



Functional outcomes of tension band wiring versus hook plating in displaced, closed, and isolated distal clavicle fractures in adults: a comparative retrospective study

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Introduction: Clavicle fractures are common among young people, generally as a consequence of car accidents, bike falls, and contact sports injuries. 15–20% of all clavicle fractures involve the lateral end of the bone. Thus, the distal clavicle fractures, in particular, have a high non-union rate ranging from 21 to 33% when treated non-operatively, underscoring the usual advice for operative treatment. While significant research has been conducted on clavicle fractures and their treatment options, no definitive guidelines or optimal approaches have been established. Hence, the aim of this study was to assess the clinical and radiological results of the two highly used surgical techniques, Tension Band Wiring (TBW) and Hook plate ones, in addition to investigating the associated functional recovery and outcomes.

Methods: Between August 2019 and 2022, An analytical retrospective comparative study, was done on 38 patients (20 TBW and 18 Hook plate) diagnosed with unstable fracture of the lateral third of clavicle (Neer 2), aged between 18 and 65 years old, and followed up for more than 12 months.

Results: TBW technique was used in 20 patients (14 males and 6 females) with mean age 39.25 years and Hook plate was used in 18 patients (14 males, 4 females) with mean age of 43.11 years. The union rate was 100% in Hook plate group and 95% in TBW group. The mean time of bony union to occur was (9.55) weeks in TBW group and (8.94) weeks in Hook plate group. The mean of constant–Murley score in the last follow-up was 85.32 in the TBW group and 87.38 in the Hook plate group. Superficial infection occurred in 3 cases in TBW group (15%). Four patients complained of impingement, three patients complained of acromial erosion and one patient complained of acromial osteolysis in the Hook plate group.

Conclusion: Both TBW and Hook plate are a good choice for the fixation of displaced distal clavicle fractures with good functional and radiological outcomes, where Hook plate have some advantages such as rigid fixation and early motion of the affected shoulder.

Keywords: distal clavicle fractures, TBW, Hook plate, functional outcomes

Introduction

The clavicle stands out as one of the most distinctive long bones, possessing various notable characteristics in its structure and shape that render it susceptible to fractures. Fractures of the clavicle rank high among the most common bone injuries, comprising 2–5% of all adult fracture, and therefore, are among the most frequent fractures seen in orthopedic practice^[1,2].

HIGHLIGHTS

- Both TBW and Hook plate are a good choice for the fixation of displaced distal clavicle fractures.
- Good functional and radiological outcomes with Hook plate method have some advantages over TBW one.
- Rigid fixation and early motion of the affected shoulder was better in the HP group.

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Previous epidemiologic studies indicate that clavicle fractures account for up to 5% of all adult fractures and up to 44% of all shoulder girdle fractures^[1,3,4]. Distal clavicle fractures (DCFs) account for 15–20% of all clavicle fractures and are observed in both young people with high-velocity trauma and the elderly due to falls (bimodal distribution)^[5] (Fig. 1).

Furthermore, DCFs are classified according to Neer classification system, into five types depending on the position of the fracture line relative to the coracoclavicular (CC) ligament. Among these, type II and type V fractures represent unstable distal clavicle fractures (UDCFs), characterized by considerable displacement resulting from the separation of the coracoclavicular ligament from the proximal fragment. Specifically,



Figure 1. Neer type II distal clavicle fracture.

Type 2 indicates that the fracture is immediately medial to the coracoclavicular ligaments or between the two ligaments, with one ruptured, but do not involve the acromioclavicular (AC) joint^[6].

As such, it was found that non-operative treatment of an unstable distal clavicle fracture (Neer 2) results in a high disunion rate of up to 33%, and subsequently, surgical therapy is often recommended^[6-10].

