A Comparative Retrospective Analysis of Tension Band Wiring and 3.5 mm Precontoured Plate Used for Fixation of Chevron Osteotomy in Type C Distal Humerus Fractures

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Abstract

Introduction Complex distal humerus fractures are rare and difficult to treat and traditionally requires an open reduction and internal fixation via a transolecranon approach. However, controversy remains regarding the better method of fixation of the chevron osteotomy. The purpose of the present study was to compare the clinical efficacy of tension band wiring (TBW) and 3.5 mm precontoured plate in treating the chevron osteotomy.

Materials and Methods A consecutive series of 49 patients who required olecranon osteotomy for type C distal humerus fractures were identified and grouped according to the construct used. Clinic–radiological evaluation was done at 3 months, 6 months, 1 year, and 2 years. A total of 34 males and 15 females with a mean age of 36.9 ± 12.64 years (18–62 years) were included in the study. Surgical duration, range of motion, Mayo elbow performance score (MEPS), and complications were noted at the follow-up.

Results The mean range of motion was initially lower in the plate group (105 degrees ± 9.9 in plate, 107 degrees ± 9.15 in TBW) that subsequently increased at 6 months. The forearm rotation was similar in both the groups. The mean MEPS was found to be higher in the plate group at 2 years (81.83 ± 5.85 in plate, 77.76 ± 8.02 in TBW). A significantly higher rate of complications, that is, nonunion (p = 0.03), loss of reduction (p = 0.03), and revision (p = 0.04) was observed in the TBW group. However, other complications such as symptomatic hardware, wound complication, and removal of hardware were found to be higher in the plate group.

Conclusion Both TBW and 3.5 mm precontoured plate provide comparable functional outcomes; however, the complication rate in terms of nonunion, loss of reduction, and revision is seen in the TBW, whereas wound complication and symptomatic hardware are more commonly seen in the plate.

Keywords
- distal humerus fractures
- olecranon plate
- chevron osteotomy
- tension band wiring
- nonunion

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Introduction

Fractures of the distal humerus are relatively uncommon and account for ~2 to 6% of all fractures.[1-3] A good exposure of distal humerus is necessary to achieve a stable and anatomically sound reconstruction making the surgical treatment of such fractures quite challenging. A large variety of approaches for distal humerus have been described; however, it has been agreed upon that olecranon osteotomy provides a superior exposure of the articular surface and thus is routinely employed in treating these fractures.[4,5] Nevertheless, approach-related complications are commonly encountered and negates the benefit of the approach. To achieve a better functional outcome in these fractures, early mobilization in postoperative period is required, which warrants a stable fixation of both the humeral fracture and the olecranon osteotomy site. Complex anatomy coupled with the subcutaneous position of proximal ulna makes it difficult to decide the most suitable fixation method for the olecranon osteotomy. Numerous methods have been used for the fixation of the osteotomy such as tension band wiring (TBW), intramedullary screw with or without TBW, olecranon plate, and olecranon nail.[6,7] However, TBW remains the most popular choice even today owing to its ease of application and surgical familiarity.[8] Complications such as nonunion, loss of reduction, implant prominence, skin necrosis have all been well described in the literature.[6] Few biomechanical and clinical studies have shown encouraging results with plate fixation[9] making it a popular choice for osteotomy fixation, but data comparing both these constructs in distal humerus fractures is still lacking. Therefore, the current study was conducted with an aim (1) to compare efficacy between the olecranon plate and TBW in terms of surgical duration and functional outcome in type C distal humerus fractures and (2) to compare the complication between the olecranon plate and TBW.

Materials and Methods

We conducted a retrospective study to compare the outcome of two commonly used methods for refixation of chevron osteotomy, the 3.5 mm precontoured low profile olecranon plate (Synthes, Oberdorf, Switzerland/Smith and Nephew, Smith & Nephew, Andover, MA, United States) and Kirschner wire (K-wire) with TBW in type C distal humerus fractures. After obtaining institutional ethical board approval, we reviewed all the cases of distal humerus fractures that underwent chevron osteotomy of olecranon from September 2016 to October 2017. All the participants were informed regarding their participation in the study and an informed written consent was obtained. The patient details, date of injury, mechanism of injury, presence of any associated injuries, surgical duration, and intraoperative complications, if any, were obtained from the institutional database. The exclusion criteria included skeletally immature patient, pathological fracture, refixation of osteotomy with other method, mangled extremity and patient with incomplete records, type A or type B distal humerus fractures, and unwillingness to participate in the study. In all the patients, osteotomy was performed according to standard AO (Arbeitsgemeinschaft fur Osteosynthesefragen) technique using oscillating saw in a chevron "V" shaped configuration with apex facing distally. The olecranon along with triceps was reflected proximally to gain access to intra-articular surface with distal humerus.

