



Functional Outcome of Modified Tension Band Wiring in Displaced Transverse Patellar Fractures: A Prospective Observational Study

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Abstract

Background: Patellar fractures account for approximately 1% of all skeletal injuries and are a frequent cause of disruption of the extensor mechanism of the knee. Displaced transverse fractures require operative restoration of the articular surface and stability of the extensor apparatus. The modified tension band wiring (TBW) technique using two parallel Kirschner wires and a stainless-steel cerclage in a figure-of-eight configuration remains the most widely employed fixation strategy worldwide owing to its biomechanical efficiency and technical familiarity. **Aim:** To prospectively evaluate the radiological, clinical, and functional outcomes of modified TBW in adult patients presenting with displaced transverse patellar fractures at a tertiary-care orthopaedic centre in South India. **Materials and Methods:** A prospective observational study was conducted between January 2007 and December 2009 at the Department of Orthopaedics, Coimbatore Medical College and Hospital, Tamil Nadu. Thirty-eight skeletally mature patients (aged 22-58 years) with isolated, closed, displaced transverse patellar fractures (AO/OTA 34-C1.1) were treated by open reduction and modified TBW under spinal anaesthesia. A standardised postoperative protocol of antibiotic prophylaxis, immediate static quadriceps strengthening, and protected weight-bearing was followed. Functional outcome was assessed using the Böstman knee score at a minimum follow-up of six months. **Results:** The cohort comprised 26 men (68.42%) and 12 women (31.58%) with a mean age of 41.8 ± 9.6 years. Slip-and-fall injuries (55.26%) and road-traffic accidents (36.84%) were the leading mechanisms. Radiological union was achieved in all 38 patients within a mean of 11.4 ± 1.8 weeks. The mean Böstman score at final follow-up was 27.18 ± 2.34 , with 16 excellent (42.11%), 16 good (42.11%), and 6 satisfactory (15.79%) results. Five complications (13.16%) were recorded, comprising one superficial wound infection, one persistent knee stiffness, and three symptomatic implant prominences requiring delayed removal. **Conclusion:** Modified tension band wiring is a safe, reproducible, and biomechanically efficient fixation method for displaced transverse patellar fractures, yielding excellent or good functional outcomes in over 84% of patients in this South Indian cohort. The technique remains the fixation of choice in resource-limited settings.

Keywords: Patella fracture; Tension band wiring; Kirschner wire; Böstman score; Functional outcome; Open reduction and internal fixation; South India.

1. Introduction

The patella is the largest sesamoid bone of the human skeleton and an integral mechanical component of



the knee extensor apparatus. Fractures of the patella account for approximately 1% of all skeletal injuries and are most often encountered in the third to sixth decades of life [1,2]. The bimodal aetiology comprises direct trauma sustained during a fall onto the flexed knee and indirect violence generated by an unbalanced contraction of the quadriceps muscle. Among the various morphological patterns described in the AO/OTA classification, transverse fractures involving the central or middle one-third of the patella are the most common, accounting for between 50% and 80% of all patellar injuries seen at tertiary trauma centres [3,4].

A displaced transverse patellar fracture invariably disrupts the extensor mechanism and creates incongruity of the patellofemoral articulation, resulting in loss of active knee extension, persistent anterior knee pain, and post-traumatic patellofemoral arthritis if treated inadequately [5]. The historical management of these fractures has progressively evolved from total or partial patellectomy in the early twentieth century to anatomic open reduction and internal fixation (ORIF), which has now been universally accepted as the standard of care for any articular displacement greater than 2-3 mm or fragment separation greater than 3 mm [6,7].

Numerous fixation strategies have been described in the literature, including circumferential cerclage wiring, modified tension band wiring (TBW) with Kirschner wires or cannulated screws, dual interfragmentary cancellous screws, suture anchors, braided polyester sutures, biodegradable implants, and circular external fixation systems [8-12]. Of these, the modified TBW technique recommended by the Arbeitsgemeinschaft für Osteosynthesefragen (AO) Group remains the most widely employed worldwide owing to its biomechanical efficiency, low cost, technical familiarity to the practising orthopaedic surgeon, and the universal availability of its components [13,14]. The principle of TBW is straightforward: two parallel longitudinal Kirschner wires resist the bending moment across the fracture, while a stainless-steel cerclage applied in a figure-of-eight pattern over the anterior surface of the patella converts the distractive tensile forces generated during knee flexion into compressive forces at the posterior articular surface, thereby promoting primary bone healing and permitting early mobilisation [15,16].

