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Research Article

Functional Outcome of Displaced Transverse Patellar Fracture Treated With Tension Band Wiring: A Prospective Interventional Study

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ABSTRACT
Background: Displaced transverse fractures of the patella disrupt the extensor mechanism of the knee and usually require surgical fixation to restore articular congruity, knee function, and early mobilization. Tension band wiring (TBW) remains the standard treatment for these fractures because it converts tensile forces into compressive forces at the fracture site during knee flexion. However, functional recovery and postoperative complications continue to vary among patients.
Methods: A prospective interventional study was conducted in the Department of Orthopaedics, Geetanjali Medical College and Hospital, Udaipur, India, between April 2024 and October 2025. Forty adult patients with displaced transverse patellar fractures underwent open reduction and internal fixation using the AO tension band wiring technique. Functional outcome was assessed using the Böstman scoring system during serial follow-up visits up to 24 weeks. Demographic characteristics, operative details, postoperative complications, and sequential improvements in pain, range of motion, stability, and overall function were analyzed using appropriate statistical methods. A p-value <0.05 was considered statistically significant.
Results: The majority of patients were 41–50 years old (72.5%), and males accounted for 60% of the study population. Road traffic accidents were the most common mechanism of injury (45%). Most procedures were completed within 70–90 minutes (82.5%). Immediate postoperative complications were uncommon, with surgical site infection and swelling each occurring in 2.5% of patients, while late complications included restricted knee motion (7.5%) and implant failure (2.5%). The mean total Böstman score was 26.63 ± 5.14. Excellent functional outcomes were achieved in 47.5% of patients, good outcomes in 37.5%, and poor outcomes in 15%, resulting in an overall satisfactory outcome rate of 85%. Significant improvements were observed in pain, range of motion, stability, and functional performance throughout the 24-week follow-up period ($p<0.01$).
Conclusion: Tension band wiring provides reliable fixation for displaced transverse patellar fractures, resulting in satisfactory functional recovery, low complication rates, and significant improvement in knee function. The technique remains an effective, reproducible, and cost-effective surgical option for appropriately selected patients.

Keywords: Patellar Fracture, Tension Band Wiring, Functional Outcome, Böstman Score, Internal Fixation, Knee Fracture.

INTRODUCTION

Patellar fractures account for approximately 0.5–1% of all skeletal fractures and represent an important injury affecting the extensor mechanism of the knee. Although relatively uncommon, these fractures can result in considerable functional impairment because the patella plays a critical role in transmitting quadriceps force and increasing the mechanical efficiency of knee extension. Disruption of the extensor mechanism may lead to pain, extensor lag, reduced range of motion, weakness of the quadriceps, and difficulty performing routine activities such as walking, climbing stairs, squatting, and rising from a seated position. Restoration of patellar anatomy and extensor mechanism continuity is therefore essential for achieving satisfactory functional recovery (1,2).

Patellar fractures most commonly occur following either direct trauma to the anterior aspect of the knee or indirect injury caused by sudden forceful contraction of the quadriceps against a flexed knee. Direct trauma, frequently associated with road traffic accidents or falls onto the knee, often produces comminuted fracture patterns, whereas indirect mechanisms usually result in displaced transverse fractures. Among the various fracture configurations, displaced transverse fractures are the most common pattern requiring operative management because displacement disrupts the extensor mechanism and compromises articular congruity.(3) If inadequately treated, these injuries may progress to persistent anterior knee pain, extensor weakness, reduced mobility, malunion, nonunion, or post-traumatic patellofemoral osteoarthritis (4).

The primary objective of surgical treatment is to restore the articular surface, achieve stable fixation, preserve patellar bone stock, and permit early knee mobilization while maintaining the integrity of the extensor mechanism. Various operative techniques have been described, including tension band wiring, cannulated screw fixation, cerclage wiring, plate fixation, partial patellectomy, and hybrid fixation constructs.(5) The choice of fixation depends on fracture morphology, degree of comminution, bone quality, and surgeon preference. However, for simple displaced transverse fractures, tension band wiring remains the most widely accepted technique because of its well-established biomechanical principle and reproducible clinical outcomes.

The principle of tension band wiring is based on converting tensile forces generated by the quadriceps mechanism into compressive forces across the fracture site during knee flexion. This dynamic compression promotes fracture stability, facilitates bone healing, and enables early rehabilitation. Standard fixation involves anatomical reduction of the fracture followed by insertion of two parallel Kirschner wires combined with an anterior figure-of-eight stainless steel wire. When performed correctly, this construct provides sufficient stability to allow early knee motion, thereby minimizing postoperative stiffness and improving functional recovery (6).

