# Results of fixation of comminuted Neer type-V distal clavicle fractures by locked plates and coracoclavicular osseo-ligamentous loop sutures

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**Background**
Distal clavicle fractures are less common than mid-shaft fractures with a higher rate of nonunion if displaced. Different methods for fixation exist and each has its advantages and disadvantages. Fixation with anatomically precontoured locked plate with lateral extension proved satisfactory results with minimal complications.
**Settings and design**
This prospective study was conducted in Banha University Hospital.
**Patients and methods**
Twenty-three patients with Neer type-V distal clavicular fractures were fixed by distal clavicular locked plate with lateral extension and loop suturing of the coracoclavicular (CC) osseo-ligamentous fragment that is small to be fixed with a screw. The outcome was evaluated clinically by the Oxford shoulder score and radiologically for union, residual deformity, and nonunion through a 12–18-month follow-up period.
**Results**
The functional outcome was excellent in 19 cases, good in three, and fair in one. Minor complications were reported in six cases including periclavicular hypoesthesia, superficial wound infection, and post-traumatic rotator cuff tendinitis.
**Conclusion**
The distal clavicle anatomically precontoured the locked plate with lateral extension combined with loop suturing of the small CC osseo-ligamentous fragment that is not amenable for fixation with a screw is an excellent option for fixation of Neer type-V distal clavicle fracture with no need for additional implant to reattach the CC ligaments.

**Keywords:**
clavicle fracture, coracoclavicular injury, locked plate, unstable distal fracture

## Introduction

Distal clavicle fractures account for 10–30% of all clavicular fractures and require special attention because they may be markedly displaced with risk of nonunion if managed conservatively, and they may extend to the acromioclavicular (AC) joint [1,2].

Different classifications exist for those fractures. All have interobserver and intraobserver variability. Neer classification depends on the relation of the fracture to the coracoclavicular (CC) ligaments, the AC joint, and their integrity. In type-V, there is marked displacement of the medial fragment with a bone fragment still attached to the CC ligaments whose fibers are intact. Robinson classified distal clavicle fractures into three types according to the fracture site in relation to the coracoid process center, displacement, and intraarticular extension into the AC joint. Recently, Cho *et al.* [3] classified these fractures according to stability and location in relation to CC ligaments into stable-nondisplaced (type-I) or unstable-displaced (type-II with four subdivisions). Neer type-V fracture is similar to Robinson type-3B1 and Cho's type-IID fractures [1,3,4] (Fig. 1).

Displaced distal clavicle fractures have a 28–44% nonunion rate with nonsurgical treatment, 20–34% of these are symptomatic and will require surgical fixation. The variable methods of surgical fixation include: transacromial K-wires, tension band, endo-button, modified Weaver-Dunn procedure, CC screw, arthroscopically assisted fixation, and different plating options according to the size of the distal fragment and the degree of comminution [1,3,4]. The subacromial hook plate may be suitable when the lateral fracture fragment is very small to allow for placement of screws; however, pain and erosion of the acromion were

