Hook plate fixation with versus without coracoclavicular reconstruction for distal clavicular fractures

Shuang Wu\(^1\ddagger\), Jialei Chen\(^1\ddagger\), Jie Zhang\(^2\), Sujan Shakya\(^1\ddagger\), Fei Xing\(^1\), Jiachen Sun\(^1\) and Zhou Xiang\(^1\)

Abstract

**Purpose**: Hook plate fixation is one of the most frequently used methods for unstable distal clavicular fractures, but it is still unknown if there is a need for coracoclavicular (CC) reconstruction. This study aimed to compare the efficacy of hook plate fixation with versus without CC reconstruction for distal clavicular fractures.

**Methods**: Eighty-one patients who underwent hook plate fixation (HP group, \(n = 45\)) or hook plate fixation plus suture anchor reconstruction (HPA group, \(n = 36\)) for Neer type II or V clavicular fractures were enrolled. Demographics, fracture characteristics, and surgical data were recorded. Union time, coracoclavicular distance (CCD), post-operative complications, Constant score, and Disabilities of the Arm, Shoulder, and Hand (DASH) score were compared between HPA and HP groups.

**Results**: Constant score in the HPA group was higher than that in the HP group (91.8 ± 3.6 vs 88.8 ± 6.0, \(P = 0.007\)). However, there were no significant differences in union time, DASH score, CCD, and post-operative complications between the two groups (\(P > 0.05\)). Hook plate fixation combined with CC reconstruction costed more (3023.7 ± 202.6 vs 2416.2 ± 167.6 EUR, \(P < 0.001\)) and prolonged operative duration (78.2 ± 9.2 vs 73.7 ± 8.3 min, \(P = 0.023\)) compared with hook plate fixation alone.

**Conclusion**: Hook plate fixation with or without suture anchor reconstruction achieved satisfactory outcomes for Neer type II or V clavicular fractures. However, hook plate fixation plus CC reconstruction showed better functional outcomes compared with hook plate fixation alone.

**Keywords**
distal clavicular fractures, hook plate, coracoclavicular reconstruction, suture anchor

Date received: 11 November 2021; Received revised 23 January 2021; accepted: 3 March 2021

Introduction

Clavicular fractures are common injuries of the shoulder girdle with an incidence of 30 per 100,000.\(^1\) The rate of occurrence of distal clavicular fractures is 10%–30% in all clavicular fractures.\(^2\) Neer types II and V clavicular fractures are displaced and unstable because of the detachment of coracoclavicular (CC) ligaments. It is difficult to achieve rigid internal fixation because distal fragments are usually...
small and comminuted. The nonunion rate of conservative treatment is as high as 22%–50%, so surgical treatment is currently recommended. Although there are many operational methods including internal fixation using hook plates, locking plates, Kirschner wires, tension band wires, and CC reconstruction, there is no gold standard of treatment.

Hook plate fixation is considered one of the popular internal fixation methods for distal clavicular fractures. Previous studies demonstrated that hook plate fixation could achieve good outcomes. However, hook plate fixation often causes many complications including subacromial impingement syndrome, acromial fractures, ligament injury, and implant-related irritation. In addition, implant removal is needed to prevent above-mentioned complications.

CC reconstruction can maintain CC distance, facilitate the healing of CC ligaments, and enhance the vertical stability of distal clavicular fractures. CC fixation can be accomplished with CC screws, endo-button devices, tight ropes, suture anchors, suspensory sutures, ligament transfer, and so on. However, for comminuted distal clavicular fractures, it is difficult to achieve stable fixation with CC reconstruction alone.

Biomechanical studies showed that the combination of plate-and-screw fixation and CC reconstruction achieved greater stability of unstable distal clavicular fractures than plate-and-screw fixation alone, suggesting the combined treatment could theoretically improve CC stability and allow early mobilization. Several studies demonstrated hook plate fixation with or without CC reconstruction achieved satisfactory clinical outcomes, and hook plate fixation plus CC reconstruction reduced complication rates for patients with acute acromioclavicular joint (ACJ) dislocations. In addition, a case series showed hook plate fixation plus suture anchor reconstruction yielded good functional outcomes with low complication rates for patients with Neer types II and V distal clavicular fractures. It seemed that the above-mentioned studies supported the combined treatment. However, to our knowledge, there are no published studies comparing hook plate fixation with CC reconstruction and hook plate fixation alone in the treatment of distal clavicle fractures.