Several approaches have been proposed including anterior and bra-strap approaches^[11-13], with trans- or extra-articular (k-wire) fixation being the most prevalent, although this involves a high risk of problems, including pain migration and loss of reduction^[6,14,15] Moreover, it was found that Plate fixation is precarious because the distal fragment is often tiny and the metaphyseal bone is soft. As a result, a hooked plate with an extension under the acromion has been designed to provide a more robust attachment (Fig. 2). However, the main concern is sub-acromial impingement or rotator cuff damage^[16].

In this regard, while significant research has been conducted on clavicle fractures and their treatment options, no definitive guidelines or optimal approaches have been established.

Aims and objectives

To study fracture union clinically and radiologically in lateral end clavicle fractures.

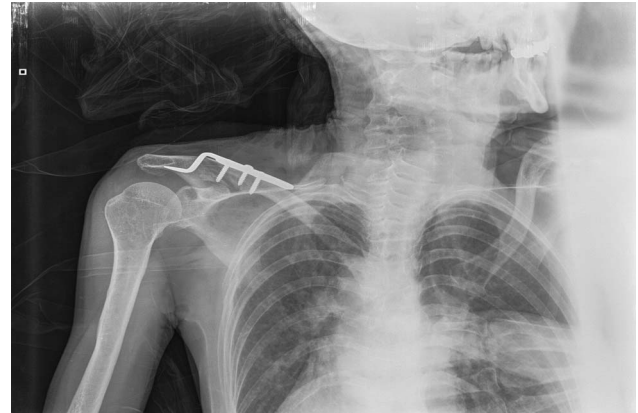


Figure 2. Neer type II distal clavicle fracture treated with hook plate fixation.

To evaluate the functional outcome of the two surgical methods. To assess the complications.

Patients and methods

This study is a comparative retrospective study of 38 patients who had unstable distal clavicle fracture (Neer 2) featured in Figure 1. treated either with TBW technique (Figs. 3 and 4) or A.O Hook plate fixation (Figure 2), and presented to the orthopedic department in a university hospital between 30 August 2019 and 30 August 2022, and all surgeries were done by orthopedic surgery consultants (4 Consultants). The work has been reported in line with the STROCCS criteria.



Figure 3. Neer type II distal clavicle fracture treated with tension band wiring fixation.



Figure 4. Tension band wiring technique.

Data were extracted from the medical records of patients in the form of case sheets, discharge cards, X-rays, etc. The type of fracture was determined by Neer's classification^[6].

Inclusion criteria

Patients with unstable distal third clavicle fracture (Neer type 2).
Age between 18 and 65 years old.

Exclusion criteria

Open fractures.
Pathological fractures.
Fractures associated with brachial plexus or pulmonary or vascular injury.
Acromioclavicular joint disruption.
Musculoskeletal disease that affects the joint.

Preoperative shoulder X-rays in AP with (10–15)° cephalic tilt (ZANCA View) and axillary view were taken. In addition, Basic lab tests were done for all patients on admission. We used A.O Hook plate with (4–7) holes, (3.5) mm screws and (12.15.18) mm of hook depth, and 2 Kirschner wires of (2.0) mm and a stainless steel wire of (18) gauge in the TBW technique.

Postoperative protocol

Arm immobilization with a sling inside the operation room under anesthesia.
I.V antibiotics and analgesic.
A sterile wound dressing was applied routinely.
The surgical stitches were removed after (10–14) days after surgery, and all patients were subjected to rehabilitation and physical treatment.

One examiner measured the outcome based on Constant–Murley score^[17] at 1.5-, 3-, 6-, 9- and 12-month intervals. In this system, both subjective and objective clinical data are included, with a maximum score of 100 points, as the following: Pain (15 points), activities of daily living (20 points), range of motion of the shoulder (40 points), and muscle power (25 points) were evaluated.

Furthermore, radiological assessment was performed immediately after surgery, followed by evaluations at 3-, 6-, 12-, and 24-week intervals to monitor healing progress and implant positioning. Recorded complications included infection, non-union, mal-union, pin migration, hardware impingement, and

stiffness. The final outcome was assessed based on union status, time to fracture union, shoulder joint range of motion, ability to perform daily activities, and return to pre-injury status.

