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Clinicoradiological Outcome of Double Screw Fixation Versus Tension Band Wiring After Olecranon Osteotomy in Complex Distal Humerus Fractures: A Prospective Randomized Study

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Abstract: ***Background: Complex distal humerus fractures (AO type 13-C) require olecranon osteotomy for adequate articular visualization. The optimal method for osteotomy fixation remains debated, with tension band wiring (TBW) being traditional but associated with hardware-related complications. Double screw fixation (DSF) offers a low-profile alternative with potentially fewer complications. Objective: To compare clinical and radiological outcomes of TBW versus DSF for olecranon osteotomy repair following surgical treatment of complex distal humerus fractures. Methods: This prospective randomized study included 60 patients (30 TBW, 30 DSF) with complex distal humerus fractures treated via olecranon osteotomy at SMS Medical College, Jaipur, from January 2024 to December 2024. Patients aged 15-60 years were followed at 01 week, 02 weeks, 01 month, and 03 months. Outcomes were assessed using Mayo Elbow Performance Score (MEPS), arc of motion, and complication rates. Results: Mean age was 41.00±12.59 years (TBW) and 42.50±11.03 years (DSF). Late postoperative complications occurred in 09 (30.00%) TBW patients versus 03 (10.00%) DSF patients (p<0.001). Implant removal was required in 06 (20.00%) TBW cases versus 02 (06.67%) DSF cases. At 03 months, mean MEPS was 87.4±7.69 (TBW) and 88.5±8.02 (DSF), with no significant difference (p=0.601). Excellent outcomes were achieved in 13 (43.33%) TBW and 17 (56.67%) DSF patients. Arc of motion was comparable: 103.87±16.01° (TBW) versus 100.07±17.75° (DSF), p=0.387. Conclusion: Both TBW and DSF achieve satisfactory functional outcomes for olecranon osteotomy fixation. However, DSF demonstrates significantly fewer late complications and lower implant removal rates, making it a more reliable and patient-preferred method for complex distal humerus fracture management.***

Keywords: Distal humerus fracture; Olecranon osteotomy; Tension band wiring; Double screw fixation; Mayo Elbow Performance Score; Elbow trauma

1. Introduction

Fractures of the distal humerus, particularly those involving the supra- and intercondylar regions, represent some of the most complex injuries in orthopaedic trauma.[1,2] The elbow joint is essential for flexion, extension, pronation, and supination movements, and any disruption to its anatomy can severely impair a patient's quality of life.[3] The primary goals in managing these fractures are anatomical restoration, stable internal fixation, and early mobilization to prevent joint stiffness.[4] Failure to achieve stable fixation can result in malunion, non-union, joint instability, post-traumatic arthritis, and long-term functional disability.[5]

Distal humerus fractures exhibit a bimodal distribution. In young adults, these fractures typically result from high-energy trauma such as road traffic accidents or falls from height.[6] In contrast, elderly individuals, particularly women with osteoporosis, are more susceptible to low-energy trauma.[7] The AO/OTA classification system categorizes these fractures into type 13-A (extra-articular), type 13-B (partial articular), and type 13-C (complete articular), with complex intra-articular fractures (type 13-C) posing the greatest surgical challenge.[8,9]

Among posterior surgical approaches, the transolecranon approach with chevron olecranon osteotomy is considered one of the most effective methods for visualizing the articular surface.[10,11] This approach provides direct visualization of the trochlea, capitellum, and both columns, facilitating accurate reduction of complex fractures.[12] However, the osteotomy must be repaired at procedure completion. Traditionally, tension-band wiring (TBW) is used, converting tensile forces into compressive forces at the fracture site.[13,14]

Despite its widespread use, TBW is associated with several drawbacks including hardware prominence, soft tissue irritation, pain at wire placement sites, implant loosening, secondary displacement, non-union, and frequently the need for hardware removal surgery.[15,16] Double screw fixation (DSF) has emerged as an alternative, using two partially threaded lag screws to achieve rigid compression with a low implant profile.[17,18] Preliminary studies suggest reduced hardware-related complications with DSF.[11] This study was designed to prospectively compare the clinical and radiological outcomes of TBW versus DSF for olecranon osteotomy fixation in patients undergoing surgical treatment for complex distal humerus fractures.

