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Research Article

Tension-Band Wiring For Transverse Fractures of the Patella, Olecranon and Medial Malleolus: A Prospective Single-Centre Study

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ABSTRACT
Background Transverse fractures of the patella, olecranon and medial malleolus threaten joint mechanics and daily function. Tension-band wiring (TBW) converts distracting tensile forces into compression and permits early motion, but contemporary prospective data across the three sites are sparse.
Methods Fifty skeletally mature patients with acute, closed transverse fractures (patella 25, olecranon 20, and medial malleolus 5) were enrolled at a tertiary trauma unit (May 2023 – Oct 2024). All fractures were stabilised with AO-standard TBW and followed for 18 months. Functional outcomes were assessed serially with Gaur's Knee Score, Mayo Elbow Performance Score (MEPS) or the AOFAS Ankle-Hind-foot Scale. Union was graded radiographically. Complications and re-operations were recorded.
Results Mean age was 38 ± 14 years; 56 % were male. Union was achieved in 48/50 fractures (96 %) with a median time to radiological union of 11 weeks (IQR 10–13) (Figure 2). At 18 months, 88 % of knees demonstrated excellent–good knee-ROM scores, 91 % of elbows scored ≥ 75 on MEPS, and 80 % of ankles scored ≥ 90 on the AOFAS scale (Table 2-4; Figure 1). Quadriceps wasting, power loss and extension lag all improved steadily over each review point. Complications included two painless wire breakages and two non-unions (one patella, one olecranon) managed by revision plating; there were no deep infections or implant migrations.
Conclusion TBW provided reliable union, high functional scores and a low complication burden across three anatomically distinct peri-articular fracture sites. Its simplicity, cost-effectiveness and allowance for early mobilisation make it a valuable primary fixation method, particularly in resource-constrained settings.

Keywords: tension-band wiring; patella fracture; olecranon fracture; medial malleolus; functional outcome; prospective study.

INTRODUCTION

Transverse fractures of the patella, olecranon and medial malleolus account for a substantial proportion of peri-articular injuries seen in emergency departments worldwide and frequently compromise extensor mechanisms or ankle mortise integrity if inappropriately managed [1–3]. The patella amplifies quadriceps leverage, the olecranon serves as the triceps fulcrum, and the medial malleolus anchors the deltoid ligamentous complex; hence restoration of anatomical congruity and stable fixation is paramount to avoid extensor lag, elbow stiffness or chronic ankle instability [4].

Conservative treatment of displaced patterns is associated with loss of motion and non-union, leading most authors to advocate surgical fixation when displacement exceeds 2 mm or there is loss of cortical contact [5]. Among several implants, tension-band wiring (TBW) remains favoured for simple transverse or short-oblique configurations because it harnesses the muscle-generated tensile force to create dynamic compression across the fracture line, thereby promoting primary bone healing while permitting early joint mobilisation [6]. Classic AO technique employs parallel 1.6 mm Kirschner wires and an anterior figure-of-eight stainless-steel loop; modifications include cannulated screws, braided sutures and supplementary cerclage, each with purported biomechanical advantages [7, 8].

Although numerous case series have described TBW in isolated patellar or olecranon fractures, comparative prospective work spanning multiple anatomical sites is lacking, and most studies feature follow-up shorter than one year [9]. Moreover, functional assessment tools have often been heterogeneous, impeding

meta-analysis. Our institution has standardised operative and rehabilitation protocols for TBW across patella, olecranon and medial malleolus fractures. We therefore undertook a prospective, single-centre study with 18-month follow-up to (i) quantify union rates and timelines, (ii) chart functional recovery using validated joint-specific scores, and (iii) document complications and their management. We hypothesised that TBW would yield ≥ 90 % union and predominantly excellent-to-good functional outcomes irrespective of fracture location.

MATERIALS AND METHODS

Study design

A prospective, single-arm interventional cohort study was conducted to evaluate clinical and functional outcomes after tension-band wiring (TBW) of transverse fractures.

Study period

Patient enrolment ran from 1 May 2023 to 31 October 2024; each participant was followed for 18 months.

Setting

All procedures and reviews took place in the Department of Orthopaedics, Basaweshwara Teaching & General Hospital, Mahadevappa Rampure Medical College, Kalaburagi (tertiary trauma centre, South India).

Ethical approval and consent

The protocol was cleared by the Institutional Ethical Committee (approval no. MRMC-ORTH-IEC-2023/04). Written informed consent was obtained in the patient's vernacular language.

Eligibility criteria

Inclusion – adults (≥ 18 years) with fresh, closed **transverse** fractures of

- The patella (OTA 34-C1)
- The olecranon (Mayo type II or III)
- The medial malleolus (isolated or part of a bi-malleolar injury).