In the TBW group: The fixation method involved trans-articular fixation through the acromioclavicular joint, supplemented with an additional cerclage wire tension band for enhanced stability (Figs. 3, 4). Following surgery, the operated shoulder was supported with a triangular sling for a period of 4–6 weeks. Gentle mobilization was permitted once pain subsided, although the full range of motion was limited due to pin impingement until implant removal.

In the Hook plate group: The operative procedure, as outlined in prior studies^[18–20], involved creating a tunnel in the sub-acromial space posterior to the acromioclavicular joint and inserting the hook into this tunnel. If necessary, the plate was contoured to match the clavicle's shape, with careful consideration given to the appropriate depth of the hook. Dynamic compression was utilized to secure the plate in place. Following surgery, the shoulder was supported with a triangular sling for a period ranging from 2 to 4 weeks. Mobilization commenced at the earliest opportunity, typically resulting in a full range of motion within three to 4 weeks.

Implant removal criteria

TBW group:

Implant failure (K-wire migration).
Deep infection.
Non-union.
After the bony union occurs, approximately within (4–6) months after surgery.

Hook plate group:

Deep infection.
Implant failure.
Impingement syndrome.
Symptomatic acromial osteolysis.
After the bony union occurs, approximately within (7–8) months after surgery.

Ethical considerations

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request. Ethical approval for this study (Ethical Committee 2022-OS-108) was provided by the Ethical Committee on 18 July 2022. In addition, the investigators ensured that the study conforms to the principles of the Declaration of Helsinki (last revised in 2013) and was conducted in accordance with the ICH Guideline for Good Clinical Practice.

Statistical analysis

The Student's *t*-test, χ^2 test with Yates' correction, Fisher's exact test, and Friedman test were used to compare the two groups. The statistic software SPSS 10.0 (SPSS, Inc.) was used to analyze the data; *p* values below 0.05 were considered significant.

Results

In this study, 38 patients who had unstable distal clavicle fracture (Neer 2) were included. Patients were divided into two groups according to two surgical techniques used in fixing their DCFs, TBW and A.O Hook plate (HP) groups. Both groups, fixation, were similar for age, gender, affected side, mechanism of the injury and the medical conditions ($p > 0.1$) (Table 1).

The mean operative duration (in min) was 69.75 in the TBW group, and 90.35 in the HP group, mean time to be able to do a full range of motion (ROM) in the affected shoulder joint (week) was 5 in the TBW and 3.5 in the HP group, and the mean time to return to daily live routine and activities (month) was 4.87 in the TBW group and 2.69 in the HP group. All those outcomes had a significant difference between the two groups. ($P=0.001$) Moreover, the mean time to bony union to occur (week) was 9.55 in the TBW group and 8.94 in the HP group, and the union rate was 95% in the TBW group and 100% in the HP group with no significant difference between them ($p < 0.1$) (Table 2).

While the mean Constant- Murley score in the TBW group, was 85.32 and the subjective result was assessed as excellent in 6 cases, good in 8 cases, fair in 4 cases and poor in 2 cases, In the HP group, it was 87.38 and the subjective result was assessed as excellent in 8 cases, good in 6 cases, fair in 4 cases and no case was assessed as poor, with no significant difference between the two groups in this regard ($p > 0.1$) (Tables 2, 3).

Regarding Complications, In the TBW group: 4 patients had complications (some patients had more than one complication), that are all shown in (Table 4).