2. Materials and Methods

Study Design and Setting: This prospective randomized interventional study was conducted at the Department of Orthopaedics, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan, India, from January 2024 to December 2024. The study was approved by the Institutional Ethics Committee (IEC No. 163/MC/EC/2023, dated 02-12-

2023) and conducted in accordance with the Declaration of Helsinki.

Sample Size and Randomization: A total of 60 patients were enrolled using consecutive sampling, with 30 patients allocated to each group. Sample size was determined at 95% confidence interval and 80% power to detect an expected difference of 35% in surgical revision requirement between groups.

Inclusion Criteria: (01) Complex distal humerus fractures (AO type 13-C) requiring olecranon osteotomy; (02) Age between 15 and 60 years; (03) Patients medically fit for surgery; (04) Provision of informed written consent.

Exclusion Criteria: (01) Ipsilateral fractures involving other limbs; (02) Severe head injury with permanent neurological deficit; (03) Patients unfit for anaesthesia or surgical intervention.

Surgical Technique: All patients underwent surgical fixation via posterior midline approach with chevron olecranon osteotomy under general anaesthesia. Patients were positioned in lateral decubitus with 90° shoulder antepulsion. The ulnar nerve was identified and protected throughout. A V-shaped osteotomy with proximal apex was performed using oscillating saw and osteotome. In the TBW group, the osteotomy was fixed using two 02 mm K-wires and stainless-steel wire in figure-of-eight configuration. In the DSF group, fixation was performed with two bicortical 04 mm cancellous screws.

Follow-up and Outcome Assessment: Patients were evaluated at 01 week, 02 weeks, 01 month, and 03 months postoperatively. Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS). Complications were categorized as immediate (wound-related) or late (infection, non-union, fixation failure, symptomatic hardware).

Statistical Analysis: Data were analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± standard deviation; qualitative variables as frequencies and percentages. A p-value ≤0.05 was considered statistically significant.

3. Results

A total of 60 patients with complex distal humerus fractures were enrolled, with 30 patients in each group. All patients completed the 03-month follow-up period. The mean age was 41.00±12.59 years in the TBW group and 42.50±11.03 years in the DSF group. Male patients predominated with 35 males (58.33%) and 25 females (41.67%). Road traffic accidents were the predominant mechanism (65.00%), followed by falls (30.00%).

Table 1: Distribution of Patients According to Age Group

Age Group (Years)	TBW Group (n=30)	DSF Group (n=30)	Total (n=60)
15-20	02 (06.67%)	00 (00.00%)	02 (03.33%)
21-30	07 (23.33%)	06 (20.00%)	13 (21.67%)
31-40	07 (23.33%)	06 (20.00%)	13 (21.67%)
41-50	05 (16.67%)	11 (36.67%)	16 (26.67%)
51-60	09 (30.00%)	07 (23.33%)	16 (26.67%)
Mean ± SD	41.00 ± 12.59	42.50 ± 11.03	41.75 ± 11.76

Table 2: Gender-wise Distribution of Patients

Gender	TBW Group (n=30)	DSF Group (n=30)	Total (n=60)
Male	18 (60.00%)	17 (56.67%)	35 (58.33%)
Female	12 (40.00%)	13 (43.33%)	25 (41.67%)

Table 3: Distribution According to Mechanism of Injury

Mechanism	TBW Group (n=30)	DSF Group (n=30)	Total (n=60)
RTA	19 (63.33%)	20 (66.67%)	39 (65.00%)
Fall	11 (36.67%)	07 (23.33%)	18 (30.00%)
Other	00 (00.00%)	03 (10.00%)	03 (05.00%)

