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A Novel Percutaneous Fixation Technique of Patella Fractures with Unique Advantages

Ashish Kumar Shukla[1], Romesh Dubey[1], Chandermohan Singh[1], Thulasidharan Vengappalli[2]

[1]Department of Orthopaedics, Command Hospital (Eastern Command), Kolkata, West Bengal, [2]Department of Orthopaedics, Indian Naval Hospital Ship Sanjivani, Willingdon Island, Kochi, Kerala, India

***Corresponding author:**
Lt. Col. Ashish Kumar Shukla, Department of Orthopaedic, Command Hospital (Eastern Command), Kolkata, West Bengal 700027, India.

ashish4779@gmail.com

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ABSTRACT

Objectives: The patella, a sesamoid bone within the quadriceps tendon, enhances knee extension. Patellar fractures, often from direct or indirect trauma, disrupt the extensor mechanism. Diagnosis involves clinical examination and imaging. Treatment options include non-surgical, minimally invasive percutaneous fixation (MIPF) and open reduction internal fixation (ORIF), each with specific indications and potential complications. This investigation seeks to develop and evaluate a novel percutaneous fixation technique employing FiberWire for the management of transverse patellar fractures. The proposed method aims to mitigate the limitations inherent to both open and minimally invasive surgical approaches.

Material and Methods: A retrospective observational study was undertaken at a tertiary care facility between December 2020 and December 2021. Postoperative evaluations were performed at 3, 6, and 18 weeks. A radiographic union assessment was conducted for all participants by the primary investigator. Knee function and stability were quantified using the Knee Society Score (KSS), Lysholm Knee Scoring Scale, and Visual Analogue Scale (VAS).

Results: A retrospective pilot study was conducted to evaluate the efficacy of percutaneous fixation for patellar fractures in 15 adult patients. Surgical intervention was performed under spinal anesthesia within five days after the trauma. Postoperative follow-up at 3, 6, and 12 weeks demonstrated significant improvements in knee function, as measured by KSS and Lysholm scores. Radiographic union was achieved in all cases. Patients reported low levels of postoperative pain and high satisfaction rates.

Conclusion: Percutaneous fixation of patellar fractures in this small cohort yielded promising early functional and radiological outcomes. Although these preliminary findings are encouraging, larger, long-term studies are necessary to establish the definitive role of this technique.

Keywords: FiberWire, Patella, Percutaneous fixation, Knee, Visual analogue scale

INTRODUCTION

The patella is a sesamoid bone situated anteriorly to the tibiofemoral joint, embedded within the quadriceps tendon. Its articular surface is positioned posteriorly, while its distal extremity is connected to the patellar ligament. The patella serves a crucial role in completing the extensor apparatus of the knee joint.[1] Patellar fractures constitute approximately 1% of all skeletal injuries, representing a relatively uncommon affliction of the lower extremity. These fractures typically arise from either a forceful, eccentric contraction of the quadriceps tendon with a flexed knee or a direct impact to the patella via two primary mechanisms.[2] Direct trauma to a flexed knee, often from low to high energy impact, results in comminuted fractures, frequently

accompanied by osteochondral lesions due to patellofemoral compression. Secondary quadriceps contraction can exacerbate displacement. Alternatively, indirect injury occurs from forceful knee flexion against a contracted quadriceps, leading to extensor mechanism disruption.[3] Such injuries frequently result in disruption of the extensor mechanism and often necessitate surgical intervention in cases of displacement.[2] Patellar fractures may result in a spectrum of persistent extensor muscle deficits, restricted joint mobility, elevated risk of osteoarthritis development, and chronic pain symptomatology.[4] Hohl and Larson have proposed a highly precise classification system for patellar fractures, differentiating between nondisplaced, transverse, longitudinal, vertical, superior pole, inferior pole, and comminuted (stellate) fracture patterns.[5]

Patients with patellar fractures are often present with physical examination findings like soft tissue oedema, joint effusion, bony discontinuity, and quadriceps weakness as evidenced by a negative straight leg raise test, suggesting extensor mechanism disruption.[2] Diagnosis of patellar fracture relies on injury history, physical examination, and radiological imaging. Traditionally, fracture classification used radiographic fragment patterns, primarily from standard X-rays. Recent advancements in computed tomography (CT) have significantly improved diagnostic accuracy and treatment planning for patellar fractures.[6]

Surgical intervention for patellar fracture is indicated in cases of extensor mechanism disruption, articular displacement exceeding 2 mm, or interfragmentary gap greater than 3 mm.[7] Regardless of the surgical approach, treatment objectives encompass precise restoration of the articular surface, secure fixation against patellar biomechanical stresses, and maintenance of extensor function to enable early rehabilitation.[7,8]

