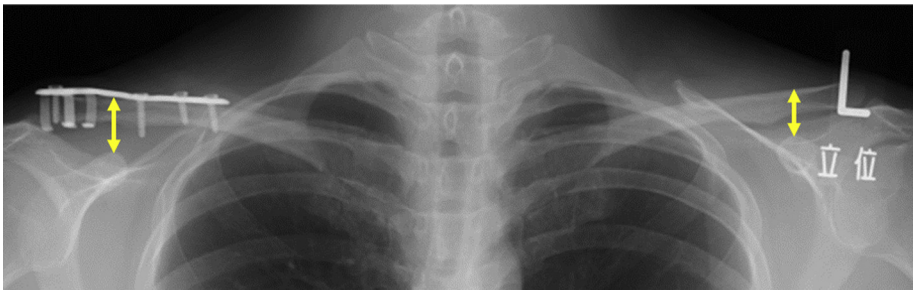

Figure 4 Measurement of the modified coracoclavicular (C-C) distance at the time of plate removal. The modified C-C distance is measured as the perpendicular distance between the top of the coracoid process and the upper border of the clavicle (*arrow lines*).

Table II
Comparison of modified coracoclavicular distance ratio (Neer type IIA vs. IIB vs. V).

	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
Comparison of postoperative complication rates (Neer type IIA vs. IIB vs. V).

	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

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 al[16] 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

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.[30,29] Previous studies comparing the clinical outcomes as per the Neer classification found no significant difference in the functional outcomes for shoulders or the complication rates between type IIA and IIB fractures[16,29] or in the frequency of complications between type II and V fractures.[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.[8,27,33,34] While it had been reported that the addition of C-C ligament augmentation provided better functional outcomes,[8,33] 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 clavicle fracture[1,5,7,14,15] and coracoid process fracture[3,17,35] 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 strength 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 factures 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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References

1. Ball SV, Sankey A, Cobiella C. Clavicle fracture following TightRope fixation of acromioclavicular dislocation. Inj Extra 2007;38:430-2. https://doi.org/10.1016/j.injury.2007.02.036.
2. Banerjee R, Waterman B, Padalecki J, Robertson W. Management of distal clavicle fractures. J Am Acad Orthop Surg 2011;19:392-401. https://doi.org/10.5435/00124635-201107000-00002.
3. Bindra J, VanDenBogaerde J, Hunter JC. Coracoid fracture with recurrent AC joint separation after Tightrope repair of AC joint dislocation. Radiol Case Rep 2015;6:624. https://doi.org/10.2484/rcr.v6i4.624.
4. Chen MJ, DeBaun MR, Salazar BP, Lai C, Bishop JA, Gardner MJ. Hook versus locking plate fixation for Neer type-II and type-V distal clavicle fractures: a retrospective cohort study. Eur J Orthop Surg Traumatol 2020;30:1027-31. https://doi.org/10.1007/s00590-020-02658-7.
5. Cho CH, Kim BS, Kwon DH. Importance of additional temporary pin fixation combined coracoclavicular augmentation using a suture button device for acute acromioclavicular joint dislocation. Arch Orthop Trauma Surg 2016;136:763-70. https://doi.org/10.1007/s00402-016-2437-5.
6. Debski RE, Parsons IM 3rd, Fenwick J, Vangura A. Ligament mechanics during three degree-of-freedom motion at the acromioclavicular joint. Ann Biomed Eng 2000;28:612-8.
7. Dunn JC, Waterman BR. Successful nonoperative management of coracoid fracture associated with suture-button fixation of acromioclavicular separation. Mil Med 2015;180:e138-41. https://doi.org/10.7205/MILMED-D-14-00232.
8. Fan J, Zhang Y, Huang Q, Jiang X, He L. Comparison of treatment of acute unstable distal clavicle fractures using anatomical locking plates with versus without additional suture anchor fixation. Med Sci Monit 2017;23:5455-61. https://doi.org/10.12659/msm.903440.
9. Fleming MA, Dachs R, Maqungo S, du Plessis JP, Vrettos BC, Roche SJL. Angular stable fixation of displaced distal-third clavicle fractures with superior precontoured locking plates. J Shoulder Elbow Surg 2015;24:700-4. https://doi.org/10.1016/j.jse.2014.09.024.
10. Fukuda K, Craig EV, An KN, Cofield RH, Chao EY. Biomechanical study of the ligamentous system of the acromioclavicular joint. J Bone Joint Surg Am 1986;68:434-40.
11. Furuhata R, Takahashi M, Hayashi T, Inagawa M, Kono A, Matsumura N, et al. Treatment of distal clavicle fractures using a Scorpion plate and influence of timing on surgical outcomes: a retrospective cohort study of 105 cases. BMC Musculoskelet Disord 2020;21:146. https://doi.org/10.1186/s12891-020-3169-9.
12. Hessmann M, Kirchner R, Baumgaertel F, Gehling H, Gotzen L. Treatment of unstable distal clavicular fractures with and without lesions of the acromioclavicular joint. Injury 1996;27:47-52.
13. Ibrahim S, Meleppuram JJ. Retrospective study of superior anterior plate as a treatment for unstable (Neer type 2) distal clavicle fractures. Rev Bras Ortop 2017;53:306-13. https://doi.org/10.1016/j.rboe.2017.05.010.
14. Inoue D, Furuhata R, Kaneda K, Ritsuno Y, Kono A, Kiyota Y, et al. Clavicle fracture at the suture hole after acromioclavicular joint reconstruction using a suture-button: a case report. BMC Musculoskelet Disord 2019;20:333. https://doi.org/10.1186/s12891-019-2720-z.
15. Kany J, Amaravathi RS, Guinand R, Valenti P. Arthroscopic acromioclavicular joint reconstruction using a synthetic ligament device. Eur J Orthop Surg Traumatol 2012;22:357-64. https://doi.org/10.1007/s00590-011-0856-0.
16. Lee W, Choi CH, Choi YR, Lim KH, Chun YM. Clavicle hook plate fixation for distal-third clavicle fracture (Neer type II): comparison of clinical and radiologic outcomes between Neer types IIA and IIB. J Shoulder Elbow Surg 2017;26:1210-5. https://doi.org/10.1016/j.jse.2016.11.046.
17. Martetschläger F, Horan MP, Warth RJ, Millett PJ. Complications after anatomic fixation and reconstruction of the coracoclavicular ligaments. Am J Sports Med 2013;41:2896-903. https://doi.org/10.1177/0363546513502459.
18. Martetschläger F, Kraus TM, Schiele CS, Sandmann G, Siebenlist S, Braun KF, et al. Treatment for unstable distal clavicle fractures (Neer 2) with locking T-plate and additional PDS cerclage. Knee Surg Sports Traumatol Arthrosc 2013;21:1189-94. https://doi.org/10.1007/s00167-012-2089-0.
19. Neer CS. Fractures and dislocations of the shoulder. In: Rockwood Jr CA, Green DP, editors. Fractures in adults. Philadelphia: Lippincott; 1984. p. 711-2.
20. Neer CS 2nd. Fractures of the distal third of the clavicle. Clin Orthop Relat Res 1968;58:43-50.