An immediate postoperative X-ray was obtained for each patient to assess the reduction and it was noted to be satisfactory if there was less than 2 mm step or gap after refixation of osteotomy. Further radiological assessment was done on follow-up visits at 3 months, 6 months, 1 year, and 2 years with serial radiographs taken in two different planes (anteroposterior and lateral view). The reduction was said to be displaced if there was increase in reduction gap with presence of radiolucency at osteotomy site. Nonunion of osteotomy was defined by persistence of radiolucency over osteotomy site even after 9 months of fixation (►**Fig. 1**). The mobilization of elbow was started according to stability of construct and reduction quality.

All patients were clinically evaluated for hardware sensitivity, elbow range of motion (ROM) (►**Fig. 2**), and any complications at all follow-up visits at 3 months, 6 months, 1 year, and 2 years. In addition to the elbow ROM, functional assessment was done by measuring forearm rotation (supination and pronation) using a full circle goniometer and by using Mayo elbow performance index score. The hardware sensitivity was graded according to De Giacomo et al.[10] Grade 1: no irritation, Grade 2: painful when leaning on elbow, and Grade 3: painful on normal ROM and hamper normal routine activity.

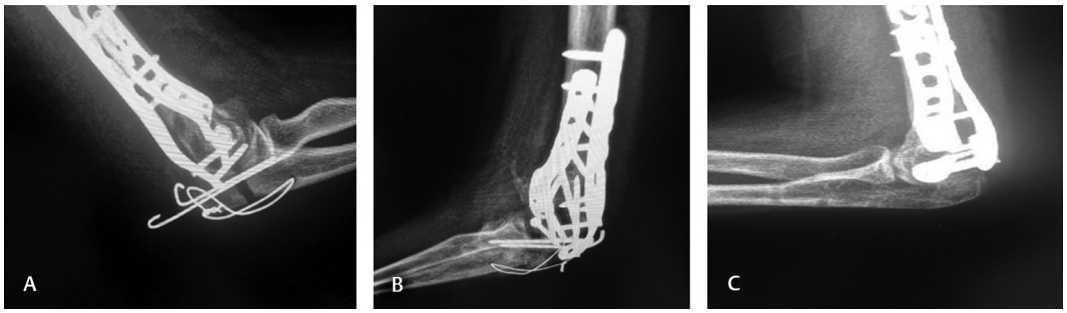

Fig. 1 (**A**) Lateral radiograph of 40 years male at 9 months showing nonunion over osteotomy site with proximal migration of K-wire. (**B**) Lateral radiograph of 40 years male at 5 months showing displacement over osteotomy site. (**C**) Complete union over osteotomy site following removal of the plate done for Grade 3 wound dehiscence.

Fig. 2 Images showing healed chevron osteotomy treated with 3.5 mm precontoured plate (**A**) and tension band wiring (**B**) and elbow range of motion shown post fixation at 2 years (**B,C,E,F**).

Fig. 3 Grade 3 hardware sensitivity (**A**), marginal skin necrosis (Grade 1) at surgical site (**B**), and Grade 2 wound complication (**C**).

Loss of reduction, nonunion, removal of hardware, and wound complications were studied for both groups (►**Figs. 1** and **3**). The wound complications were further classified according to De Giacomo et al.[10] Grade 1: marginal skin necrosis but implant not exposed. Grade 2: wound dehiscence with proximal extent of implant exposed. Grade 3: skin necrosis with entire length of implant exposed.