This study aimed to investigate the role of CC reconstruction in patients who underwent hook plate fixation for Neer types II and V distal clavicular fractures before January 2011 and May 2021. Inclusion criteria were: (1) Neer type II or V clavicular fractures, (2) fresh fractures within 3 weeks, (3) hook plate fixation with or without suture anchor reconstruction, (4) normal shoulder function before fractures, and (5) at least 1 year of follow-up. Sixteen patients were excluded for the following reasons: a history of shoulder injury (3 patients), less than 1 year of follow-up (4 patients), loss of follow-up (6 patients), and refusal to participate in the study (3 patients). Finally, this study included 36 patients who underwent hook plate fixation plus suture anchor reconstruction (HPA group) and 45 patients who underwent hook plate fixation alone (HP group).

![Figure 1](chart.jpg) shows the flow chart of this study.

Demographic parameters included age, sex, body mass index, injury severity score, fracture side, injury type, fracture pattern, time to surgery, and follow-up time. Operation-related indices included intraoperative blood loss, surgical time, operation-related cost, and hospitalization time. For clinical outcomes, we analyzed fracture healing rate, fracture union patterns, time to surgery, and follow-up time. For radiographical outcomes, we measured the coracoclavicular distance (CCD) of the injured side at the last follow-up.

**Surgical technique**

All the operations were performed by six senior orthopedic surgeons with more than 10 years’ experience. Patients underwent open reduction and internal fixation (ORIF) under general anesthesia in the supine position. A 10-cm skin incision was made parallel to the clavicle, and then the deltoid-trapezius fascia was incised. The fracture was temporarily reduced using reposition forceps. The hook of the hook plate (DePuy Synthes, Raron, Switzerland) was inserted under the acromion, and fixed with locking screws after confirming the reduction of fractures via C-arm fluoroscopy. Whether we performed CC reconstruction or not was dependent on the surgeons’ preferences and personal experience. In HPA group, patients received hook plate fixation and CC reconstruction. CC ligaments were explored and identified. Then, a suture anchor (3.5-mm titanium anchor with two sutures, Smith & Nehpew, Andover, MA, USA) was fixed in the base of the coracoid process. The sutures were tied around the clavicle and the hook plate. In HP group, patients received hook plate fixation alone.

**Post-operative rehabilitation**

Patients were encouraged to wear sling protection for 4 weeks post-operatively. Slight pendulum movement, circumduction exercise, and passive range of motion...
exercise were encouraged from the first day after surgery. The shoulder abduction angle should be <90°. One month later, the intensity of physical exercise was gradually increased. About 3 months later, the patients began to engage in normal activities. The hook plates were removed when bone union and joint functional recovery were achieved.

Statistical analysis

Statistical analyses were conducted using SPSS 21.0 (IBM Corp, NY, USA). Between-group differences were compared using independent t-test, independent Mann–Whitney U test, and Pearson chi-square test. Statistical significance was defined as P < 0.05.

Results

The baseline data are shown in Table 1. The mean follow-up time was 4.4 ± 3.0 years. There were no significant differences in baseline characteristics between HP and HPA groups (P > 0.05).

Study outcomes are shown in Table 2. Mean time to implant removal was 11.6 ± 2.0 months. Operation time in HPA group was longer than that in HP group (78.2 ± 9.2 vs 73.7 ± 8.3 min, P = 0.023). There was significant difference in operation expense between HPA and HP groups (3023.7 ± 202.6 vs 2416.2 ± 167.6 EUR, P < 0.001). No significant differences were found in blood loss, hospitalization time, and time to implant removal (P > 0.05).

Constant score in HPA group was significantly higher than that in HP group (91.8 ± 3.6 vs 88.8 ± 6.0, P = 0.007), while the two groups showed no difference in DASH score (2.6 ± 2.3 vs 4.4 ± 7.6, P = 0.672). Fracture union time did not significantly differ between the two groups (P > 0.05). HPA group had a shorter CCD than HP group while no significant difference was found (9.7 ± 2.1 vs 10.5 ± 2.1 mm, P = 0.087). Figure 2 shows radiological results of typical cases.
The HPA group had fewer complications than the HP group while the difference was not significant (17% vs 29%, P = 0.197). All patients in HPA group achieved radiographic union. One patient in HP group suffered nonunion, and then achieved fracture healing after a reoperation. Five cases in HPA group and nine cases in HP group suffered implant-related discomfort, and the symptom improved after implant removal. One patient had subacromial osteolysis in HPA group, while three had subacromial osteolysis in HP group.