Table 4: Distribution According to AO Fracture Classification

AO Type	TBW Group (n=30)	DSF Group (n=30)	Total (n=60)
13-C1	09 (30.00%)	16 (53.33%)	25 (41.67%)
13-C2	07 (23.33%)	08 (26.67%)	15 (25.00%)
13-C3	14 (46.67%)	06 (20.00%)	20 (33.33%)

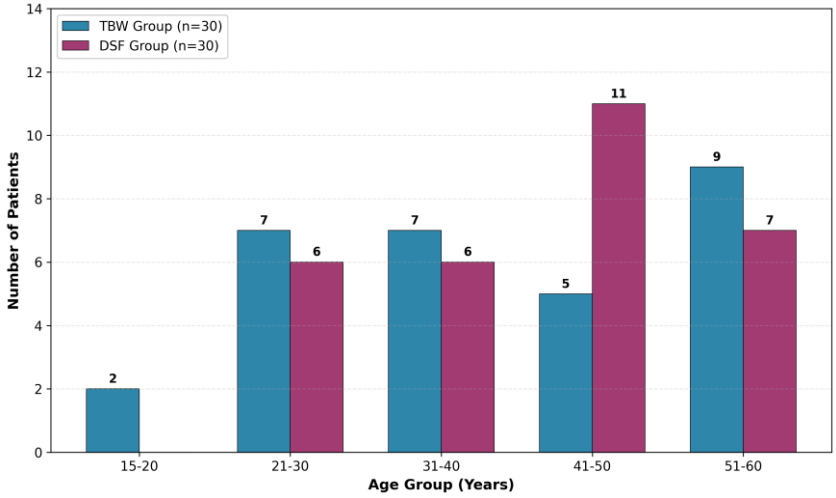

Figure 1: Distribution of Patients According to Age Group

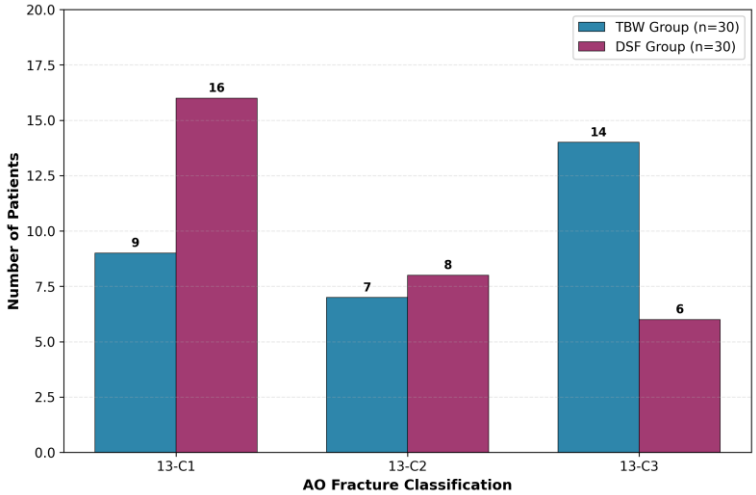

Figure 2: Distribution of AO Fracture Types Between Groups

Postoperative Complications: Immediate postoperative complications occurred in 04 patients (13.33%) in the TBW group and 03 patients (10.00%) in the DSF group. Late postoperative complications were significantly more frequent in the TBW group: 09 cases (30.00%) versus 03 cases (10.00%) in DSF ($p<0.001$). Implant removal was required in 06 patients (20.00%) in TBW versus 02 patients (06.67%) in DSF.