**Figure 1**
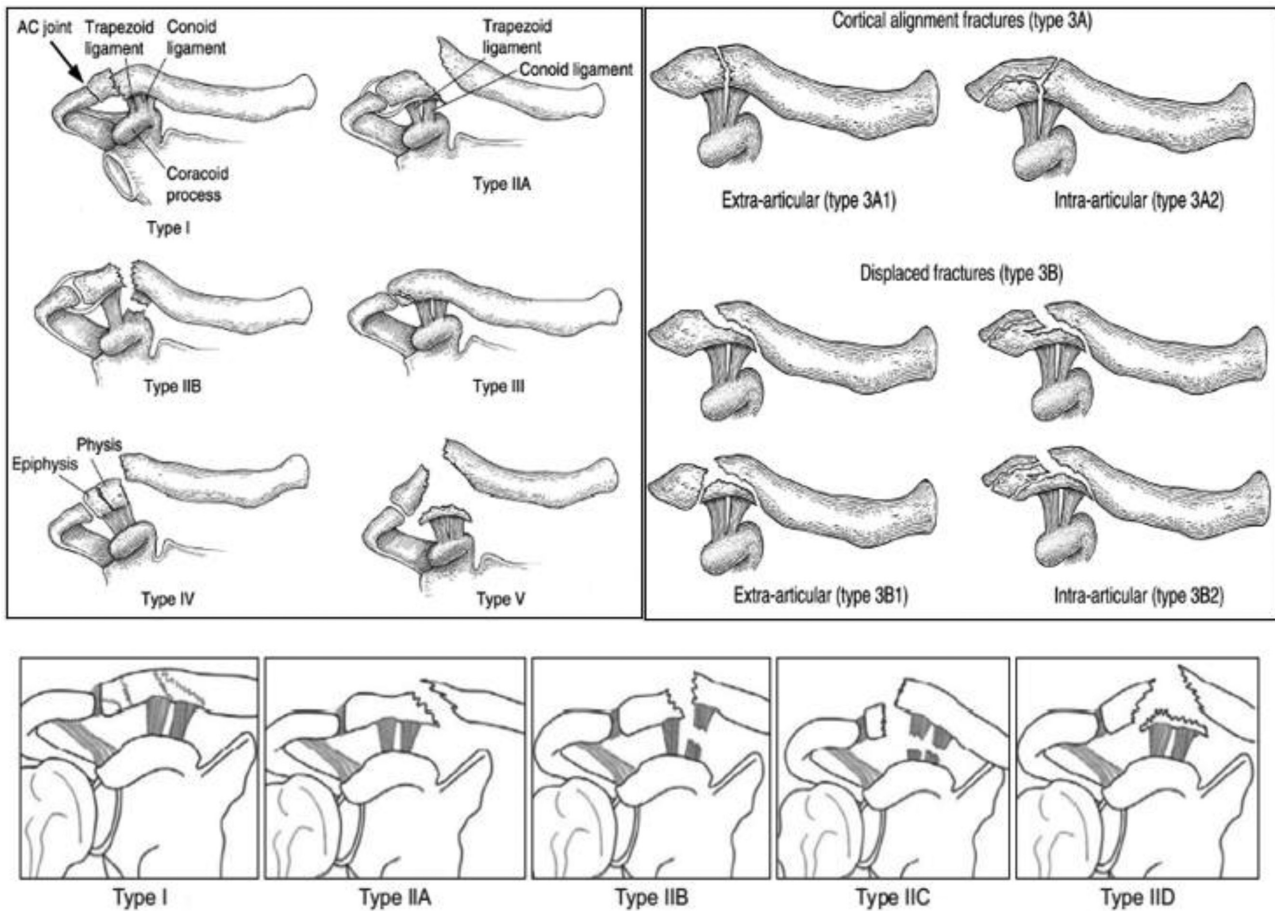


Three classification systems for distal clavicle fracture. Neer classification (left), Robinson classification (right), and Choi classification (bottom).

reported and necessitate a second surgery for plate removal. Transacromial wiring may be an unfavorable option as they may break or migrate into the chest or the neck. Conventional locked compression plate with uniplanar placement of screws in the lateral fracture fragment may be insufficiently rigid fixation. The anatomically precontoured locked distal clavicular plate with lateral extension allows for multiplanar fixation of many screws in the lateral fracture fragment thus offering a more rigid and anatomical fixation even if the lateral fragment is small [5–7].

## Patients and methods

This prospective study was conducted in Benha University Hospital from January 2016 till December 2019 on 23 patients with displaced, offended Neer type-V/Robinson type-3BI/Cho type-IID distal clavicle fractures with the medial fragment displaced evidently and stretching the skin. The study was conducted after ethical approval from the Department of Orthopedic surgery at Banha university hospital and patients consent. Patients

with open fractures, associated neurovascular or other skeletal injuries of the upper limb, or younger than 18 years old were excluded from the study. Preoperative radiographs were reviewed for fracture classification and preoperative planning.

All cases were operated within 4 days after the injury through the standard approach to the lateral clavicle with the patient in beach chair position under general anesthesia and fixed with 3.5 mm anatomically precontoured superior distal clavicle locked plate with lateral extension. After reduction of the main fragments, the plate was fixed to the medial fragment with 3–4 (3.5 mm) locked cortical screws, and to the lateral fragment with as many locked screws (2.7 mm) as possible according to the size of the bone. The osseo-ligamentous fragment attached to the CC ligaments was clamped and reduced to its original position on the undersurface of the clavicle and then fixed by two underrunning heavy nonabsorbable suture loops (Polyester-Ethibond-2) tied over the superior surface of the plate because this osseo-ligamentous fragment was not sizable enough to be fixed with a screw through the plate in all cases (Fig. 2).

Intraoperative radiographs were taken for confirmation of fracture reduction, plate position, and screw lengths.

Intraoperatively, care was given to preservation of the supraclavicular nerves during dissection as much as possible. After completion of fixation, the wound was thoroughly irrigated and closed in layers.