**Discussion**

This is the first study to compare the clinical and radiographical outcomes between hook plate fixation plus CC reconstruction and hook plate fixation alone for unstable distal clavicle fractures. Both methods achieved satisfactory outcomes at the last follow-up, whereas the combined treatment provided significantly higher Constant score than hook plate alone despite similar DASH score. HPA group showed less union time, shorter CCD, and a lower...
complication rate compared with HP group, while the between-group differences were not significantly different. However, the combined method costed more and prolonged operative duration compared with hook plate fixation only.

The CC ligament connects the acromial extremity of the clavicle and the coracoid process of the scapula, and maintains the vertical stability of the acromioclavicular joint. In Neer type II or V distal clavicular fractures, distal fragments can be displaced caudally by the deadweight of the upper extremity, the pectoralis muscles, and the latissimus dorsi.17 Contrarily, the proximal fragments can be pulled superiorly by the trapezius and sternocleidomastoid muscles.17,18 As a result, Neer type II or V distal clavicular fractures are unstable and displaced, and are associated with high nonunion rates. Previous studies showed surgical treatment reduced the complication rates of distal clavicle fractures.19,20 A multi-center, prospective, randomized controlled trial demonstrated surgical treatment provided more satisfactory outcomes for displaced distal clavicular fractures than non-operative treatment within 6 months after operation.21 Therefore, ORIF such as hook plate fixation, locking plate fixation, K-wires, and CC reconstruction has been commonly used to treat distal clavicular fractures.22

Hook plate fixation is an easy and reliable technique for unstable distal clavicular fractures. With the leverage spread across the ACJ, the hook of the hook plate can reduce the stress on the fracture site and help maintain fracture reduction.23 The hook plate can recreate the biomechanics of the ACJ and firmly fix the small fragments of distal clavicular fractures.11 However, the subacromial hook frequently involves the subacromial joint and often causes some complications including acromion osteolysis, shoulder impingement, and rotator cuff injuries.24 An autopsy study found the hook tail significantly reduced the subacromial space, and impingement between the humeral head and the lateral hook easily occurred during the movement of the shoulder joint.25

Erdle et al. suggested CC instability might increase the risk of hook plate-specific complications.26 The suture anchor is a kind of miniature internal fixation that is used to connect tendons, ligaments, and bones. It is simple to operate and can effectively reconstruct CC ligaments; thus, it has been considered to treat distal clavicular fractures.27–29 Suture anchor fixation can resist the upward pull at the proximal end of fractures, and enhance the vertical stability of clavicular fracture fragments and hook plates. Therefore, we speculate that suture anchors can lower the risk of implant-related complications by limiting the movement of the subacromial hook and increasing CC stability.

We found no significant difference in CCD between the two groups. These findings were consistent with previous comparative studies comparing the clinical and radiographical outcomes of hook plate fixation with or without CC reconstruction for acute ACJ dislocations (Table 3).14,30 However, Chen et al. reported the combined treatment was better than hook plate fixation alone for the maintenance of reduction.9 In addition, patients with combined fixation suffered less acromion osteolysis than those with hook plates alone, which suggested CC reconstruction helped maintain CCD and reduce implant-related irritation.9,14

In this study, HPA group showed lower incidence of subacromial erosion and implant-related discomfort while there was no statistical difference in the complication rate between the two groups. The incidence of subacromial osteolysis was 6.8%–25%,6,11,18 and the incidence of implant-related irritation was 6.5%–84% after hook plate
Table 3. Comparative studies examining hook plate fixation with or without coracoclavicular reconstruction for acute acromioclavicular dislocations.