Despite its long-standing acceptance, the success of TBW depends on rigorous attention to operative technique, the quality of bone, the precision of articular reduction, the postoperative rehabilitation regimen, and the compliance of the patient. Reported complication rates in published series range from 0% to 22%, with the most frequently cited adverse events being symptomatic implant prominence, superficial wound infection, knee stiffness, secondary loss of reduction, and implant breakage [17,18]. Functional outcomes assessed using validated knee scoring systems such as the Böstman knee score have, however, remained favourable in the majority of contemporary series [19,20].

In the South Indian context, where road-traffic accidents and falls during agricultural labour or domestic activity contribute substantially to the burden of musculoskeletal trauma, patellar fractures are encountered at every level of the orthopaedic care pyramid. However, prospective audits documenting the surgical and functional outcomes of TBW from this region remain limited. The present prospective observational study was therefore undertaken to evaluate the radiological union rate, complication profile, and functional outcomes of modified tension band wiring in patients presenting with displaced transverse patellar fractures at a tertiary-care orthopaedic department located in Coimbatore, Tamil Nadu.



2. MATERIALS AND METHODS

2.1. *Study design and setting*

This was a prospective, single-centre, observational study conducted at the Department of Orthopaedics, Coimbatore Medical College and Hospital, Coimbatore, Tamil Nadu, South India, between January 2007 and December 2009. Coimbatore Medical College Hospital is a 1500-bed tertiary-care teaching hospital that serves the western districts of Tamil Nadu and the adjoining regions of Kerala and Karnataka, and receives in excess of 4000 trauma admissions annually.

2.2. *Ethical considerations*

The study protocol, the informed consent document, and the data collection proforma were reviewed and approved by the Institutional Human Ethics Committee of Coimbatore Medical College and Hospital. The investigation was conducted in compliance with the principles of the Declaration of Helsinki (revised 2008) and the Indian Council of Medical Research (ICMR) Ethical Guidelines for Biomedical Research on Human Subjects. Written informed consent was obtained from each participant prior to enrolment.

2.3. *Sampling and sample size*

A consecutive sampling strategy was adopted. All adult patients presenting to the orthopaedic outpatient or emergency department during the study period with a clinical and radiological diagnosis of displaced transverse patellar fracture meeting the eligibility criteria were considered for enrolment. Based on prior published series suggesting an excellent-to-good outcome of approximately 80% with TBW and a 5% margin of error at a 95% confidence level, a minimum sample of 36 patients was calculated. A final cohort of 38 patients was prospectively recruited.

2.4. *Inclusion criteria*

Patients of either gender aged between 18 and 60 years; closed displaced transverse patellar fracture (AO/OTA 34-C1.1) with articular displacement greater than 2 mm or fragment separation greater than 3 mm; presentation within 14 days of injury; and willingness to comply with the structured follow-up protocol were included.

2.5. *Exclusion criteria*

Patients with comminuted, stellate or vertical patellar fracture patterns; open fractures (Gustilo type II or III); pathological fractures; polytrauma with associated long-bone fractures requiring concurrent fixation; pre-existing ipsilateral knee pathology (osteoarthritis, prior knee surgery, ligamentous injury); patients medically unfit for regional anaesthesia; and those who declined informed consent were excluded.

2.6. *Surgical technique*

All procedures were performed by a single team of senior orthopaedic surgeons under subarachnoid block with the patient supine and a small sandbag placed beneath the ipsilateral knee. After standard antiseptic preparation and draping, a midline longitudinal incision was made over the anterior aspect of the patella. Sequential dissection through the subcutaneous tissue, the prepatellar bursa, and the retinaculum exposed



the fracture site. Haematoma and interposed soft tissue were debrided, and the articular surface was inspected through the fracture defect. Anatomical reduction was achieved using a pointed reduction forceps and confirmed under image-intensifier guidance.

Two parallel longitudinal Kirschner wires (1.6-2.0 mm diameter) were introduced from the proximal pole of the patella, traversing the fracture line and exiting through the distal pole. An 18-gauge stainless-steel cerclage wire was passed in a figure-of-eight configuration deep to the prominences of the K-wires, anterior to the patella. The wire was tightened at the superolateral aspect of the patella to engage the cortices on both sides of the fracture. The proximal ends of the K-wires were then bent, shortened and rotated 180° to engage the patellar bone, while the distal ends were trimmed flush. The retinacular tear was repaired with absorbable sutures and the wound was closed in layers over a closed-suction drain.

2.7. Postoperative protocol

Intravenous cefazolin (1 g) was administered for 24 hours, followed by oral cefuroxime axetil (500 mg twice daily) for five days. The closed-suction drain was removed at 48 hours. Static quadriceps strengthening exercises were initiated on the first postoperative day, and assisted active knee flexion was started from day three. Touch-down weight-bearing was permitted with a long knee immobiliser and crutches from day two, progressing to full weight-bearing by week three. Cutaneous sutures were removed on the tenth postoperative day.