Postoperatively, the shoulder was immobilized in a shoulder immobilizer arm sling with a belt around the waist of the patient in neutral shoulder position for 2 weeks till the wound healed and then passive shoulder motions were allowed for 3 weeks followed by gradual restoration of the range of active shoulder motions. All patients were not allowed for heavy labor work for 6 months after the operation or till complete radiological union is observed. The follow-up period was 12–18 months with radiographic images taken at 2, 4, and 6 weeks postoperatively and then every 4 weeks to assess for the signs of radiological union. The final outcome was assessed clinically by the Oxford shoulder score and radiologically by images at the final follow-up visit. The Oxford shoulder score incorporated assessment of pain and the ability to do activities of daily life and work. Twelve questions assess the shoulder function during the past 4 weeks. Answers were grades from five (excellent) to one (very bad) to a total of 60 points. Results were reported as satisfactory function, more than 40–48 points (excellent); mild disability, 30–39 points (good), moderate disability, 20–29 points (fair); or severe disability, 0–19 points (poor)(http://www.orthopaedicscores.com).
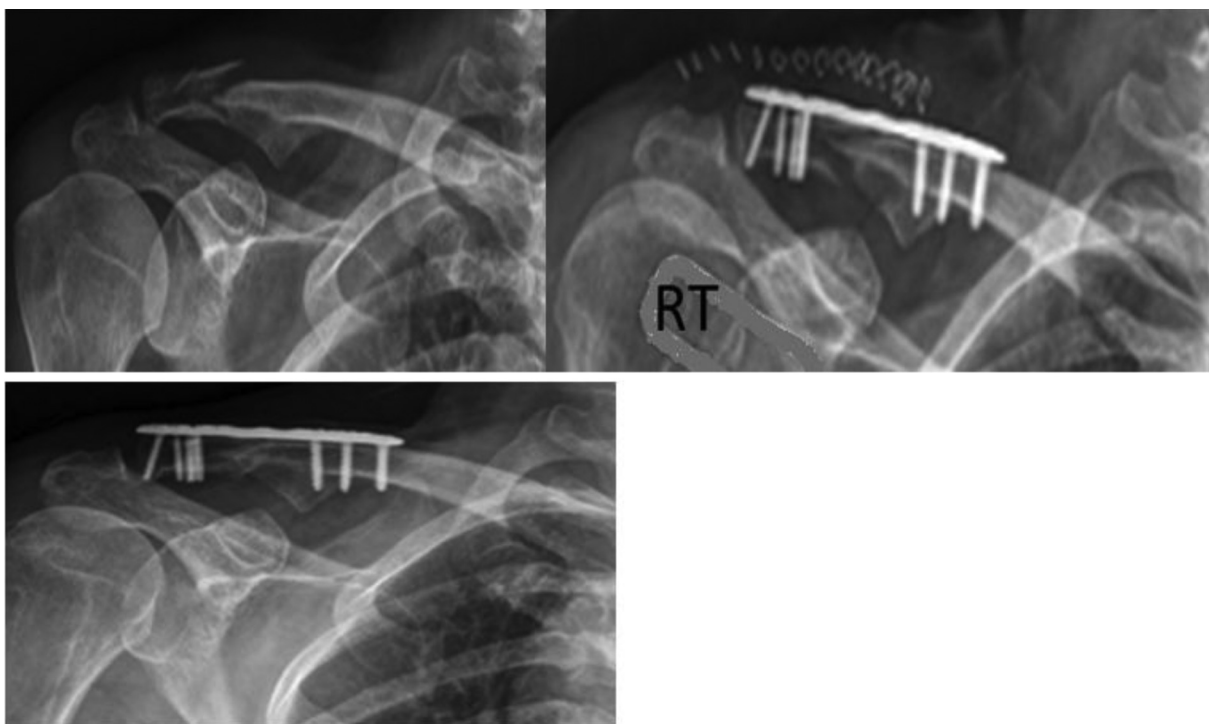
Radiological results were reported according to Neer criteria for union (new bone trabeculae crossing the

**Figure 2**
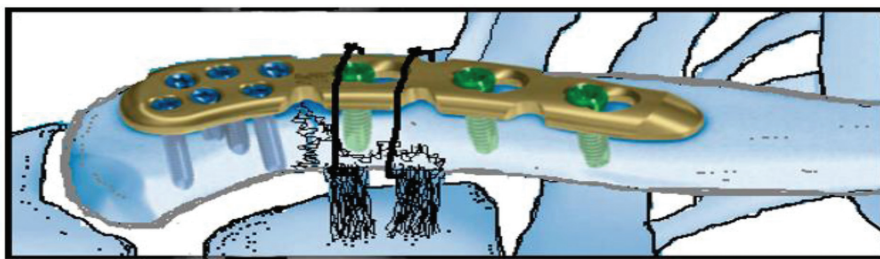


Schematic drawing of the fixation technique.

**Figure 3**



Serial radiographs of a case; preoperative (left), postoperative (right), and 4 months after fixation showing union (bottom).

fracture site and filling the fracture gap), malunion, and nonunion.