Table 1
Comparison between studied groups as demographic data, surgical approach, time from injury to surgery. (n = 38)

Characteristics	TBW group (N=20)	HP group (N=18)	P
Age (years)			
Mean	39.25	43.11	0.8
± SD	± 11	± 14	
Sex, n (%)			
Male	14 (70)	14 (77.8)	0.5
Female	6 (30)	4 (22.2)	
Affected side, n (%)			
Right	17 (85)	13 (72.2)	0.3
Left	3 (15)	5 (27.8)	
Dominant hand, n (%)			
Right	18 (90)	13 (72.2)	0.14
Left	2 (10)	5 (27.8)	
Mode of trauma, n (%)			
RTA	12 (60)	12 (66.7)	0.9
Fall from a height	5 (25)	4 (22.2)	
Other trauma	3 (15)	2 (11.1)	
Medical conditions, n (%)			
D.M	2 (10)	1 (5.6)	0.6
Renal failure	1 (5)	0	0.3
Mechanism of injury, n (%)			
Fall onto shoulder	16 (80)	15 (83.3)	0.7
Fall on outstretched hand	4 (20)	3 (16.7)	
Surgical approach, n (%)			
Horizontal	19 (95)	16 (88.9)	0.3
Bra-strap	1 (5)	2 (11.1)	
Time from injury to surgery, n (%)			
1–5 days	18 (90)	17 (94.4)	0.3
> 5 days	2 (10)	1 (5.6)	

TBW, tension band wiring; HP, hook plate; RTA, road traffic accident.

Table 2

Comparison between studied group as operative duration, time to full ROM, time to bony union to occur, and the CMS (n = 38)

Results	TBW group	HP group	P
Operative duration (min)	69.75 ± 8.9	90.35 ± 5.3	0.0001
Time to full ROM (week)	5 ± 0.8	3.50 ± 0.6	0.0001
Time to bony union (week)	9.55 ± 1.9	8.94 ± 1.2	0.2
Union rate	95%	100%	0.8
Time to return to daily life routine (month)	4.87 ± 1.3	2.69 ± 0.5	0.001
Constant–Murley score (12 months)	85.32 ± 3.9	87.38 ± 4.2	0.3

CMS, Constant-Murley score; HP, hook plate; ROM, range of motion; TBW, tension band wiring.

Initially, infection was identified in three patients (No. 2, No. 5, No. 14); it presented as a superficial infection and was effectively managed with oral antibiotics and regular sterile dressing changes. Additionally, wire migration occurred in two patients, resulting in partial loss of reduction in patient No. 14 (Fig. 5), while patient No. 15 experienced total loss of reduction, necessitating reoperation utilizing the same technique. Moreover, sub-acromial impingement was observed in patients No. 2 and No. 5, leading to restricted shoulder abduction beyond 90° until implant removal. Furthermore, skin erosion due to irritation by the k-wire endings was noted in patients No. 2 and No. 5. Non-union occurred in one patient (No. 14), who was a 59-year-old female with diabetes mellitus and chronic renal failure, requiring re-surgery with iliac bone grafting and the same technique. The final Constant–Murley score for this patient was 69.

Mal-union, characterized by angulation of 28°, occurred in one patient (No. 15), a 38-year-old farmer, although it did not significantly impact daily living activities. Additionally, acromioclavicular joint osteoarthritis was observed in patients No. 14 and No. 15, which was effectively managed with non-steroidal anti-inflammatory drugs and physical therapy sessions. Stiffness was noted in one patient (No. 14), primarily in the morning, and resolved with movement initiation.

In the HP group, five patients experienced complications, with some patients experiencing more than one complication. Sub-acromial impingement was identified in four patients (No. 22, No. 24, No. 29, No. 33), resulting in restricted shoulder abduction beyond 90° until implant removal. Furthermore, sub-acromial erosion occurred in three patients (No. 22, No. 29, No. 33), leading to moderate pain. Additionally, Acromial osteolysis was observed in one patient (No. 26), presenting in the fourth month post-surgery; although asymptomatic, the implant was removed, and the osteolysis was addressed.