2.8. Follow-up and outcome assessment

Patients were reviewed at two-week intervals for the first month, monthly until radiological union, and three-monthly thereafter for a minimum follow-up of six months. Clinical assessment of knee range of motion, tenderness, swelling, and active straight-leg raise was complemented by anteroposterior and lateral radiographs of the knee. Radiological union was defined as the presence of bridging trabeculae across the fracture line on both views and the absence of pain on weight-bearing. Functional outcome at the final follow-up was assessed using the Böstman knee scoring system, which evaluates eight clinical parameters - pain, atrophy of the quadriceps, range of motion, ability to perform stair climbing and squatting, work activity, knee giving way, and walking aids - and yields a maximum composite score of 30. Results were graded as excellent (28-30), good (20-27) or satisfactory (<20)

2.9. Statistical analysis

Data were captured on a structured proforma and entered into Microsoft Excel 2007. Continuous variables were summarised as mean \pm standard deviation, while categorical variables were reported as frequencies and percentages. Comparisons between subgroups were made using the unpaired t-test for continuous variables and the chi-square test for categorical variables. Statistical analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA), with a two-tailed p-value < 0.05 considered statistically significant.

3. RESULTS

3.1. Demographic and injury characteristics

A total of 38 patients with displaced transverse patellar fractures were recruited and completed the study. The cohort comprised 26 men (68.42%) and 12 women (31.58%), giving a male-to-female ratio of 2.17:1.



The mean age of the cohort was 41.8 ± 9.6 years (range 22-58 years). Slip-and-fall injuries accounted for the majority of fractures ($n = 21$; 55.26%), followed by road-traffic accidents ($n = 14$; 36.84%) and sports-related trauma ($n = 3$; 7.90%). The right side was involved in 23 patients (60.53%) and the left side in 15 patients (39.47%). The complete demographic and injury profile of the cohort is presented in Table 1.

Table 1: Demographic and injury characteristics of the study cohort (n = 38)

Variable	Category	Number	%
Gender	Male	26	68.42
	Female	12	31.58
Age group (years)	18-30	9	23.68
	31-45	17	44.74
	46-60	12	31.58
Mode of injury	Slip and fall	21	55.26
	Road-traffic accident	14	36.84
	Sports injury	3	7.90
Side of injury	Right	23	60.53
	Left	15	39.47

3.2. Time to presentation, surgery and union

The mean interval between injury and hospital presentation was 2.6 ± 1.4 days (range 1-9 days), and surgery was performed within a mean of 3.4 ± 1.2 days after presentation (range 1-7 days). The mean operative duration was 58 ± 12 minutes, and the estimated intraoperative blood loss was 65 ± 20 mL. Radiological union was achieved in all 38 patients (100%) without the need for any secondary procedure for non-union or revision fixation. The mean time to radiological union was 11.4 ± 1.8 weeks (range 9-15 weeks). No patient demonstrated loss of reduction or implant migration on serial radiographs.

3.3. Complications

A total of five complications (13.16%) were observed in the cohort and are summarised in Table 2. One patient (2.63%) developed a superficial surgical-site infection that was managed conservatively with daily dressings and a one-week course of oral co-amoxiclav, with complete resolution within three weeks. One patient (2.63%) presented with persistent knee stiffness at three months, attributable to non-compliance with the prescribed physiotherapy programme; range of motion improved partially with intensified rehabilitation. Three patients (7.90%) reported symptomatic implant prominence necessitating elective removal of the K-wires and tension-band wire after radiological union (mean time to removal, 9.2 months). No deep infection, implant failure, non-union, or refracture was recorded.

Table 2: Complications observed in the study cohort

Complication	Number	%	Outcome
Superficial wound infection	1	2.63	Resolved
Persistent knee stiffness	1	2.63	Improved



Symptomatic implant prominence	3	7.90	Removed
Total	5	13.16	—

3.4. Functional outcome

The mean Böstman knee score at the final follow-up was 27.18 ± 2.34 (range 19-30). The distribution of functional outcomes is detailed in Table 3. Sixteen patients (42.11%) achieved an excellent outcome, 16 patients (42.11%) a good outcome, and 6 patients (15.79%) a satisfactory outcome. Cumulatively, 84.22% of patients achieved an excellent-to-good functional result. The mean active knee flexion at the final follow-up was $132^\circ \pm 8^\circ$, and the mean active extension lag was $2.1^\circ \pm 1.4^\circ$. All patients had returned to their pre-injury occupational activity by a mean of 5.8 ± 1.6 months postoperatively.