## Results

Among the 23 patients there were 20 (86.9%) males and three (13%) females. Eighteen (78%) patients had right side fractures and five (21.7%) patients had left side fractures. The mechanism of injury was by motor vehicle collision in 11 (47.8%) cases and fall on the side of the shoulder in 12 (52%) cases. Age of the patients ranged from 22 to 48 years (average, 35 years). Surgery was done after 1–4 days after injury (average, 2.5 days).

The Oxford shoulder score was excellent (satisfactory function) in 19 (82.6%) cases (score above 40), good (mild disability) in three (13%) cases (score 35–40), and fair (moderate disability) in one (4.3%) case (score 24). Radiologically, there were no cases of malunion, nonunion, or loosening of the implants (Figs 3 and 4). Four (17%) cases showed delayed union during the follow-up period. These four cases united at about 8 months after surgery except one of them showing signs of union at 9 months after surgery and his clinical outcome was fair.

No major complications were faced during this study but some minor complications were recorded in six (26%) patients during the rehabilitation period. Three (13%) cases reported persistent periclavicular hypoesthesia due to inadvertent injury of the supraclavicular nerve branches during surgery. One (4.3%) case showed superficial wound infection within the first postoperative week. This was successfully treated with culture-specific antibiotic and wound care. Two (8.6%) cases experienced shoulder pain of post-traumatic rotator cuff tendinitis that responded well to subacromial injections of corticosteroids (Table 1).

The follow-up period was 12–18 months (average, 15 months). Seventeen (73.9%) patients completed 18 months of follow-up and were recalled on request for reassessment.

## Discussion

Fractures of the distal clavicle are uncommon but have a relatively high incidence of nonunion. The increased functional demands of most patients necessitate increased number of operative fixation. The distal

**Figure 4**
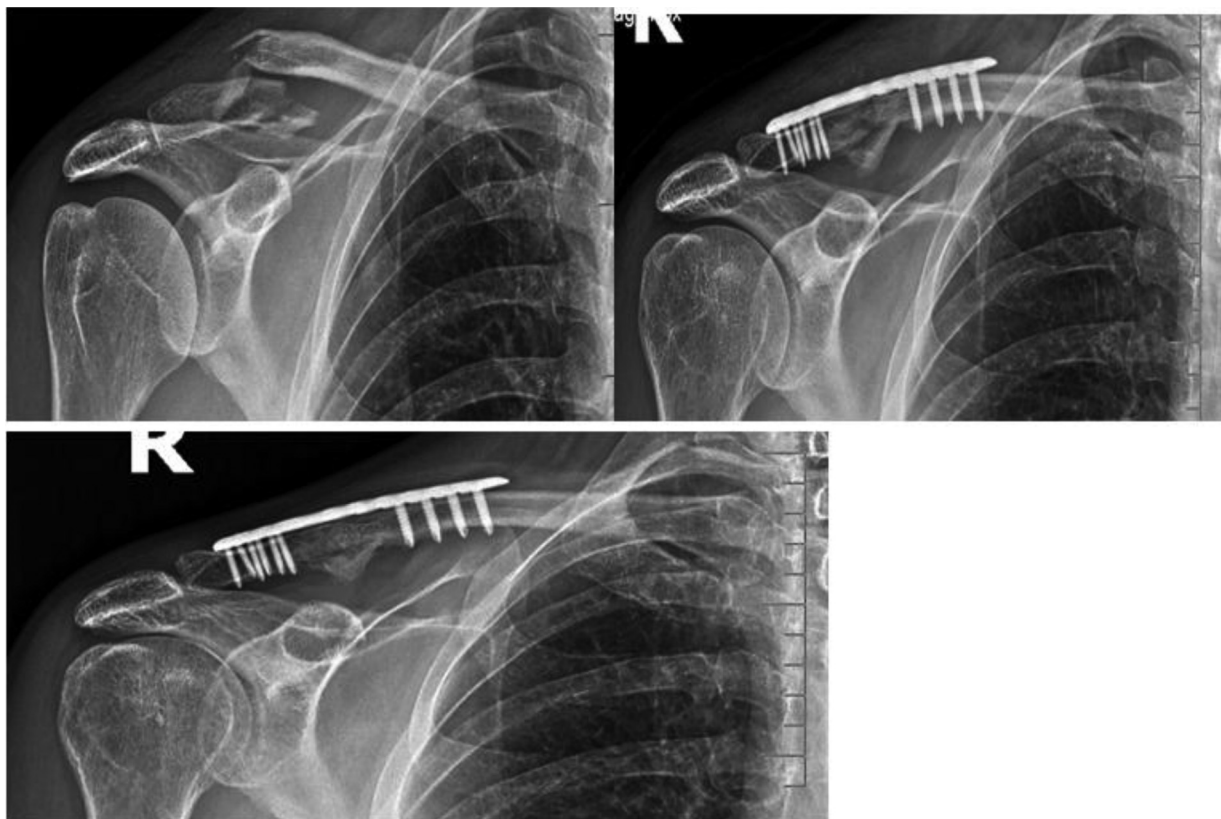


A case with obvious comminution and small lateral fragments (left). Postoperative radiograph (right) shows maximized fixation in the lateral fragment. Follow-up radiograph after 3 months (bottom) shows union and the maintained CC distance.