Statistical Analysis

Statistical analysis was done using Stata software (Version 14.2, StataCorp LLC, Texas, United States). Mean, standard deviation (SD), and range were calculated. Data were represented in the form of continuous and categorical variables. Continuous variables were analyzed with the help of Student's *t*-test, whereas chi-squared test and Fischer's exact test were used to analyze the categorical variables. All the tests were two-tailed and significance was defined at $p < 0.05$.

Results

Forty-nine patients were included in our study and were divided as plate group (n = 21) and TBW group (n = 28) according to the construct used for the fixation of the chevron osteotomy. The mean age of our study population was 36.9 years (SD: 12.64, range: 18–62 years) with 69.4% of the patients being male (n = 34). The most common mechanism of injury was road traffic accident (n = 25) with the right limb being most commonly involved (n = 33; 67.38%). The baseline patient characteristics have been summarized in ►**Table 1**.

All the patients underwent surgical procedure within 2 days of hospital admission that was performed by two senior surgeons. In both the groups, there was no significant intraoperative complication. On immediate postoperative radiographs, none of the patients had unsatisfactory reduction (gap > 2 mm). The mean surgical time in plate group (199.5 minute, SD: 20.6; range: 165–240 minutes) was lesser than that in the TBW group (215.8 minutes, SD: 22.2; range:

Table 1 Baseline characteristics of the study population

	Plate (n = 21)	TBW (n = 28)
Mean age (±SD, Range)	38.8 years (±12.7, 18–61 years)	35.4 (±12.5, 18–62 years)
Sex (number, %)		
Male	14 (66.66%)	20 (71.42%)
Female	7 (33.33%)	8 (28.57%)
Side of injury (number, %)		
Right	16 (76.19%)	17 (60.71%)
Left	5 (23.80%)	11(39.28)
Mechanism of injury (number, %)		
Fall from standing height	4 (19%)	4 (14.28%)
Fall from height	6 (28.57%)	7 (25%)
Motor vehicle collision	9 (42.85%)	16 (57.14)
Sports	1 (4.76%)	0
Others	1 (4.76%)	1 (3.57%)
Associated injuries (number, %)	Hip fracture—1 (4.76%) Metacarpal fracture—4 (19%) Spinal injury—3 (14.28%) Fracture SOF—1 (4.76%) Fracture distal radius—1 (4.76)	Fracture SOF—3 (10.71%) Metacarpal fracture—2 (7.14%) Abdominal injury—2 (7.14%) Spinal injury 1 (3.57%) Bimalleolar fracture—1(3.57%)

Abbreviations: SD, standard deviation; SOF, shaft of femur; TBW, tension band wiring.

180–280 minutes); however, the results just fell short of reaching statistical significance (p = 0.05).

The mean flexion arc was initially seen higher in the TBW group at 3 months that decreased thereafter (►**Table 2**). The mean flexion arc of the plate group was 129 degrees; SD (2.34) and that of the TBW group was 124 degrees; SD (4.98) at 2 years. The forearm rotation observed was approximately equal in both the groups at measured interval of time with no significant difference observed between the two (p >0.05) (►**Table 2**). The mean pronation and supination (2 years) observed in the plate group were 65 degrees; SD (1.68) and 81 degrees; SD (1.83), respectively, and in the TBW group the mean pronation and supination were 64 degrees; SD (1.96) and 81 degrees; SD (2.26), respectively. The MEPS was noted to be higher in the plate group at 3, 6, 12, and 24 months follow-up; however, no significant difference was observed between the two (p >0.05) (►**Table 2**).

Nonunion and revision both were only found to be significantly higher in TBW group (p = 0.03, respectively in both) (►**Table 3**). The loss of reduction was also observed to be significantly higher (p = 0.04) in the TBW group as compared with the plate group (►**Table 3**). The surgical wound healed without any complications in 35 patients, Grade 1 wound dehiscence was found to be higher in the TBW group, whereas Grade 2 and 3 wound dehiscence was found to be higher in the plate group. Plate group was associated with significantly higher Grade 3 wound complication (p = 0.02) (►**Table 3**). Three patients in the plate group developed a deep infection requiring additional surgical debridement followed by implant removal in the second stage. Grade 1 and 2 hardware sensitivity was found to be higher in the TBW group, whereas Grade 3 sensitivity was found to be higher in the plate group; however, no overall significant difference was observed between both the groups (p = 0.533) (►**Table 3**). In hardware symptomatic patients, the most common site for TBW group was knot site followed by K-wire, while in plate group, the most common site was the proximal bend followed by plate edges. When comparing the removal of hardware, it was observed that the percentage was higher in the plate group (n = 6; 28.6%) as compared with the TBW group (n = 3; 10.7%); however, the difference was nonsignificant (p = 0.146).