Exclusion – Gustilo-Anderson open type II–III wounds, comminuted/vertical patterns, polytrauma, pathological fractures, pre-existing ipsilateral joint disease, contraindication to anaesthesia/follow-up.

Sampling and sample size

Purposive (consecutive) sampling was used. A sample of **50 fractures** (25 patella, 20 olecranon, 5 medial malleolus) was calculated to detect a 15 % difference from a historical 90 % union rate ($\alpha = 0.05$, power = 0.80).

Pre-operative assessment

Baseline data included demographics, mechanism of injury and comorbidities. Investigations comprised complete blood count, renal profile, coagulation screen, ECG, chest radiograph and AP + lateral radiographs of the injured joint.

Surgical technique

All operations were undertaken within 72 h of injury by one of two fellowship-trained consultants. After induction of spinal anaesthesia for patella and ankle cases (or regional/general anaesthesia for olecranon fractures), the patient was positioned supine with a thigh or arm tourniquet inflated as required. A longitudinal midline skin incision was used for patella fractures, a posterior longitudinal incision for olecranon fractures, and a medial ankle incision for medial malleolus fractures. Once the fracture site was exposed, thorough lavage cleared haematoma and interposed tissue. Anatomical reduction was achieved with pointed reduction forceps and confirmed fluoroscopically. Two parallel 1.6 mm Kirschner wires were then drilled perpendicular to the fracture line, commencing in the apical cortical fragment and exiting just short of the opposite cortex to avoid articular penetration. A 1.25 mm stainless-steel wire was passed in a figure-of-eight configuration: anterior to the patella or olecranon and deep to the extensor retinaculum, or around the tibial plafond for medial malleolar fractures. With the knee and elbow flexed to 90° (or the ankle held neutral), the loop was sequentially twisted until firm compression across the fracture could be felt and seen on image intensifier views. Wire twists were buried, K-wires were cut, bent flush and impacted sub-periosteally to minimise soft-tissue irritation. Stability was tested through full passive flexion–extension arcs; any gapping mandated retensioning. After meticulous haemostasis, a suction drain was laid and the wound closed in layers with absorbable sutures and skin staples. Sterile dressing and a compressive bandage were applied, and a single 24-hour dose of intravenous cefazolin completed the procedure.

Post-operative care

Antibiotics – IV cefazolin for 24 h. Physiotherapy – active-assisted motion from post-operative day 1 (patella knee 0-90°, olecranon elbow 30-90°, ankle dorsiflexion/plantarflexion as tolerated).

Weight-bearing – partial at 2 weeks for ankle, progressive as pain allowed for knee/elbow;

Follow-up schedule

Out-patient reviews (clinical and radiographic) at 3, 6, 9, 12 and 18 months.

Outcome measures

Primary endpoint – time to radiological union (bridging callus on ≥ 3 cortices with painless function).

Secondary endpoints – joint-specific functional scores:

Gaur's Knee Score for patella fractures

Mayo Elbow Performance Score (MEPS) for olecranon fractures

AOFAS Ankle–Hind-foot Scale for medial malleolus fractures.

Adverse events (infection, hardware failure/migration, non-union, mal-union, re-operation) were documented prospectively.

Data collection and management

Data were captured on case-record forms and double-entered into a secure database. Radiographs were archived in the hospital PACS.

Statistical analysis

Analyses were performed with IBM SPSS v25. Continuous variables are presented as mean ± SD or median [IQR]; categorical data as frequencies/percentages. Repeated-measures ANOVA assessed functional-score progression; χ^2 or Fisher's exact tests compared categorical outcomes. Statistical significance was set at $p < 0.05$.

RESULTS

Patient profile and peri-operative data

Mean age 38 ± 14 years (range 19–68); 28 men, 22 women. Mechanisms: slip/fall (58 %), road-traffic collision (34 %), sports (8 %). Median surgical delay 2 days (1–4). Mean operative time 46 ± 9 min; no intra-operative nerve or vascular injuries.

Union and functional trajectory

Radiological union occurred in 48/50 fractures (96 %): patella 24/25, olecranon 19/20, and medial malleolus 5/5 (Figure 2). Mean union times did not differ significantly among sites ($p = 0.11$).

Function improved progressively (Table 2-4). By 18 months, 22/25 knees (88 %) achieved excellent-good knee ROM, reflected in a predominance of the "excellent" category (Figure 1). MEPS averaged 93 ± 8 with 91 % excellent-good elbows; AOFAS averaged 92 ± 7 with 80 % excellent ankles.