| Studies/groups     | Age, year | VAS | Constant score | ASES score | Taft score | CCD | Acromion osteolysis | Distal clavicle osteolysis | ACJ arthritis | Peri-implant fracture | Follow-up time, month | Removal time, month |
|--------------------|-----------|-----|----------------|------------|------------|-----|---------------------|--------------------------|---------------|-----------------------|----------------------|---------------------|
| Chang, 2019¹⁴      |           |     |                |            |            |     |                     |                          |               |                       |                      |                     |
| HP                 | 26 50.0   | 1.5 | N/A            | 87.7       | 31.6       | N/A | 118.9⁴                 | 57.7%⁵                 | N/A           | 30.8%                 | 11.0                 | 6.7                 |
| HP + mersilene suture | 21 44.0  | 1.1 | N/A            | 92.1       | 33.5       | N/A | 118.9⁴                 | 23.8%⁶                 | N/A           | 14.3%                 | 9.5                  | 6.2                 |
| Liu, 2020¹⁵        |           |     |                |            |            |     |                     |                          |               |                       |                      |                     |
| HP                 | 112 46.0  | 1.9 | 89.5           | N/A        | N/A        | N/A | 58.0%                | N/A                     | N/A           | 7%                    | N/A                  | 3.4                 |
| HP + nylon tape    | 105 50.0  | 1.8 | 91.5           | N/A        | N/A        | N/A | 24.0%***              | N/A                     | N/A           | 1%                    | N/A                  | 3.4                 |
| Seo, 2020³⁰        |           |     |                |            |            |     |                     |                          |               |                       |                      |                     |
| HP                 | 47 44.6   | 1.9 | 84.0           | 87.9       | N/A        | N/A | 126.3⁷                 | 40.4%                | N/A           | 25.5%                 | 18.7                 | 4.2                 |
| HP + suture        | 73 46.9   | 1.8 | 83.8           | 89.2       | N/A        | N/A | 112.6⁸*              | 43.8%                | N/A           | 21.9%                 | 18.1                 | 4.0                 |
| Chen, 2021⁹        |           |     |                |            |            |     |                     |                          |               |                       |                      |                     |
| HP                 | 19 44.5   | 1.2 | 94.5           | N/A        | 34.3       | 10.2 | 100.8⁹*               | 52.6%                 | N/A           | 10.5%                 | 38.5                 | 5.3                 |
| HP + mersilene suture | 19 46.4  | 1.2 | 93.9           | N/A        | 32.8       | 10.6 | 91.5¹⁰**             | 15.8%*                | N/A           | 5.3%                  | 32.7                 | 5.7                 |

VAS, visual analog scale; ASES, the American Shoulder and Elbow Surgeons; UCLA, the University of California at Los Angeles; CCD, coracoclavicular distance; ACJ, acromioclavicular joint; HP, hook plate; N/A, not applicable

¹The height in percentage compared to the contralateral shoulder between the upper border of the coracoid process and the inferior cortex of the clavicle.
²Severe subacromial osteolysis (depression >2 mm or cut-out of acromion).
³Relative coracoclavicular distance was defined as the ratio of the absolute coracoclavicular distance to the absolute acromiocoracoid distance.
⁴P < 0.05; ⁵P < 0.001 (compared with hook plate alone).
Table 4. Comparative studies examining internal fixation with or without coracoclavicular reconstruction for unstable distal clavicle fractures.