21. Neer CS 2nd. Fracture of the distal clavicle with detachment of the coracoclavicular ligaments in adults. J Trauma 1963;3:99-110.
22. Nordqvist A, Petersson C, Redlund-Johnell I. The natural course of lateral clavicle fracture. 15 (11-21) year follow-up of 110 cases. Acta Orthop Scand 1993;64:87-91.
23. Oki S, Matsumura N, Iwamoto W, Ikegami H, Kiriyama Y, Nakamura Y, et al. The function of the acromioclavicular and coracoclavicular ligaments in shoulder motion: a whole-cadaver study. Am J Sports Med 2012;40:2617-26. https://doi.org/10.1177/0363546512458571.
24. Page RS, Bhatia DN. Noncomminuted lateral end clavicle fractures associated with coracoclavicular ligament disruption: technical considerations for optimal anatomic fixation and stability. Int J Shoulder Surg 2014;8:86-9. https://doi.org/10.4103/0973-6042.140116.
25. Robinson CM, Court-Brown CM, McQueen MM, Wakefield AE. Estimating the risk of nonunion following nonoperative treatment of a clavicular fracture. J Bone Joint Surg Am 2004;86:1359-65. https://doi.org/10.2106/00004623-200407000-00002.
26. Rokito AS, Zuckerman JD, Shaari JM, Eisenberg DP, Cuomo F, Gallagher MA. A comparison of nonoperative and operative treatment of type II distal clavicle fractures. Bull Hosp Jt Dis 2002-2003;61:32-9.
27. Salazar BP, Chen MJ, Bishop JA, Gardner MJ. Outcomes after locking plate fixation of distal clavicle fractures with and without coracoclavicular ligament augmentation. Eur J Orthop Surg Traumatol 2021;31:473-9. https://doi.org/10.1007/s00590-020-02797-x.
28. Seo J, Heo K, Kim SJ, Kim JK, Ham HJ, Yoo J. Comparison of a novel hybrid hook locking plate fixation method with the conventional AO hook plate fixation method for Neer type V distal clavicle fractures. Orthop Traumatol Surg Res 2020;106:67-75. https://doi.org/10.1016/j.otsr.2019.10.014.
29. Shin SJ, Ko YW, Lee J, Park MG. Use of plate fixation without coracoclavicular ligament augmentation for unstable distal clavicle fractures. J Shoulder Elbow Surg 2016;25:942-8. https://doi.org/10.1016/j.jse.2015.10.016.
30. Shin SJ, Roh KJ, Kim JO, Sohn HS. Treatment of unstable distal clavicle fractures using two suture anchors and suture tension bands. Injury 2009;40:1308-12. https://doi.org/10.1016/j.injury.2009.03.013.
31. Singh A, Schultzel M, Fleming JF, Navarro RA. Complications after surgical treatment of distal clavicle fractures. Orthop Traumatol Surg Res 2019;105:853-9. https://doi.org/10.1016/j.otsr.2019.03.012.
32. Theodorides AA, Watkins CEL, Venkateswaran WB. Brachial plexus injury following the use of LARS suture passer during an open Weaver-Dunn procedure. J Shoulder Elbow Surg 2013;22:e1-5. https://doi.org/10.1016/j.jse.2013.01.009.
33. Xu H, Chen WJ, Zhi XC, Chen SC. Comparison of the efficacy of a distal clavicular locking plate with and without a suture anchor in the treatment of Neer IIb distal clavicle fractures. BMC Musculoskelet Disord 2019;20:503. https://doi.org/10.1186/s12891-019-2892-6.
34. Zhang C, Huang J, Luo Y, Sun H. Comparison of the efficacy of a distal clavicular locking plate versus a clavicular hook plate in the treatment of unstable distal clavicle fractures and a systematic literature review. Int Orthop 2014;38:1461-8. https://doi.org/10.1007/s00264-014-2340-z.
35. Zheng YR, Lu YC, Liu CT. Treatment of unstable distal-third clavicule fractures using minimal invasive closed-loop double endobutton technique. J Orthop Surg Res 2019;14:37. https://doi.org/10.1186/s13018-019-1073-5.