**Table 1 Results and complications**

|  | n (%) |
|---|---|
| Oxford shoulder score |  |
|   Excellent | 19 (score: >40) (82.6) |
|   Good | 3 (score: 35–40) (13) |
|   Fair | 1 (score: 24) (4.3%) |
| Complications |  |
|   Supraclavicular nerve injury | 3 (13) |
|   Superficial infection | 1 (4.3) |
|   Rotator cuff tendinitis | 2 (8.6) |
|   Delayed union | 4 (17) |

end of the clavicle is fixed to the scapula by the AC and CC ligaments protecting the clavicle from both horizontal and vertical stresses. Disruption of these ligaments or marked displacement of the fracture fragments would result in fracture nonunion or malunion with a degree of permanent disability [4–7].

Various implants are used for fixation of the distal clavicle fractures such as transacromial wires, hook plate, locked plates, tension band, endo-button reconstruction of the CC ligament and transcoracoid screw. Each technique has its advantages and disadvantages. Controversy exists in the literature regarding the proper fixation method for each fracture type and whether to reconstruct the CC ligament or not [1,2,4,5,7].

Oh et al. [6] in a systematic review of different treatment modalities in 425 unstable distal clavicle fractures concluded that nonsurgical treatment resulted in 33.3% nonunion and 6.7% other complications, while surgical treatment resulted in 1.6% nonunion and 22.2% other complications. The nonunion rate was not significantly different among different surgical treatment options but was significantly higher with hook plate and tension band wiring than with CC stabilization, intramedullary fixation, and interfragmentary fixation plating. However, the functional outcome was generally acceptable with nonsurgical treatment in some patients despite the high rate of nonunion. They recommended that CC stabilization, plating with interfragmentary fixation, and intramedullary screw fixation are preferred due to their low complication rates; also, nonsurgical treatment should be considered only after sufficient counseling with the patient regarding the possibility of nonunion [6].

The anatomically precontoured distal clavicle locked plate with a lateral extension offers an excellent option for fixation of these fractures. It helps in reduction of

the major fracture fragments, allows for rigid fixation especially in weak bones, and multiple screws can be placed in the usually small distal fracture fragment in Neer types II and V fractures [8–10]. Sajid et al. [11] studied four different modalities of locking plates for the treatment of distal clavicle fractures (with or without bone graft, locked compression plate, and small fragment locked compression plate) to detect the pitfalls in the technique. They concluded that the locking plate should be augmented with a CC sling to improve the outcome [11]. On the contrary, Lee et al. [12] reported bony union without major complications in 35 cases of Neer type-II lateral clavicle fractures fixed with a precontoured locked plate without CC stabilization. This could be explained from our point of view by the intactness of both CC ligaments in Neer type IIA fracture and the trapezoid ligament in Neer type IIB fractures. Zhang et al. [13] compared the results of fixation of unstable distal clavicle fractures by locked plate in 36 cases and by hook plate in 30 cases. They found no significant difference in union rate between the two plates. However, the distal clavicle locked plate had a lower rate of complications and hardware-related symptoms, thus facilitating return to work better than the hook plate.

Sambandam et al. [14] found that the clinical outcome was better in cases fixed with flexible implant (tension band and K-wires) than with rigid implant only because the flexible implants were more easily removed.

Instability due to injury of the CC ligaments is a main concern in treating unstable distal clavicle fractures mainly Neer types II and V. Accordingly, few studies were conducted on the combined fixation of these fractures by locked plate and augmentation or repair of the CC ligaments using suture anchors or endo-buttons. Shin et al. [15] reported satisfactory clinical outcome and union in 25 unstable distal clavicle fractures fixed with precontoured locking plates without CC ligament augmentation. They achieved union in all cases; however, there was an increase in the CC distance of about 10% in comparison with the noninjured side regardless of the fracture subtype. They claimed that this increase in the CC distance did not affect the functional outcome of patients on the Constant and University of California-Los Angeles (UCLA) scores [15]. Johnston et al. [16] used locked plates and CC suture buttons in unstable distal clavicle fractures and reported good clinical outcome. Mirbolook et al. [17] used pinning and suture anchors in 43 unstable distal clavicle fractures and reported 86% excellent

functional outcome on Constant-Murley Shoulder Outcome Score with a mean time to union of 4.46 ±0.96 months. We may explain these results by the different questionnaires of each functional outcome score used in each study. In our study, we preferred to reattach the osseous fragment of the CC ligaments with less invasive suture loops to its original place on the undersurface of the clavicle without drilling more holes in the already comminuted fracture site.