| Studies/groups       | N   | Age, year | Fracture type | Fracture union | Union time, week | DASH score | Constant score | CCD, mm | Complications (%) | Follow-up time, month |
|----------------------|-----|-----------|---------------|----------------|------------------|------------|----------------|---------|------------------|-----------------------|
| Seyhan, 2015<sup>22</sup> |     |           |               |                |                  |            |                |         |                  |                       |
| Tension band + K-wire| 10  | 34.2      | Neer II       | 100%           | 17.3             | N/A        | 95.0           | N/A     | 50.0             | 32.4                  |
| LP + CC screw       | 12  | 36.0      | Neer II       | 100%           | 14.0             | N/A        | 95.3           | N/A     | 25.0             | N/A                   |
| LP + endo-button    | 14  | 37.6      | Neer II       | 100%           | 10.6             | N/A        | 99.1<sup>**</sup> | N/A     | 21.4             | N/A                   |
| Fan, 2017<sup>28</sup> |     |           |               |                |                  |            |                |         |                  |                       |
| LP                   | 10  | 40.2      | Neer II       | 100%           | 10.3             | 4.1        | 83.1           | 11.7    | 10.0             | 21.8                  |
| LP + suture anchor  | 18  | 36.9      | Neer II       | 100%           | 9.6              | 2.8        | 91.7<sup>**</sup> | 8.9     | 11.1             | 18.4                  |
| Tang, 2018<sup>29</sup> |     |           |               |                |                  |            |                |         |                  |                       |
| LP                   | 22  | 45.4      | Neer IIb      | 100%           | N/A              | N/A        | 91.7           | 26.0<sup>a</sup> | 4.5              | 16.3                  |
| LP + suture anchor  | 18  | 43.4      | Neer IIb      | 100%           | N/A              | N/A        | 93.1<sup>*</sup> | 12.7<sup>a</sup> | 5.6              | N/A                   |
| Xu, 2019<sup>32</sup> |     |           |               |                |                  |            |                |         |                  |                       |
| LP                   | 16  | 50.7      | Neer IIb      | 100%           | 16.1             | 4.1        | 90.1           | N/A     | 31.2             | 16.0                  |
| LP + suture anchor  | 18  | 45.5      | Neer IIb      | 100%           | 13.9             | N/A        | 94.6<sup>a</sup> | N/A     | 16.7             | 17.5                  |
| Salazar, 2020<sup>33</sup> |     |           |               |                |                  |            |                |         |                  |                       |
| LP                   | 16  | 42.0      | Neer II, V    | 100%           | N/A              | 4.1        | N/A            | N/A     | 31.3             | 31.2                  |
| LP + suspensory suture | 7  | 45.0      | Neer II, V    | 100%           | N/A              | 4.5        | N/A            | N/A     | 42.9             | 42.9                  |
| Deey Hazra, 2021<sup>34</sup> |     |           |               |                |                  |            |                |         |                  |                       |
| LP                   | 14  | 43.2      | Neer IIb      | 100%           | N/A              | N/A        | 91.8           | 9.8     | N/A              | 28.8                  |
| LP + double-button  | 17  | 43.1      | Neer IIb      | 100%           | N/A              | N/A        | 95.2           | 11.9    | N/A              | 17.8                  |
| Current study       |     |           |               |                |                  |            |                |         |                  |                       |
| HP                   | 45  | 40.3      | Neer IIb, V   | 98%            | 13.7             | 4.4        | 88.8           | 10.5    | 28.9             | 55.2                  |
| HP + suture anchor  | 36  | 43.8      | Neer IIb, V   | 100%           | 12.2             | 2.6        | 91.8<sup>**</sup> | 9.7     | 16.7             | 50.4                  |

DASH, Disabilities of the Arm, Shoulder, and Hand; CCD, coracoclavicular distance; N/A, not applicable; LP, locking plate; CC, coracoclavicular; HP, hook plate.

<sup>a</sup>Percentage deviation of coracoclavicular distance of injured side compared to healthy side.

<sup>*</sup>P < 0.05, <sup>**</sup>P < 0.01 (significant between-group differences).
fixation among patients with distal clavicular fractures. Some studies demonstrated that the combined treatment of hook plates and CC reconstruction offered good outcomes and reduced the complication rate of hook plate fixation in the treatment of acute ACJ dislocations. The incidence of subacromial osteolysis was 40.4%–58.0% after hook plate fixation alone, and was 15.8%–43.8% after combined fixation (Table 3). Seo et al. found that the direct repair of CC ligaments could help maintain reduction of the CC joint, suggesting that CC reconstruction might reduce the stress on the acromion.

Some studies showed promising outcomes of locking plate fixation with CC reconstruction for distal clavicular fractures (Table 4). A previous study demonstrated satisfactory outcomes in 16 patients who underwent hook plate fixation and CC reconstruction. However, in the present study, patients with combined treatment had better Constant score than those with hook plate fixation alone at the last follow-up. CC reconstruction could increase the stability of the CC joint, and help achieve better short-term functional outcomes during the early post-operative period. Liu and Yang found the patients of Rockwood type V ACJ separation who underwent hook plate fixation and CC reconstruction had higher Constant score and lower Visual Analog Scale score than those who received hook plate fixation alone before implant removal. Similarly, Chang et al. found the combined treatment showed less pain and better functional outcomes within 6 months after operation. It is therefore suggested that additional CC reconstruction allowed patients to do more physical exercise and improve early functional outcomes.

This study had a few limitations. First, CC reconstruction increased trauma, cost more, prolonged operative time, and caused some complications including loss of reduction, coracoid fractures, and brachial plexus injuries. Second, this was a single-center retrospective control study with a small sample size. Third, short-term results were not available as we did not evaluate functional and radiographical outcomes within one year after operation.

Conclusions
Hook plate fixation with or without CC reconstruction provided satisfactory outcomes for Neer type II or V distal clavicular fractures. However, hook plate fixation with suture anchor reconstruction had better functional outcomes than hook plate fixation alone.