Table 5: Immediate Postoperative Complications

Complications	TBW Group (n=30)	DSF Group (n=30)	Total (n=60)
Yes	04 (13.33%)	03 (10.00%)	07 (11.67%)
No	26 (86.67%)	27 (90.00%)	53 (88.33%)

Table 6: Late Postoperative Complications

Complications	TBW Group (n=30)	DSF Group (n=30)	p-Value
Yes	09 (30.00%)	03 (10.00%)	<0.001
No	21 (70.00%)	27 (90.00%)	

Table 7: Implant Removal Due to Late Complications

Implant Removal	TBW Group (n=30)	DSF Group (n=30)	Total (n=60)
Yes	06 (20.00%)	02 (06.67%)	08 (13.33%)
No	24 (80.00%)	28 (93.33%)	52 (86.67%)

Functional Outcomes: Mayo Elbow Performance Score (MEPS) showed progressive improvement in both groups. At 03 months, mean MEPS was 87.4±7.69 (TBW) and 88.5±8.02 (DSF), with no statistically significant difference ($p=0.601$). Excellent outcomes were achieved in 13 (43.33%) TBW and 17 (56.67%) DSF patients. The mean arc of motion at 03 months was 103.87±16.01° (TBW) and 100.07±17.75° (DSF), $p=0.387$.

Table 8: Comparison of Mayo Elbow Performance Scores Over Time

Follow-up	TBW (Mean ± SD)	DSF (Mean ± SD)	p-value
01 Week	41.10 ± 05.76	40.60 ± 04.96	0.702
02 Weeks	70.60 ± 06.49	71.60 ± 06.54	0.581
01 Month	79.30 ± 05.98	81.10 ± 05.82	0.251
03 Months	87.40 ± 07.69	88.50 ± 08.02	0.601

Table 9: Functional Outcome at 03 Months Based on MEPS Grading

MEPS Grade	TBW (Mean ± SD)	DSF (Mean ± SD)	Total (n=60)
Excellent (90-100)	13 (43.33%)	17 (56.67%)	30 (50.00%)
Good (75-89)	17 (56.67%)	13 (43.33%)	30 (50.00%)
Fair (60-74)	00 (00.00%)	00 (00.00%)	00 (00.00%)
Poor (<60)	00 (00.00%)	00 (00.00%)	00 (00.00%)

Table 10: Comparison of Arc of Motion at 03 Months

Parameter	TBW Group	DSF Group	p-value
Arc of Motion (°)	103.87 ± 16.01	100.07 ± 17.75	0.387