Discussion

The purpose of this study was to compare the outcome and complication rates between the precontoured olecranon plate and TBW in fixing the chevron osteotomy in type C distal humerus fractures. Our study demonstrated that the TBW and plate had comparable outcome, although a few complications were specific to each group. A retrospective study by Coles et al[11] involving 70 patients with distal humerus fractures demonstrated the efficacy of olecranon osteotomy for complex distal humerus fractures; however, no comparative evaluation was presented regarding the different methods of fixation. Woods et al[12] reviewed 160 patients retrospectively and compared different methods of fixation for the olecranon osteotomy; however, functional outcomes were not reported in their study. Hewins et al[9] reported a favorable outcome in osteotomies fixed with 3.5 mm contoured plate with respect to the forces acting on the site. De Giacomo et al[10] found the length of the plate to be an independent predictor of loss of motion at the elbow as opposed to the fracture characteristics. The present study demonstrated a decreased flexion arc initially in the plate group at 3 months that improved later on and a better MEPS in the plate group; however, it failed to show any statistically significant difference between both. Our finding reiterates the observation of Schmidt-Horlohe´ et al[13] regarding the outcome of the plate; however, we used a 3.5 mm precontoured plate in our study instead of a one-third tubular plate. To the best of our knowledge, this is the first study comparing the functional outcomes between both the fixation constructs in a chevron osteotomy. Operative time is an important factor in any surgery and has shown to influence complication rates such as surgical site infection, delirium, and venous thromboembolism.[14,15] We found a lesser surgical duration for the plate group, but the results were only weakly significant. Further, it might be inappropriate to overlook other parameters such as complexity of the fracture, fatigue of the operating surgeons, and comorbidity of the patient and to generalize the results based on a single factor.[14,16]

Table 2 Functional outcome of the study group

	Plate (*n* = 21) Mean (±SD) Range		TBW (*n* = 28) Mean (±SD) range		*p*-Value
3 months					
Flexion arc	105±9.97 deg	85–116 deg	107±9.15 deg	85–118 deg	0.460
Pronation	60 ±5.65 deg	50–65 deg	60±5.87 deg	48–68 deg	0.972
Supination	76±3.67 deg	70–80 deg	75±4.57 deg	66–82 deg	0.560
MEPS	68.33 ± 14.77 deg	40–90	61.96 ± 13.83 deg	35–90	0.128
6 months					
Flexion arc	115±7.18 deg	102–122 deg	112±9.05 deg	95–120 deg	0.252
Pronation	64±2.31 deg	58–68 deg	64±3.31 deg	55–68 deg	0.845
Supination	76±3.21 deg	70–80 deg	75±3.92 deg	70–82 deg	0.263
MEPS	71.90 ± 14.18	45–90	67.14 ± 14.30	40–85 deg	0.253
1 year					
Flexion arc	117±4.19 deg	110–125 deg	114±5.37 deg	105–120 deg	0.107
Pronation	65±1.13 deg	62–67 deg	63±1.97 deg	60–66 deg	0.297
Supination	78±2.29 deg	75–82 deg	78±2.78 deg	75–84 deg	0.964
MEPS	78.24 ± 8.82	65–90	74 ± 9.67	60–90	0.176
2 years					
Flexion arc	129±2.34 deg	125–132 deg	124 ±4.98 deg	112–130 deg	0.128
Pronation	65±1.68 deg	64–70 deg	64 ±1.96 deg	60–68 deg	0.264
Supination	81±1.83 deg	76–84 deg	81 ±2.26 deg	75–84 deg	0.562
MEPS	81.83 ± 5.85	65–90	77.76 ± 8.02	60–90	0.168

Abbreviations: deg, degrees; MEPS, Mayo elbow performance score; SD, standard deviation; TBW, tension band wiring.