Acknowledgements
Not applicable.

Authors’ contributions
All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Shuang Wu, Jialei Chen, Jie Zhang, and Sujan Shakya. The first draft of the manuscript was written by Shuang Wu and Jialei Chen. Zhou Xiang, Fei Xing, and Jiachen Sun critically revised the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. The study was supervised by Zhou Xiang.

Authorship declaration
All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors. All authors are in agreement with the manuscript.

Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Our study was funded by National Natural Science Foundation of China (Grant number 31870961), Science & Technology Department of Sichuan Province (Grant number 2020YFS0140), and Clinical Research Incubation project of West China Hospital of Sichuan University (Grant number 2019HXXFH041).

Ethics approval
This retrospective study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of West China Hospital of Sichuan University approved this study.

Informed consent
Informed consent was obtained from all individual participants included in the study.

Data, materials and/or code availability
The original data of this study are available from the corresponding author for reasonable request.

ORCID iDs
Shuang Wu https://orcid.org/0000-0002-9029-1379
Sujan Shakya https://orcid.org/0000-0002-0243-0843

References
1. Frima H, van Heijl M, Michelitsch C, et al. Clavicle fractures in adults; current concepts. Eur J Trauma Emerg Surg 2020; 46: 519–529. DOI: 10.1007/s00068-019-01122-4.
2. Ockert B, Wiedemann E and Haasters F. Laterale Klaviku- 
lafraktur. Der Unfallchirurg 2015; 118: 397–406. DOI: 10. 
1007/s00131-015-0003-1.

3. Lee KW, Lee SK, Kim KJ, et al. Arthroscopic-assisted 
locking compression plate clavicular hook fixation for un-
stable fractures of the lateral end of the clavicle: a pro-
spective study. Int Orthop 2010; 34: 839–845. DOI: 10.1007/
s00264-009-0925-8.

4. Ochen Y, Frima H, Houwert RM, et al. Surgical treatment of 
Neer type II and type V lateral clavicular fractures: com-
parison of hook plate versus superior plate with lateral ex-
tension: a retrospective cohort study. Eur J Orthop Surg 
Traumatol 2019; 29: 989–997. DOI: 10.1007/s00590-019-
02411-9.

5. Moverley R, Little N, Gulihar A, et al. Current concepts in the 
management of clavicle fractures. J Clin Orthop Trauma 
2020; 11: S25–S30. DOI: 10.1016/j.jcot.2019.07.016.

6. Zhang C, Huang J, Luo Y, et al. Comparison of the ef-
cacy of a distal clavicular locking plate versus a clavicular hook plate 
for treatment of unstable distal clavicle fractures. Acta Orthop Trauma 
2021; 22: 127. DOI: 10.1186/s12891-020-03726-z.

7. Han C, Wu K, Jhan S-W, et al. Is coracoclavicular re-
xtraction necessary in hook plate fixation for acute un-
stable acromioclavicular dislocation?. BMC Musculoskelet 
Disord 2021; 22: 224–230. DOI: 10.1016/j.jsel.2017.08.017.

8. Seo J, Heo K, Kim S-J, et al. 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. 
DOI: 10.1016/j.otsr.2019.10.014.

9. Liu C-T and Yang T-F. Hook plate with or without cor-
acoclavicular ligament augmentation in the treatment of acute 
acromioclavicular separation. BMC Musculoskelet 
Disord 2020; 21: 701. DOI: 10.1186/s12891-020-03726-z.

10. Wu S, Chen J, Zhang J, et al. Clavicular hook plate with 
coracoclavicular ligament augmentation by suture anchor in 
treatment of unstable distal clavicle fractures. Chin J 
Repar Reconstr Surg 2021; 35: 978–983. DOI: 10.7507/
1002-1892.202101094.

11. Yagnik GP, Jordan CJ, Narvel RR, et al. Distal clavicle 
fracture repair: clinical outcomes of a surgical technique 
utilizing a combination of cortical button fixation and cor-
acoclavicular ligament reconstruction. Orthop J Sports Med 
2019; 7: 232596711986792. DOI: 10.1177/
2325967119867920.

12. Renger RJ, Roukema GR, Reurings JC, et al. The clavicle 
hook plate for Neer type II lateral clavicle fractures. J Orthop 
Trauma 2009; 23: 570–574. DOI: 10.1097/BOT.
0b013e318193d878.