Seyhan et al. [18] compared the results of fixation of 36 unstable distal clavicle fractures among three groups (tension band with CC suture, precontoured locking plate with CC screw, and precontoured locking plate with CC TightRope). They reported statistically significant better results in the third group. Also, Han et al. [19] reported satisfactory outcome and union within 12 weeks without major complications in their study on unstable distal clavicle fractures fixed with precontoured locking plate and CC suture anchor augmentation.

Rieser et al. [8] studied the biomechanical stability and stiffness of various fixation techniques of lateral clavicle fractures in 21 cadaveric specimens. They found that the combined locking distal clavicle plate and CC reconstruction had the maximum resistance to compression, decreased displacement, and increased fixation stiffness compared with either fixation method alone.

Recently, the precontoured locked plate has become the treatment of choice for unstable distal clavicle fractures (Neer types II and V) when the distal fragment is sizeable enough to hold multiple screws [3,20]. If the distal clavicular fragment is very small to hold screws, the subacromial hook plate may be a suitable option. Several studies have reported satisfactory outcome and union rate with the hook plate [21,22]; however, hook-related complications such as subacromial pain, acromial fracture, osteolysis and cut-out, and rotator cuff impingement were reported. Accordingly, many researchers recommended removal of the hook plate in 3–6 months after surgery [21,23,24].

Early restoration of shoulder motions is essential after fixation of distal clavicle fractures to avoid the complications of prolonged immobilization and to improve the functional outcome. Early mobilization depends mainly on the rigidity of fixation especially in fractures with comminution. Xu et al. [25] compared the clinical outcomes of fixation by distal clavicular locking plate alone and the combined use of the plate

with CC suture anchors for unstable Neer IIb distal clavicle fractures. Both techniques showed good results on Constant-Murley Score; however, the combined locking plates and CC suture anchors provided more stability in the early postoperative period and allowed for early mobilization. They recommended combined fixation with locking plate and CC suture anchors for elderly patients and for comminuted fractures to provide more stability in the early postoperative stage [25]. In our study, the rigidity of fixation allowed the patients to start passive range of motion shoulder exercises 2 weeks after surgery. This was reflected on the final clinical outcome for shoulder functions.

The other option is to reattach the CC ligaments to the clavicle without hardware fixation of the fracture. Reattachment by reducing the increased CC distance with a screw (Bosworth technique) to allow the CC ligaments to heal had been substituted by using sutures, anchors, tapes, or suture buttons because screw loosening, malposition, and limitation of shoulder motions were common complications [26,27]. Several studies have reported satisfactory results and union rates after isolated CC fixation with tape, suture anchors, or bidirectional loops without major complications; however, enlargement of the clavicular hole was observed in many patients and required a second operation for removal of the suture loops and buttons for fear of clavicular fracture through the preformed hole [17,28,29].

The transacromial intramedullary K-wires (Neer's technique) or Knowles pen had been fallen out of favor for the management of displaced distal clavicular fractures due to subsequent K-wires breakage and the serious risk of migration of the metal into the surrounding soft tissues and vital structures [30,31]. However, Kwak et al. [32] used multiple transacromial-transcortical 2.0 mm Steinmann pins augmented with interfragmentary 2.7 mm screws and reported satisfactory results with no pin migration. Also, tension band wiring fixation for displaced distal clavicle fractures had been fallen out of favor due to the risk of wire migration and fracture through the holes drilled in the clavicle for fixation of CC ligaments [33].

In this prospective study, we evaluated the results of fixation of displaced comminuted extra-articular distal clavicle fractures (Neer type-V) with separation of the CC ligaments from the clavicle while still attached to a bone fragment which is not suitable for fixation with lag screw. We used the anatomically precontoured

distal clavicle locked plate with lateral extension to obtain a rigid fixation in both the medial and lateral fragments of the clavicle. The CC osseo-ligamentous fragment was fixed back to the clavicle in its original site by two heavy underrunning suture loops tied over the plate to avoid drilling more holes in the clavicle that could be subjected to stresses and predispose to refracture.