Table 3: Distribution of Böstman knee scores at the final follow-up

Grade	Score range	Number of patients	Percentage
Excellent	28-30	16	42.11
Good	20-27	16	42.11
Satisfactory	< 20	6	15.79
Total	—	38	100.00

3.5. Subgroup observations

The functional outcome did not differ significantly with respect to gender (mean Böstman score: men 27.31 vs. women 26.92; $p = 0.62$) or side of injury (right 27.22 vs. left 27.13; $p = 0.91$). Patients younger than 45 years achieved a numerically higher mean Böstman score than older patients (27.74 vs. 26.42), although the difference did not reach statistical significance ($p = 0.07$).

4. DISCUSSION

This prospective single-centre observational study evaluated the surgical and functional outcomes of modified tension band wiring (TBW) in 38 South Indian adults with displaced transverse patellar fractures. Radiological union was achieved in all patients within a mean of 11.4 weeks, with 84.22% of patients attaining excellent-to-good Böstman scores and an overall complication rate of 13.16%. These findings reaffirm the long-recognised efficacy of TBW as a fixation strategy for transverse patellar fractures and corroborate the experience reported by previous Indian and international investigators [3,12,14].

The mean radiological union time of 11.4 weeks observed in our cohort compares favourably with the 12-14 weeks reported by Schmal et al. and the 10-12 weeks documented by Aksoy et al. in their respective series [11,18]. The 100% union rate underscores the biomechanical robustness of the figure-of-eight configuration, which transforms tensile forces at the anterior surface into compressive forces at the articular surface during knee flexion, thereby providing optimal mechanical stimulus for primary bone healing [13]. John et al. demonstrated in a cadaveric biomechanical investigation that the position of the cerclage twist and the orientation of the loop significantly influence the load-to-failure characteristics, with diagonally oriented twists at the superolateral pole providing the most uniform compression [13].

A complication rate of 13.16% in our series falls within the 0-22% range previously reported in the literature. Earlier Indian series have reported postoperative infection rates of between 3% and 10% [11,12], whereas Ong et al. reported no complications in their smaller series of combined cerclage and TBW fixation



[12]. Symptomatic implant prominence remains the most frequently encountered late complication of TBW, occurring in approximately 8-30% of cases depending on the gauge of wire used, the site of the cerclage twist, the volume of soft-tissue cover, and the patient's body habitus [13,14]. In our cohort, three of the five complications (60%) involved symptomatic implants, all of which resolved completely after planned implant removal once radiological union was confirmed. The single case of postoperative knee stiffness was attributable to non-compliance with the physiotherapy regimen rather than to inadequate fixation, emphasising the importance of patient education and structured rehabilitation in achieving optimal functional recovery.

The mean Böstman score of 27.18 in our cohort is comparable with the scores of 26.54, 27.36, and 28.10 reported by other contemporary tension-band-wiring series [16,19,21]. The proportion of patients in our series who achieved excellent-to-good outcomes (84.22%) lies at the upper end of the published range. The numerically lower mean score among patients older than 45 years may reflect age-related decline in muscle strength and rehabilitation capacity, an observation consistent with the findings of Veselko and Kastelec, who reported that age >50 years was the strongest independent predictor of inferior functional recovery after patellar fixation [9]. These observations emphasise the need for tailored, age-appropriate rehabilitation protocols and intensified physiotherapy in older patients.

The principal limitations of the present study include its single-centre design, the absence of a comparator arm employing alternative fixation strategies (cannulated screws, polyester braided sutures, or biodegradable implants), and the relatively short minimum follow-up of six months. The Böstman score, while reproducible, does not capture patient-reported quality-of-life dimensions. Future randomised controlled trials powered to detect modest differences between TBW and contemporary fixation techniques, and incorporating patient-reported outcome measures with longer follow-up, are warranted to inform evidence-based selection of fixation strategies for displaced transverse patellar fractures.

5. CONCLUSION

Modified tension band wiring using two parallel Kirschner wires and a stainless-steel figure-of-eight cerclage remains a safe, simple, and biomechanically efficient surgical option for the management of displaced transverse patellar fractures. In this prospective observational study of 38 adult patients treated at a tertiary-care orthopaedic centre in Coimbatore, Tamil Nadu, the technique yielded uniform radiological union within a mean of 11.4 weeks and a clinically meaningful Böstman score of 27.18, with 84.22% of patients achieving excellent-to-good functional outcomes. The complication profile was modest and was dominated by symptomatic implant prominence, which was readily amenable to delayed removal. Adherence to careful operative technique - meticulous reduction, parallel placement of K-wires, snug application of the figure-of-eight cerclage, and burying of the wire ends - in combination with a structured early rehabilitation programme is the cornerstone of a successful outcome. Modified tension band wiring therefore continues to be a worthy fixation choice in resource-limited South Indian settings.

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