13. Hall JA, Schenmitsh CE, Vicente MR, et al. Operative Versus 
Nonoperative Treatment Of Acute Displaced Distal Clavicle 
Fractures: A Multicenter Randomized Controlled Trial. 
J Orthop Trauma 2021; 35: 660–666. DOI: 10.1097/bot.
0000000000002211.

14. Oh JH, Kim SH, Lee JH, et al. Treatment of distal clavicle 
fracture: a systematic review of treatment modalities in 425 
fractures. Arch Orthop Trauma Surg 2011; 131: 525–533. 
DOI: 10.1007/s00402-010-1196-y.

15. Rokito AS, Zuckerman JD, Shaari JM, et al. A comparison of 
nonoperative and operative treatment of type II distal clavicle 
fractures. Bull Hosp Jt Dis 2002; 61: 32–39.

16. Boonard M, Sumanont S, Arirachakaran A, et al. Fixation 
method for treatment of unstable distal clavicle fracture: 
systematic review and network meta-analysis. Eur J Orthop 
Traumatol 2018; 28: 1065–1078. DOI: 10.1007/s00590-
018-2187-x.

17. Chen MJ, DeBaun MR, Salazar BP, et al. Hook versus locking 
plate fixation for Neer type-II and type-V distal clavicle 
fractures: a retrospective cohort study. Eur J Orthop 
Traumatol 2020; 30: 1027–1031. DOI: 10.1007/s00590-020-
02658-7.

18. Stegeman SA, Naac H, Huvenaars KH, et al. Surgical 
treatment of Neer type-II fractures of the distal clavicle. Acta 
Orthop 2013; 84: 184–190. DOI: 10.3109/17453674.2013.
786637.

19. Deng Z, Cai L, Ping A, et al. Anatomical research on the 
subacromial interval following implantation of clavicle hook 
plates. Int J Sports Med 2014; 35: 857–862. DOI: 10.1055/s-
0034-1367050.
IIB lateral clavicle fractures. *Arch Orthop Trauma Surg* 2017; 137: 651–662. DOI: 10.1007/s00402-017-2645-7.

27. Xu H, Chen WJ, Zhi XC, et al. 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. DOI: 10.1186/s12891-019-2892-6.

28. Fan J, Zhang Y, Huang Q, et al. Comparison of treatment of acute unstable distal clavicle fractures using anatomical locking plates with versus without additional suture anchor fixation. *Med Sci Monitor* 2017; 23: 5455–5461. DOI: 10.12659/msm.903440.

29. Tang H, Yin Y, Han Q, et al. [Effectiveness of anatomical locking plate internal fixation combined with coracoclavicular ligament reconstruction for Neer type IIb distal clavicle fractures]. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2018; 32: 1181–1186. DOI: 10.7507/1002-1892.201803127.

30. Seo J-B, Kim S-J, Ham H-J, et al. Comparison between hook plate fixation with and without coracoclavicular ligament suture for acute acromioclavicular joint dislocations. *J Orthop Surg* 2020; 28: 23094990209005. DOI: 10.1177/2309499020905058.

31. Wang H-K, Liang L-S, He R-G, et al. Comparative analysis of locking plates versus hook plates in the treatment of Neer type II distal clavicle fractures. *J Int Med Res* 2020; 48: 030006052091806. DOI: 10.1177/0300060520918060.

32. Seyhan M, Kocaoglu B, Kiyak G, et al. Anatomic locking plate and coracoclavicular stabilization with suture endobutton technique is superior in the treatment of Neer type II distal clavicle fractures. *Eur J Orthop Surg Traumatol* 2015; 25: 827–832. DOI: 10.1007/s00590-015-1617-2.

33. Salazar BP, Chen MJ, Bishop JA, et al. Outcomes after locking plate fixation of distal clavicle fractures with and without coracoclavicular ligament augmentation. *Eur J Orthop Surg Traumatol* 2020; 31: 473–479. DOI: 10.1007/s00590-020-02797-x.

34. Dey Hazra RO, Blach RM, Ellwein A, et al. Additional coracoclavicular augmentation reduces revision rates in the treatment of lateral clavicle fractures as compared to angle-stable plate osteosynthesis alone. *Arch Orthop Trauma Surg* 2021. Epub ahead of print 4 May 2021. DOI: 10.1007/s00402-021-03893-1.