This combined technique of fixation in this specific type of distal clavicle fractures proved union in all of our cases without major complications. Our final results according to the Oxford shoulder score and follow-up radiographic images were excellent in 19 (82.6%) cases, good in three (13%) cases, and fair in one (4.3%) case. We had no cases of malunion or nonunion, and no cases required removal of the implants. The three cases with good results had lower clinical outcome score because they reported mild to moderate pain in the shoulder with daily activities, delayed union, and permanent periclavicular hypoesthesia. The patient scored fair had delayed union, superficial wound infection, pain, moderate difficulty in shoulder functions, and periclavicular hypoesthesia. It is worth mentioning that the four (17%) cases showed delayed union for 5–9 months were all smokers. Hypoesthesia at the area of the clavicle reported in three (13%) cases was due to inadvertent intraoperative injury of the supraclavicular nerve branches, thus we strongly recommend meticulous intraoperative dissection and retraction to avoid this complication as it may have an implication on the clinical outcome. Vaishya *et al.* [34] used the same plate for fixation of unstable distal clavicle (Neer type-II) fractures in 32 cases. Their outcome on the Constant-Murley score showed excellent and good results in 26 (81.2%) cases [excellent in seven (21.85%) patients and good in 19 (59.37%)], and moderate in six (18.75%) cases. Their main complication was asymptomatic malunion in one case and nonunion in one case [34]. We think that these complications were because of inadequate fixation of the lateral fracture fragments that were small as they did not fill all the six lateral holes of the plate.

Klein *et al.* [35] evaluated treatment of distal clavicle fractures (Neer type-II) by hook plate in 22 cases and superior locked plate with suture augmentation of the CC ligaments in 16 cases. They achieved union in 36 (94.7%) cases and had complications in six (27.2%) cases in the form of two infections, one hardware failure and three peri-implant fractures. The complication rates were higher in fractures fixed with hook plate after 4 weeks from injury [35].

Our results are comparable to the studies by Klein and colleagues and Vaishya and colleagues; however, we had lower rates of complications, no malunion or nonunion, no implant failure, and no peri-implant fractures. The reported minor complications in our study (supraclavicular nerve injury and wound-related complications) could be prevented by meticulous dissection and handling of tissues together with stressing on the patients to quit smoking.

## Conclusions

Fractures of the distal clavicle are uncommon and different variants exist. It is recommended to surgically fix the unstable variants. Although multiple fixation options are available, there is no consensus on a gold standard fixation method and each subtype of these fractures needs special planning and selection of the most suitable implant. Several studies had highlighted that the anatomically precontoured distal clavicle locked plate with lateral extension provides better functional outcomes with lower complications rate in comparison with the other methods. Reattachment of the CC ligaments to the clavicle restores the normal anatomy and stability of the clavicle and has an implication on the clinical outcome. More studies with higher level of evidence are required to define the best treatment modality for these fractures.

**Conflicts of interest**
There are no conflicts of interest.

## References

1 Banerjee R, Waterman B, Padalecki J, Robertson W. Management of distal clavicle fractures. J Am Acad Orthop Surg 2011; 19:392–401.

2 Ockert B, Wiedemann E, Haasters F. Distal clavicle fractures. Classifications and management. Unfallchirurg 2015; 118:397–406.

3 Cho CH, Kim BS, Kim DH, Choi CH, Dan J, Lee H. Distal clavicle fractures: a new classification system. Orthop Traumatol Surg Res 2018; 104:1231–1235.

4 Bishop JY, Jones GL, Lewis B, Pedroza A. MOON Shoulder Group. Intra- and interobserver agreement in the classification and treatment of distal third clavicle fractures. Am J Sports Med 2015; 43:979–984.

5 Khan LA, Bradnock TJ, Scott C, Robinson CM. Fractures of the clavicle. J Bone Joint Surg Am 2009; 91:447–460.

6 Oh JH, Kim SH, Lee JH, Shin SH, Gong HS. Treatment of distal clavicle fracture: a systematic review of treatment modalities in 425 fractures. Arch Orthop Trauma Surg 2011; 131:525–533.

7 Boonard M, Sumanont S, Arirachakaran A, Sikarinkul E, Ratanapongpean P, Kanchanatawan W, Kongtharvonskul J. Fixation method for treatment of unstable distal clavicle fracture: systematic review and network meta-analysis. Eur J Orthop Surg Traumatol 2018; 28:1065–1078.

8 Rieser GR, Edwards K, Gould GC, Markert RJ, Goswami T, Rubino LJ. Distal-third clavicle fracture fixation: a biomechanical evaluation of fixation. J Shoulder Elbow Surg 2013; 22:848–855.

9 Tiren D, Vroemen JP. Superior clavicle plate with lateral extension for displaced lateral clavicle fractures: a prospective study. J Orthop Traumatol 2013; 14:115–120.

10 Stegeman SA, Nacak H, Huvenaars KH, Stijnen T, Krijnen P, Schipper IB. Surgical treatment of Neer type-II fractures of the distal clavicle: a meta-analysis. Acta Orthop 2013; 84:184–190.