Despite its widespread acceptance as the gold standard for displaced transverse patellar fractures, tension band wiring is not without limitations. Hardware prominence, wire migration, implant failure, symptomatic irritation, infection, and secondary implant removal remain frequently reported complications. Furthermore, variations in surgical technique, fracture characteristics, patient demographics, rehabilitation protocols, and duration of follow-up contribute to differences in functional outcomes among published studies(7). Recent comparative studies have also evaluated newer fixation techniques, including cannulated screws and low-profile plating systems, reporting reduced implant-related complications in selected fracture patterns while demonstrating fracture union rates comparable to conventional tension band wiring (8,9).

Assessment of postoperative functional outcome is an essential component in determining the success of patellar fracture management. Several validated scoring systems have been described, among which the Böstman score remains one of the most commonly used tools because it comprehensively evaluates pain, range of motion, quadriceps muscle function, walking ability, stair climbing, knee stability, and return to work. Together with radiological assessment, functional scoring provides an objective measure of clinical recovery and allows comparison between different treatment strategies (10).

MATERIALS AND METHODS

Study Design and Setting

This prospective interventional study was conducted in the Department of Orthopaedics, Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India, between April 2024 and October 2025.

Study Population

A total of 40 consecutive adult patients diagnosed with displaced transverse patellar fractures and scheduled for operative fixation were included. Patients aged 18–60 years with radiologically confirmed displaced transverse fractures and willingness to participate were eligible for inclusion.

Patients with comminuted patellar fractures, open fractures (Gustilo–Anderson type II or III), associated major skeletal injuries, those medically unfit for anesthesia, or those unwilling to provide informed consent were excluded from the study.

Preoperative Evaluation

All patients underwent detailed clinical evaluation, including demographic characteristics, mechanism of injury, associated comorbidities, and physical examination. Standard anteroposterior and lateral radiographs of the affected knee were obtained

to confirm the diagnosis, determine fracture configuration, and assess fracture displacement. Routine pre-anesthetic investigations were performed before surgery.

Surgical Technique

All procedures were performed under spinal anesthesia with the patient in the supine position using standard aseptic precautions. A midline longitudinal incision was made over the patella to expose the fracture site. Hematoma and interposed soft tissues were removed, and anatomical reduction of the fracture fragments was achieved using reduction clamps under fluoroscopic guidance.

Internal fixation was performed according to the standard AO tension band wiring technique. Two parallel Kirschner wires were inserted longitudinally across the fracture, followed by placement of an 18-gauge stainless steel wire in a figure-of-eight configuration over the anterior surface of the patella. The wire was tightened to convert tensile forces generated during knee flexion into compressive forces across the fracture site. After satisfactory reduction and fixation were confirmed fluoroscopically, the Kirschner wires were bent and buried proximally to minimize migration, and the wound was closed in layers after repair of the retinacular tissues where necessary.

Postoperative Management

All patients received intravenous antibiotic prophylaxis and standard analgesic therapy according to institutional protocol. Static quadriceps strengthening exercises were initiated on the first postoperative day. Depending on pain tolerance and fixation stability, patients were encouraged to begin early mobilization with full weight-bearing as tolerated. Wound inspection was performed on the second postoperative day, and sutures were removed approximately 14–15 days after surgery.

Follow-up and Outcome Assessment

Patients were followed at 2 weeks, 4 weeks, 8 weeks, 12 weeks, and 24 weeks after surgery. During each visit, clinical examination and radiographic evaluation were performed to assess fracture healing, implant position, knee range of motion, pain, stability, and postoperative complications.

Functional outcome was assessed using the Böstman scoring system, a validated knee-specific scoring system with a maximum score of 30 points. The score evaluates pain, range of motion, work capacity, quadriceps muscle atrophy, walking ability, knee effusion, episodes of giving way, and stair-climbing ability. Functional outcomes were classified as excellent (28–30 points), good (20–27 points), and poor (<20 points).

Immediate postoperative complications, including surgical site infection and wound-related problems, as well as late complications such as implant failure and restricted knee motion, were documented throughout the follow-up period.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were summarized as frequency and percentage. Changes in clinical parameters during follow-up were analyzed using repeated-measures analysis, and appropriate parametric or non-parametric statistical tests were applied wherever indicated. A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Baseline Demographic and Injury Characteristics of the Study Participants (N = 40)

	Variable	Number Of Cases	Percentage
Age (Years)	30–40 Yrs	5 (12.5)	12.5
	41–50 Yrs	29 (72.5)	72.5
	51–60 Yrs	6 (15.0)	15.0
Sex	Male	24 (60.0)	60.0
	Female	16 (40.0)	40.0
Mechanism Of Injury	Road Traffic Accident	18 (45.0)	45.0
	Fall From Height	14 (35.0)	35.0
	Accidental Fall	8 (20.0)	20.0
Side Involved	Right	22 (55.0)	55.0
	Left	18 (45.0)	45.0