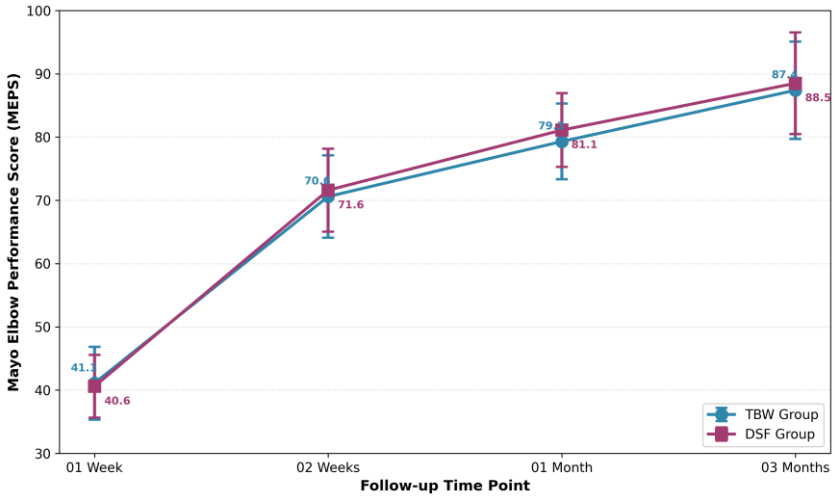

Figure 3: Progression of MEPS Over Follow-up Period

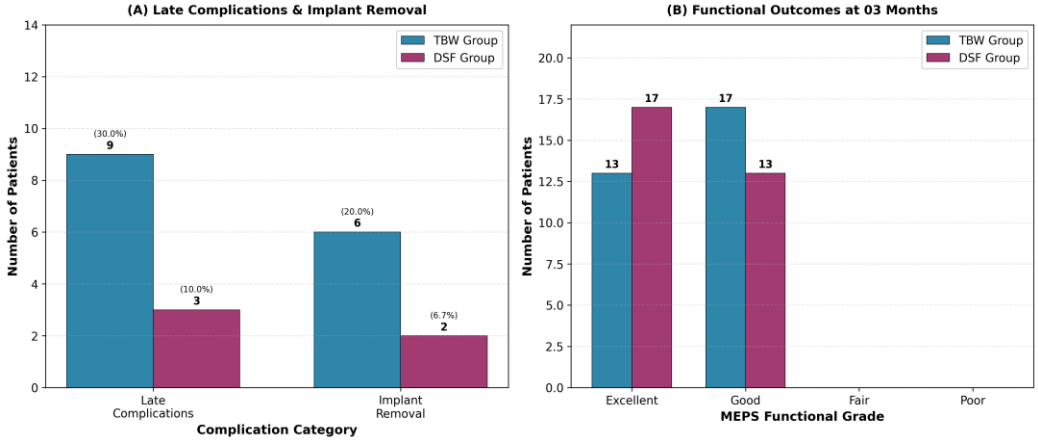

Figure 4: Complications and Functional Outcomes Comparison

4. Discussion

This prospective randomized study compared the outcomes of tension band wiring (TBW) versus double screw fixation (DSF) for olecranon osteotomy repair following surgical management of complex distal humerus fractures. Our findings demonstrate that while both techniques achieve satisfactory functional outcomes, DSF is associated with significantly fewer late complications and lower implant removal rates.

The mean age of our cohort (41.75±11.76 years) aligns with previous studies by Tian et al. who reported a mean age of 40.8±9.6 years in patients undergoing olecranon osteotomy and double-plate fixation for AO type C fractures.[19] Similarly, Dumartinet-Gibaud et al. in their landmark study comparing DSF and TBW reported mean ages of 44.2±13.7 years in the screw group and 46.5±11.8 years in the TBW group.[11] The male predominance in our study (58.33%) is consistent with findings by Munde et al. who reported 65% male patients in their series on double tension band wiring, reflecting higher exposure to road traffic accidents in this demographic.[20]

Road traffic accidents accounted for 65% of injuries in our study, which mirrors the findings of Bahroun et al. who reported high-energy trauma as the predominant mechanism in young adults with intercondylar fractures.[6] The higher proportion of 13-C3 fractures in the TBW group (46.67%) versus DSF (20.00%) represents a potential confounding factor, as more comminuted fractures typically require extensive surgical intervention. However, this distribution pattern aligns with Yıldız et al. who found no significant outcome differences among various fixation modalities when technique execution was optimal.[21]

Our primary finding of significantly higher late complications in the TBW group (30.00% versus 10.00%, $p<0.001$) strongly corroborates existing literature. Dumartinet-Gibaud et al. reported late complications in 56% of TBW cases compared to only 21% in DSF, with 24% experiencing fixation failure and 44% suffering from implant irritation in the TBW cohort.[11] Phadnis et al. in their comparative study of all-suture fixation versus TBW and plate fixation reported a 36% reoperation rate in TBW cases versus merely 02% in the suture group and 11% in the plate group.[22] Midtgaard et al. in their biomechanical cadaveric study observed hardware failure in 08 of 10 TBW constructs during cyclic loading, underscoring the vulnerability of this technique under physiological loads.[23]

The higher implant removal rate in TBW (20.00% versus 06.67%) is directly attributable to hardware prominence and soft tissue irritation inherent to K-wire and figure-of-eight wire constructs. Lee et al. in their study using TBW with ring pins observed that 33.3% of patients required implant removal due to persistent discomfort.[24] Woods et al. in their large series of 160 patients after olecranon osteotomy noted a 28% overall revision rate in the TBW group, significantly

higher than screw-and-washer constructs.[25] The low-profile nature of DSF minimizes subcutaneous implant prominence, thereby reducing patient discomfort and the need for secondary surgery.