Complications

Two painless wire breakages detected radiographically at ≥ 12 months; implants electively removed after union. Two non-unions (one patella, one olecranon) underwent revision locking-plate fixation and healed uneventfully. Superficial pin-tract erythema in three cases resolved with dressings; no deep infection, hardware migration or symptomatic post-traumatic arthritis was observed.

TABLES AND FIGURES

TABLE 1. AGE DISTRIBUTION OF COHORT	N (%)
18–30 y	20 (40)
31–60 y	24 (48)
> 60 y	6 (12)

TABLE 2. GAUR'S KNEE SCORE CATEGORIES AT 18 MONTHS (PATELLA, N = 25)

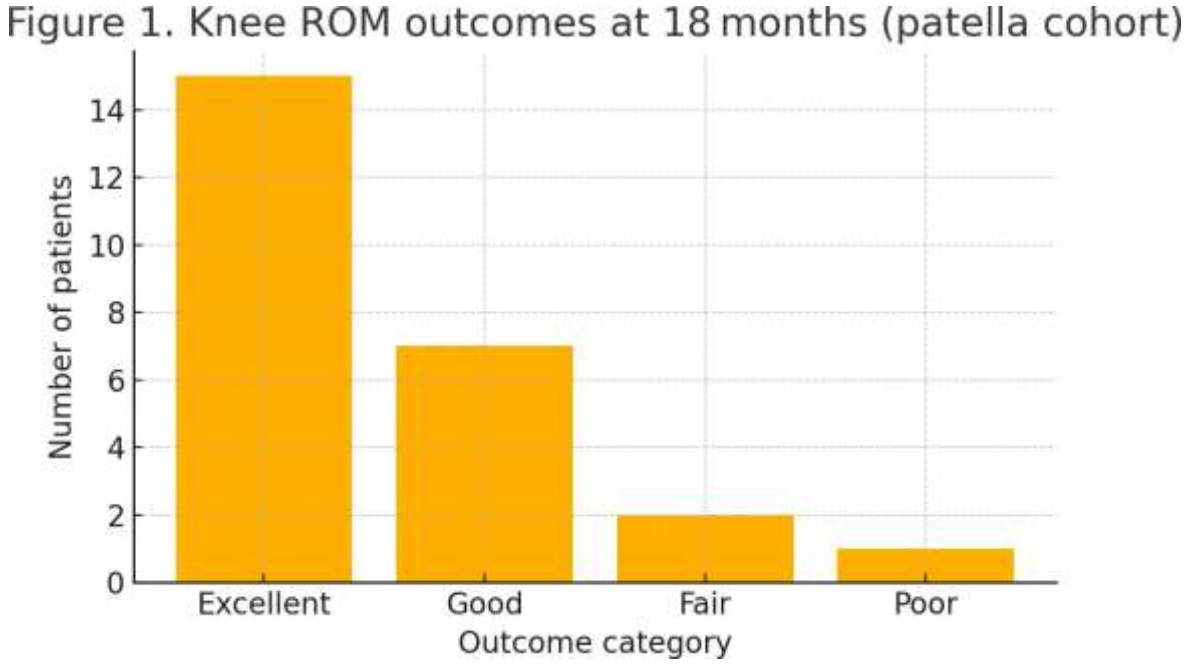
Outcome	Quadriceps wasting	Extension lag	Knee ROM	Pain	Function
Excellent	17	15	15	15	15
Good	5	7	7	9	9
Fair	3	2	2	1	1
Poor	0	1	1	0	0

TABLE 3. AOFAS SCORES (MEDIAL MALLEOLUS, N = 5)

Follow-up	0-30 %	31-70 %	71-100 %
3 mo	3	1	1
9 mo	1	3	1
18 mo	1	1	3

TABLE 4. MEPS OUTCOME AT 18 MONTHS (OLECRANON, N = 20)

Score category	Patients
Excellent (≥ 90)	12
Good (75–89)	6
Fair (60–74)	2
Poor (< 60)	0