11 Sajid S, Fawdington R, Sinha M. Locking plates for displaced fractures of the lateral end of clavicle: potential pitfalls. Int J Shoulder Surg 2012; 6:126–129.

12 Lee SK, Lee JW, Song DG, Choy WS. Precontoured locking plate fixation for displaced lateral clavicle fractures. Orthopedics 2013; 36:801–807.

13 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; 38:1461–1468.

14 Sambandam B, Gupta R, Kumar S, Maini L. Fracture of distal end clavicle: a review. J Clin Orthop Trauma 2014; 5:65–73.

15 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; 25:942–948.

16 Johnston PS, Sears BW, Lazarus MR, Frieman BG. Fixation of unstable type II clavicle fractures with distal clavicle plate and suture button. J Orthop Trauma 2014; 28:e269–e272.

17 Mirbolook A, Sadat M, Golbakhsh M, Mousavi MS, Gholizadeh A, Saghari S. Distal clavicular fracture treatment with suture anchor method. Acta Orthop Traumatol Turc 2016; 50:298–302.

18 Seyhan M, Kocaoglu B, Kiyak G, Gereli A, Turkmen M. Anatomic locking plate and coracoclavicular stabilization with suture endo-button technique is superior in the treatment of Neer Type II distal clavicle fractures. Eur J Orthop Surg Traumatol 2015; 25:827–832.

19 Han L, Hu Y, Quan R, Fang W, Jin B, Huang L. Treatment of Neer IIb distal clavicle fractures using anatomical locked plate fixation with coracoclavicular ligament augmentation. J Hand Surg Am 2017; 42:1036.e1–1036.e6.

20 Kim DW, Kim DH, Kim BS, Cho CH. Current concepts for classification and treatment of distal clavicle fractures. Clin Orthop Surg 2020; 12:135–144.

21 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; 26:1210–1215.

22 Tiren D, van Bemmel AJ, Swank DJ, van der Linden FM. Hook plate fixation of acute displaced lateral clavicle fractures: mid-term results and a brief literature overview. J Orthop Surg Res 2012; 7:2.

23 Muramatsu K, Shigetomi M, Matsunaga T, Murata Y, Taguchi T. Use of the AO hook-plate for treatment of unstable fractures of the distal clavicle. Arch Orthop Trauma Surg 2007; 127:191–194.

24 Good DW, Lui DF, Leonard M, Morris S, McElwain JP. Clavicle hook plate fixation for displaced lateral-third clavicle fractures (Neer type II): a functional outcome study. J Shoulder Elbow Surg 2012; 21:1045–1048.

25 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.

26 Fazal MA, Saksena J, Haddad FS. Temporary coracoclavicular screw fixation for displaced distal clavicle fractures. J Orthop Surg (Hong Kong) 2007; 15:9–11.

27 Macheras G, Kateros KT, Savvidou OD, Sofianos J, Fawzy EA, Papagelopoulos PJ. Coracoclavicular screw fixation for unstable distal clavicle fractures. Orthopedics 2005; 28:693–696.

28 Yang SW, Lin LC, Chang SJ, Kuo SM, Hwang LC. Treatment of acute unstable distal clavicle fractures with single coracoclavicular suture fixation. Orthopedics 2011; 34:172.

29 Kanchanatawan W, Wongthongsalee P. Management of acute unstable distal clavicle fracture with a modified coracoclavicular stabilization technique using a bidirectional coracoclavicular loop system. Eur J Orthop Surg Traumatol 2016; 26: 139–143.

30 Jou IM, Chiang EP, Lin CJ, Lin CL, Wang PH, Su WR. Treatment of unstable distal clavicle fractures with Knowles pin. J Shoulder Elbow Surg 2011; 20:414–419.

31 Tsai CH, Hsu HC, Huan CY, Chen HT, Fong YC. Late migration of threaded wire (schanz screw) from right distal clavicle to the cervical spine. J Chin Med Assoc 2009; 72:48–51.

32 Kwak SH, Lee YH, Kim DW, Kim MB, Choi HS, Baek GH. Treatment of unstable distal clavicle fractures with multiple steinmann pins-a modification of neer's method: a series of 56 consecutive cases. J Orthop Trauma 2017; 31:472–478.

33 Choi S, Kim SR, Kang H, Kim D, Park YG. Modified tension band fixation and coracoclavicular stabilisation for unstable distal clavicle fracture. Injury 2015; 46:259–264.

34 Vaishya R, Vijay V, Khanna V. Outcome of distal end clavicle fractures treated with locking plates. Chin J Traumatol 2017; 20:45–48.

35 Klein SM, Badman BL, Keating CJ, Devinney DS, Frankle MA, Mighell MA. Results of surgical treatment for unstable distal clavicular fractures. J Shoulder Elbow Surg 2010; 19:1049–1055.