Moreover, one patient (No. 33) experienced acromioclavicular joint osteoarthritis and stiffness, both of which were successfully managed with non-steroidal anti-inflammatory drugs and phy-

Table 3

Comparison between studies group as the subjective assessment according to CMS (n = 38)

Constant–Murley	TBW group, n (%)	HP group, n (%)	P
Excellent	6 (30)	8 (44.4)	0.4
Good	8 (40)	6 (33.3)	
Fair	4 (20)	4 (22.2)	
Poor	2 (10)	0	

CMS, Constant-Murley score; HP, hook plate; TBW, tension band wiring.

Table 4
Comparison between studied groups as regard complications (n = 38)

Complications	TBW group (N=20), n (%)	HP group (N=18), n (%)	P
Infection	3 (15)	0	0.12
Implant failure	2 (10)	0	0.2
Sub-acromial impingement	2 (10)	4 (22.2)	0.2
Skin erosion	2 (10)	0	0.2
Sub-acromial erosion	0	3 (16.7)	0.12
Acromial osteolysis	0	1 (5.6)	0.3
Non-union	1 (5)	0	0.3
Mal-union	1 (5)	0	0.3
AC osteoarthritis	2 (10)	1 (5.6)	0.3
Stiffness	1 (5)	1 (5.6)	0.8

HP, hook plate; TBW, tension band wiring.

sical therapy. Regarding complications, no significant difference was found between the two study groups ($P > 0.1$).

Discussion

Clavicle fractures are prevalent among the most frequent bone injuries encountered, accounting for 2–5% of all adult fractures and thus constituting a significant proportion of fractures treated in orthopedic practice^[1,2].

Numerous studies advocate for open reduction and internal fixation as the preferred approach for Neer Type 2 fractures of the distal clavicle due to their propensity for delayed healing^[6,15,20–22]. However, comparing the efficacy of two treatment modalities with adequate sample sizes in distal clavicular fractures presents a considerable challenge. Hence, the aim of this study was to assess the clinical and radiological results of the two highly used surgical techniques, the Tension Band Wiring (TBW) and Hook plate ones,



Figure 5. Implant failure (k-wire migration).

in addition to investigating the associated functional recovery and outcomes.

The anatomical characteristics of the clavicle, characterized by its narrow and less dense structure, pose difficulties for screw fixation. Furthermore, its subcutaneous location predisposes patients to skin irritation induced by implants, necessitating their subsequent removal^[23].

Various fixation methods exhibit distinct advantages and drawbacks when compared to one another, and as of yet, none have been universally designated as the “gold standard”^[24].

Fixation using transacromial Kirschner wires is associated with a higher risk of non-union, hardware failure, wire migration, and loss of reduction^[6,14]. Plate fixation tends to be reliable due to the small size of the distal fragment and the soft nature of the metaphyseal bone. Consequently, a hooked plate with an extension under the acromion has been developed to provide more stable fixation^[16].

In our study, lateral end clavicle fractures (Neer type 2) were predominantly observed in young, active patients, with ages ranging from 23 to 64 years and mean ages of 39.25 years in the TBW group and 43.11 years in the HP group. These findings align with previous studies by Elmohamady *et al.*^[25], who reported mean ages of 37.4 years in the TBW group and 35.5 years in the HP group, and Flinkkilä *et al.*^[18], who noted mean ages of 35 years in the TBW group and 43 years in the HP group. Similarly, Lee *et al.*^[26] reported mean ages of 35.9 years in the TBW group and 43.4 years in the HP group.

Furthermore, our study revealed a higher prevalence of lateral end clavicle fractures in males compared to females, with 28 males and 10 females included. This gender distribution is consistent with findings reported by Elmohamady *et al.*^[25], who included 25 males and 15 females, and Flinkkilä *et al.*^[18], who reported 32 males and 7 females. Additionally, we found that road traffic accidents (RTAs) were the most common cause of lateral end clavicle fractures (Neer type 2), a trend that was also observed in the two lastly mentioned studies.