Table 3 Complications and comparison of the study group

	Plate (*n* = 21)		TBW (*n* = 28)		*p*-Value
	Number	%	Number	%	
Loss of reduction	1	4.76%	3	10.71%	0.04
Nonunion	0		6	21.4%	0.03
Removal of hardware	6	28.6%	3	10.7%	0.146
Revision	0		6	21.4%	0.03
Wound complication					
Grade 1	2	28.6%	3	42.9%	0.55
Grade 2	2	28.6%	4	57.1%	0.25
Grade 3	3	42.97%	–	–	0.02
Hardware sensitivity					
Grade 1	12	57.14%	18	64.28%	0.533
Grade 2	5	23.8%	7	25%	
Grade 3	4	19%	3	10.7%	

The refixation of chevron osteotomy is associated with number of complications, nonunion being the most commonly cited complication, as high as 31% in some published studies.[12,17] In our study, we observed an overall nonunion rate of 21.4%, all being from TBW group. Woods et al[12] reported a nonunion rate of 21.3% in the TBW group that was similar to our study reemphasizing the technical and biomechanical fallacies of TBW as compared with the plate. The nonunion rate in the plate reported in other studies[12,13] is high as compared with our study and this could be due to the patient and fracture characteristics. We found a significantly higher loss of reduction in the TBW group as compared with the plate. Wilson et al[18] who performed a biomechanical comparison on the identical transverse fracture of the olecranon found that modern precontoured plate is better at providing fracture compression at the articular surface. Our finding also questions the validity of the articular compression at the fracture site and raises concerns regarding the biomechanical

stability of the TBW construct. Moreover, it could have also resulted from migration of the K-wires following physiotherapy, which was not apparent in the radiographs or else could have resulted from inadequate tightening of the TBW intraoperatively, thus loosening out on the biomechanical stability. Further studies are required to investigate on these factors and see the outcomes of TBW. The revision surgery was only found to be required in the TBW group caused due to the nonunion of the osteotomy site which was not observed in the plate group.

The subcutaneous position of proximal ulna and stretching of soft tissues during elbow flexion make the wound over posterior aspect of elbow susceptible to wound dehiscence and wound infections following implant fixation. In a retrospective study by Kundel et al,[19] 98 patients with distal humerus fractures were reviewed and an infection rate of 10% was noted that resolved without any intervention. Woods et al[12] reported an infection rate of 18.8% in the plate group and 8.5% in TBW group. We directly studied the wound complication rate in our study population and found an overall complication rate of 28.57% with Grade 3 wound complication developing in 21.42% (n = 3) in the plate group and none in the TBW group. None of the patients in our study suffered from an open fracture as seen in other studies.[12] In our opinion, this could have been caused due to greater soft tissue stripping in the plate group.

The percentage of asymptomatic hardware was higher in the TBW group (64.28%) as compared with the plate group (57.14%); however, the difference was not significant. Our results grossly reflect that precontoured plate causes more symptoms due to its contour, structure, and its position on the dorsal ulna.[20] Symptomatic implants often require removal, and this is another common problem associated with olecranon osteotomy. Again, we observed that the patients who required implant removal for symptomatic implant were higher in the plate group (28.6%) as compared with the TBW group (10.17%). Past studies[12] have shown higher implant removal rates in TBW as opposed to plate, but in our study the implant removal rates for symptomatic implants were almost similar in both groups (3 patients in each group, 10.71% in TBW and 14.28% in plate); however, three more patients required implant removal for wound complications and infection in the plate group. Similar findings were reported by Duckworth et al[21] where they compared both the method of fixation in a simple ulna fracture, that is, although the patient reported outcome was similar in both the groups, complications such as infection and resurgery was exclusively associated with plate fixation.

The main limitations of our study are its retrospective nature and a small sample size. Further, owing to the small sample size, we did not perform any subgroup analysis to assess the difference between the two types of plates used.

Conclusion

In this series, we observed chevron osteotomies fixed with precontoured olecranon plate yield a comparable functional outcome to TBW. However, complications such as nonunion and loss of reduction were unique to TBW as opposed to the 3.5 mm precontoured plate that had its own set of complications such as greater hardware sensitivity, wound complications, and infections. Further studies are required to demonstrate the clinical efficacy of one method over the other.

Conflict of Interest

None declraed.

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