The biomechanical rationale for these clinical observations merits consideration. Tension band wiring functions optimally under ideal conditions by converting tensile forces generated by the triceps into compressive forces at the osteotomy site during elbow flexion.[26] However, this mechanism requires precise surgical technique with parallel K-wire placement and adequate wire tensioning. Jones et al. in their synthetic ulna model demonstrated that transcortical screw fixation provided equivalent overall strength to TBW but with significantly less cyclic displacement, suggesting improved inter-cycle stability.[27] Ernstbrunner et al. further showed that all-suture tension band tape matched TBW for gap formation and ultimate load while eliminating metal prominence concerns.[28] These biomechanical findings support the clinical superiority of low-profile fixation constructs in reducing hardware-related complications while maintaining adequate stability for bone healing.

The clinical implications of our findings extend beyond immediate surgical outcomes to encompass healthcare resource utilization and patient quality of life. The threefold higher implant removal rate in TBW (20.00% versus 06.67%) translates to additional surgical procedures, hospital admissions, rehabilitation requirements, and time away from work for affected patients. Spierings et al. in their comprehensive review of 1,700 olecranon osteotomies reported overall infection rates of 04.2% and union problems in 03.7% of cases, emphasizing the importance of meticulous technique selection.[29] Furthermore, Ocalan et al. observed substantially more implant irritation and removal requirements with olecranon plates and K-wire constructs compared to cancellous screws following trans-olecranon approaches, favoring lower-profile constructs when skin-related complications are a concern.[30] Given the comparable functional outcomes between techniques, the significantly lower complication and reoperation rates with DSF position it as the more cost-effective and patient-friendly option for olecranon osteotomy fixation in complex distal humerus fractures.

Despite differences in complication rates, functional outcomes were comparable between groups. Mean MEPS at 03 months (87.4±7.69 TBW versus 88.5±8.02 DSF) aligns closely with studies by Tian et al. who reported mean MEPS of 91.2 and 92.1 in perpendicular and Y-plate groups respectively.[19] Haglin et al. found no significant difference in final MEPS between TBW (mean 89.7) and plate fixation (mean 90.3) following distal humerus ORIF.[31] The comparable arc of motion (103.87° TBW versus 100.07° DSF) falls within the functional range reported by Munde et al. (104.5°) and Allende et al. (100°), confirming both methods restore satisfactory elbow mobility for activities of daily living.[20,32]

The slightly higher proportion of excellent outcomes in DSF (56.67% versus 43.33%) may be attributed to reduced postoperative discomfort and better implant tolerance, allowing patients to participate more aggressively in rehabilitation protocols. Chen et al. in their systematic review and meta-analysis found that olecranon osteotomy yielded better functional outcomes than triceps-sparing approaches (pooled OR 2.38), likely due to superior articular exposure enabling precise reduction.[33] Our study reaffirms that both fixation methods are capable of achieving favorable outcomes when combined with meticulous surgical technique and appropriate postoperative rehabilitation.

5. Conclusion

In this prospective randomized study comparing tension band wiring and double screw fixation for olecranon osteotomy in complex distal humerus fractures, both techniques provided satisfactory functional outcomes with comparable MEPS scores and range of motion at 03 months. However, double screw fixation was associated with significantly fewer late postoperative complications (10.00% versus 30.00%), reduced need for implant removal (06.67% versus 20.00%), and a higher proportion of excellent outcomes. These findings suggest that double screw fixation may be considered a more reliable and patient-preferred method for olecranon osteotomy repair in the surgical management of complex distal humerus fractures.

6. Limitations

This study has several limitations: (01) single-center design limiting generalizability; (02) relatively small sample size; (03) short follow-up duration (03 months); (04) reliance on MEPS alone for functional assessment; (05) lack of standardized radiological union scoring; and (06) potential influence of surgeon preference on outcomes.

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