Table 2. Operative Characteristics and Postoperative Complications

Variable	Number Of Cases	Percentage
Duration Of Surgery		
70–80 Min	16 (40.0)	40.0
81–90 Min	17 (42.5)	42.5
91–100 Min	3 (7.5)	7.5
>100 Min	4 (10.0)	10.0
Blood Transfusion	6 (15.0)	15.0
Associated Fracture Fixation	6 (15.0)	15.0
Immediate Complications	2 (5.0)	5.0
Late Complications	4 (10.0)	10.0

Table 3. Functional Outcome According To the Böstman Scoring System

Outcome	Number Of Cases (%)
Excellent	19 (47.5)
Good	15 (37.5)
Poor	6 (15.0)
Mean Total Böstman Score	**26.63 ± 5.14**

Table 4. Mean Clinical Parameters during Follow-Up

Follow-Up	Pain	Range Of Motion	Stability	Function
Baseline	7.78 ± 0.70	2.85 ± 0.36	3.85 ± 0.36	2.85 ± 0.36
4 Weeks	5.30 ± 0.72	5.33 ± 0.73	6.18 ± 1.03	5.18 ± 1.03
8 Weeks	2.83 ± 1.03	7.18 ± 1.03	8.03 ± 1.37	7.03 ± 1.37
12 Weeks	1.83 ± 1.03	9.03 ± 1.37	9.03 ± 1.37	8.88 ± 1.71
24 Weeks	1.43 ± 0.50	9.38 ± 1.07	9.55 ± 0.93	9.28 ± 1.32

Table 5. Statistical Analysis of Serial Clinical Recovery

Variable	F-Value	P-Value
Pain	360.55	<0.001
Range Of Motion	308.75	<0.001
Stability	167.63	<0.001
Function	176.88	<0.001

DISCUSSION

The present prospective interventional study evaluated the functional outcomes of displaced transverse patellar fractures treated with tension band wiring. The findings demonstrated that this technique provides reliable fracture fixation with satisfactory functional recovery, as evidenced by a mean Böstman score of 26.63 ± 5.14, with 85% of patients achieving excellent or good outcomes. Significant improvements were observed in pain, range of motion, knee stability, and functional performance throughout the 24-week follow-up period. Furthermore, postoperative complications were infrequent and generally manageable, supporting the continued role of tension band wiring as an effective treatment for appropriately selected transverse patellar fractures.

The majority of patients in the present study were middle-aged adults (41–50 years), with a male predominance and road traffic accidents representing the most common mechanism of injury. These findings are consistent with previous reports demonstrating that patellar fractures predominantly affect economically active individuals exposed to high-energy trauma. Bava et al. similarly reported a predominance of middle-aged male patients, with road traffic accidents accounting for the majority of injuries, while Thiyagarajan et al. observed comparable demographic characteristics in patients undergoing tension band wiring. Likewise, Muralidhar et al. reported that displaced transverse patellar fractures occurred more frequently among active adults, reflecting the increased occupational and physical demands of this

population. The similarity of demographic characteristics across these studies suggests that the epidemiology of displaced transverse patellar fractures remains relatively consistent across different clinical settings (11,12,13).

Functional recovery following tension band wiring in the present study was favorable. Nearly half of the patients achieved excellent functional outcomes, while over one-third achieved good outcomes, resulting in an overall satisfactory outcome rate of 85%. Progressive reductions in pain together with improvements in knee motion, stability, and functional performance were observed throughout follow-up, with all parameters demonstrating highly significant improvement. These findings closely correspond with those reported by Javali et al., who documented a comparable mean Böstman score and predominantly good-to-excellent outcomes following tension band wiring. Similarly, Prasad et al. demonstrated excellent postoperative functional recovery using tension band fixation, with high Böstman scores at six months. A meta-analysis by Zhang et al. also confirmed that tension band wiring consistently achieves reliable fracture union and satisfactory functional recovery despite the availability of alternative fixation techniques. Although newer implants such as cannulated screws and low-profile plates may reduce implant-related irritation in selected fracture patterns, conventional tension band wiring continues to provide dependable clinical outcomes with excellent restoration of knee function when meticulous surgical technique and structured rehabilitation are employed. The present findings therefore reinforce the continued value of tension band wiring as a cost-effective and reproducible technique, particularly in resource-limited healthcare settings where implant availability and treatment cost remain important considerations (7,14,15).

The incidence of postoperative complications in the present study was low. Immediate complications were limited to isolated cases of surgical site infection and wound inflammation, whereas late complications consisted mainly of restricted knee motion and a single case of implant failure. Similar complication profiles have been reported in previous studies evaluating tension band wiring. Muralidhar et al. observed low rates of superficial infection and implant-related complications, while Bava et al. also reported minimal postoperative morbidity with satisfactory fracture healing. Although hardware irritation and secondary implant removal remain recognized limitations of conventional tension band wiring, careful implant placement, meticulous soft-tissue handling, and early supervised rehabilitation can substantially reduce these complications. The low complication rates observed in the present study further support the safety and reliability of this fixation method when standard surgical principles are followed (12,13).

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