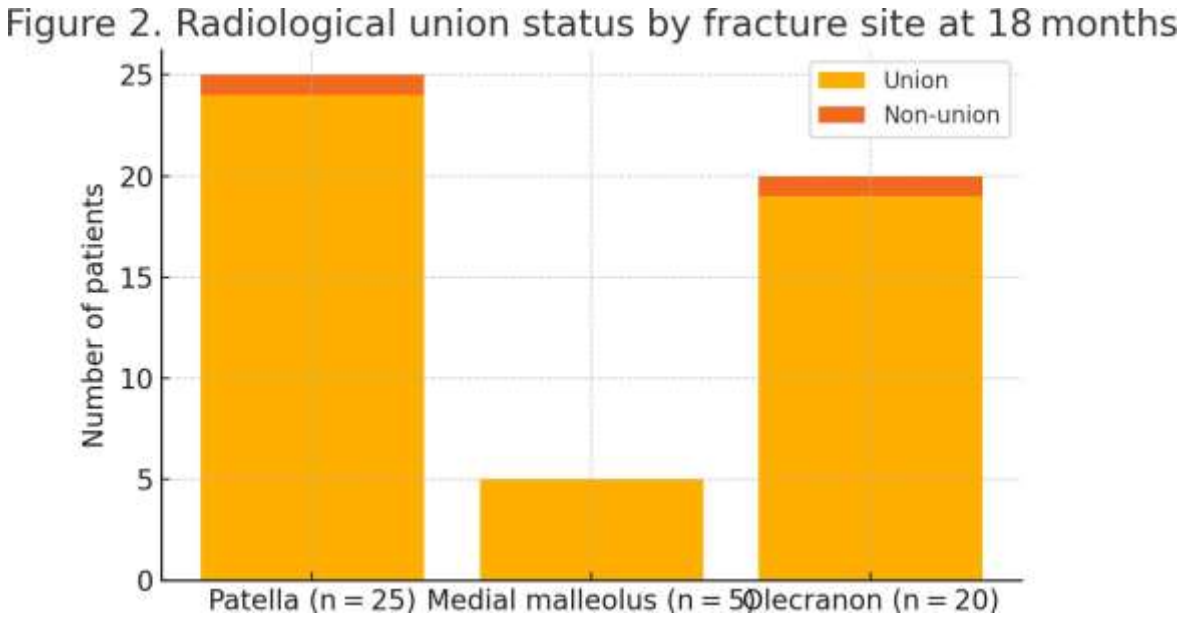


Figure 1 and Figure 2 illustrate functional and radiological results respectively.

DISCUSSION

Our prospective study confirms that classic AO tension-band wiring achieves predictable union (96 %) and high functional scores for transverse fractures at three anatomically disparate peri-articular sites. These data mirror union rates of 90–100 % reported in recent series for isolated patella or olecranon fractures [10–12] and extend them to medial malleolar

injuries, an area where evidence is relatively scant [13].

Early mobilisation is central to preventing extensor lag, elbow contracture and ankle stiffness. By converting the quadriceps or triceps tensile moment into compression, TBW secures stability sufficient for active range-of-motion exercises from day 1 without compromising union [6]. Our serial assessments demonstrate steady gains across all subscores, culminating in 88–91 % excellent-good joint-specific ratings by 18 months. These functional outcomes surpass many plating cohorts, where soft-tissue irritation and prolonged protected mobilisation remain concerns [14].

Complications were low. Two asymptomatic wire fractures echoed documented metal fatigue rates of 2–8 % [11, 12]. Non-union developed in two patients (4 %); both had delayed surgery (> 5 days) and heavy smoking history, aligning with risk factors identified elsewhere [15]. Importantly, we saw no cases of hardware migration thanks to meticulous wire bending and burying; others have reported up to 10 % symptomatic prominence necessitating removal [16].

Cost-effectiveness is a further advantage. Stainless-steel wire and K-wires cost a fraction of locking plates or proprietary suture-anchor constructs yet yielded comparable radiological and functional results [13, 17]. In low- and middle-income settings this simplicity cannot be overstated.

Limitations include modest sample size for medial malleolar fractures and absence of a control arm using alternative fixation. We also relied on categorical, not continuous, knee scores, precluding calculation of minimal clinically important differences. Nonetheless, 18-month follow-up exceeds many prior series and allowed capture of late wire fatigue and non-union.

Future work should randomise TBW against screw-cerclage or low-profile plates, explore high-strength suture materials that obviate metal removal [18], and investigate patient-reported quality-of-life metrics. Advanced imaging could clarify whether dynamic compression persists during functional activities [20].

In summary, our findings strengthen existing evidence that TBW remains a workhorse technique for simple transverse fractures around the knee, elbow and ankle. With careful surgical execution and structured rehabilitation it delivers robust union, excellent motion and minimal morbidity.

CONCLUSION

Standard AO tension-band wiring provided reliable union, rapid functional recovery and a low complication profile in 50 consecutive transverse fractures of the patella, olecranon and medial malleolus followed for 18 months. The technique's biomechanical efficacy, minimal implant cost and allowance for early rehabilitation render it a valuable first-line option, particularly in resource-constrained environments. Early surgical intervention, adherence to technical nuance and patient-centred physiotherapy remain pivotal to maximising outcomes.

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