In our investigation, complete bony union was observed in all patients of the HP group (100%) and 19 patients of the TBW group (95%). The mean duration for bony union was 9.5 weeks (ranging from 7 to 15 weeks) in the TBW group and 8.9 weeks (ranging from 7 to 12 weeks) in the HP group. These findings closely parallel those reported by Elmohamady *et al.*^[25], who documented union rates of 90% in the TBW group and 95% in the HP group, with a mean union time of 10 weeks in both groups, as well as by Lee *et al.*^[26], who reported union rates of 95% in the TBW group and 100% in the HP group. Only one case of the TBW group had symptomatic non-union associated with complete loss of reduction that required secondary surgery with bone graft, and the final CMS was 69 points.

Moreover, In our study, the mean Constant–Murley score at the final follow-up was 85.32 ± 3.9 in the TBW group and 87.38 ± 4.2 in the HP group, indicating satisfactory joint function. Subjectively, outcomes in the TBW group were categorized as excellent in 6 cases, good in 8 cases, fair in 4 cases, and poor in 2 cases. In contrast, outcomes in the HP group were assessed as excellent in 8 cases, good in 6 cases, fair in 4 cases, and no instances of poor outcomes were noted. These findings are consistent with those reported by Elmohamady *et al.*^[25], who documented mean Constant–Murley scores of 87.6 in the TBW group and 86.5 in the HP group. Similarly, Flinkkilä *et al.*^[18] reported mean Constant–Murley scores of 84 in the TBW group

and 90 in the HP group, while Lee *et al.*^[26] observed mean Constant–Murley scores of 88 in the TBW group and 90 in the HP group. Additionally, in our study, infection was recorded in 3 cases (15%) of the TBW group, with no instances reported in the HP group.

Regarding skin erosion, it was documented in 2 cases (10%) of the TBW group, with no instances recorded in the HP group. Implant failure, showed in Figure 5, was observed in 2 cases (10%) of the TBW group, whereas no occurrences were noted in the HP group. Sub-acromial impingement was noted in 2 cases (10%) of the TBW group and 4 cases (22.2%) of the HP group. Acromial osteolysis was observed in only 1 case (5.6%), which occurred in the HP group. These findings align with those reported by Elmohamady *et al.*^[25], where infection was documented in 4 cases (20%) of the TBW group, with no instances reported in the HP group. Implant failure occurred in 4 cases (20%) of the TBW group and 2 cases (10%) of the HP group, while sub-acromial impingement was noted in 7 cases (35%) of the HP group, with no cases reported in the TBW group. Similarly, in the study by Flinkkilä *et al.*^[25], infection was recorded in 4 cases (18.1%) of the TBW group, with no occurrences in the HP group. Implant failure was observed in 12 cases (54.4%) of the TBW group and was absent in the HP group. Additionally, Lee *et al.*^[26] reported infection in 2 cases (10%) of the TBW group, with no instances recorded in the HP group. Implant failure occurred in 3 cases (15%) of the TBW group and 1 case (3.12%) of the HP group, while skin erosion was noted in 2 cases (20%) of the TBW group, with no occurrences reported in the HP group.

This study had various limitations. It was a retrospective study and not randomized, which could have a selection bias. Also, the study sample was not large enough, but when we calculated the study power, it was (80-90)%.

Conclusion

Both surgical techniques have proven to be able to provide a good reduction, stability, and to achieve a bony union with a very close period between them, so the choice of the surgical method must take into account the patient's lifestyle and occupational requirements, as hook plate allows for earlier mobilization and an earlier return to work and daily life routine. Future researchers should do prospective and randomized controlled trials that are necessary to control bias. In addition, the sample size should be studied further with a longer follow-up period.

Ethical approval

Ethical approval for this study was provided by the Ethical Committee NO. 2022-OS-108) was provided by the Ethical Committee on 18 July 2022.

Patient consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

M.E.: conceptualization, collecting data, analyzing, writing and revising the manuscript. M.S.: clinical supervision, conceptualization, reviewing and editing the manuscript. S.Y.: clinical supervision, reviewing the manuscript.

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The authors declare no conflicts of interest.

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Data are available upon reasonable request.

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