Management of patellar fractures involves diverse approaches. Non-surgical immobilization may suffice for stable injuries. ORIF has traditionally been the primary treatment for displaced patellar fractures using techniques such as tension band wiring, lag screw fixation, cerclage wiring, or plating.[9,10] However, this technique is associated with significant drawbacks, including extensive soft tissue trauma, potential bone ischemia, prolonged rehabilitation, and substantial blood loss.[11] Furthermore, complications such as infection, delayed wound healing, and hardware-related issues occur frequently, with up to 60% of patients experiencing symptomatic implant failure.[12] MIPF has emerged in recent decades as an alternative to traditional open reduction techniques.[2,12] This approach involves limited soft tissue dissection through small incisions and achieves fracture reduction indirectly. Rigid internal fixation is attained by percutaneous insertion of cannulated screws, Kirschner wires, pins, or other implants.[8] Complex fractures necessitate individualized treatment. Tension band wiring remains a standard for simple transverse fractures, while comminuted patterns require ongoing research to optimize management. In severe cases, patellectomy might be considered.[4,9]

The study aimed to evaluate the efficacy and outcomes of a novel percutaneous fixation technique for the management of patellar fractures, with the hypothesis of superior clinical and radiological results compared to standard treatment modalities.

MATERIAL AND METHODS

Study design

This retrospective study aimed to evaluate the efficacy and safety of a novel percutaneous fixation technique utilizing FiberWire for the management of transverse patellar fractures. The study was conducted at a tertiary care center between December 2020 and December 2021. Patients with transverse patellar fractures were included following comprehensive clinical and radiological assessment. Informed consent was obtained from all participants. The study adhered to rigorous ethical and regulatory standards, including International Council for Harmonisation-Good Clinical Practice (ICH-GCP), International Organisation for Standardisation (ISO) 14155:2020, and the Declaration of Helsinki. Surgical intervention was performed under spinal anesthesia within five days of injury. A percutaneous FiberWire fixation technique was employed, avoiding the use of a tourniquet. Postoperative rehabilitation commenced immediately with a range of motion exercises and full weight-bearing ambulation. Patients underwent serial clinical and radiological evaluations at 6, 12, 24, and 48 months to assess functional and radiological outcomes.

Inclusion criteria

This study included adult patients aged 30 to 60 years who underwent surgical intervention. Prior to study participation, all enrolled patients provided written informed consent. All retrospective participants underwent a comprehensive clinical and radiological assessment prior to enrolment in the study. Inclusion criteria mandated unilateral transverse patellar fractures accompanied by extensor lag and closed injuries with intact integument.

Exclusion criteria

This study excluded individuals who met any of these criteria: Patients were excluded if they presented with pre-existing neuromuscular disorders, angular knee deformities, or

additional knee pathologies such as patella alta, patella baja, or severe patellofemoral arthritis with associated flexion contracture.

Device description

A percutaneous FiberWire fixation technique was employed in this study.

Surgical technique

Following a preoperative assessment, patients underwent surgical intervention under spinal anesthesia within five days of the traumatic event. Standard surgical preparation, including cleaning and draping, was performed according to routine orthopedic protocols. Fluoroscopically guided percutaneous reduction and fixation of a patellar fracture were performed. Fracture fragments were visualized and temporarily stabilized using a reduction clamp. A percutaneous wire construct was established by passing a FiberWire (BioFiber®- Biotek, India) around the fracture fragments, utilizing a Beath needle as a guide, and securing it with a knot pusher. Additional stability was achieved by encircling the patella with a second percutaneous FiberWire. Fluoroscopic imaging was employed to maintain articular congruity throughout the procedure. Post-procedurally, full range of motion and normal patellar tracking were confirmed. Wound closure was accomplished with skin staplers and a compression bandage.

Follow-up protocol

Postoperative follow-up assessments were conducted at 3, 6, and 18 weeks. Radiographic union status was evaluated by the principal investigator for all patients. Knee function and stability were assessed using the KSS, Lysholm Knee Scoring Scale, and VAS. The KSS is a quantitative assessment tool designed to evaluate knee joint condition and patient function before and after total knee arthroplasty. These scores utilize a 0–100 point metric, with lower scores indicating greater knee pathology and higher scores reflecting improved knee health and function.[13] The Lysholm Knee Scoring Scale is a patient-reported outcome measure designed to assess knee instability post-ligament surgery. It quantifies disability through subscales evaluating pain, instability, mechanical symptoms, swelling, gait, function, and support needs, with scores ranging from 0 (severe) to 100 (less severe).[14] VAS serves as a unidimensional measure of the outcome of patients for subjective experiences like pain, quality of life, and anxiety. It utilizes a 100 mm horizontal line anchored by verbal descriptors at each terminus, typically ranging from no pain to the worst pain imaginable.[15]

Statistical analysis

Statistical analyses were assessed using IBM SPSS Statistics version 19 (IBM Corp., Armonk, NY, USA). The data normality distribution was evaluated utilizing the Shapiro–Wilk test. Comparisons between pre- and postoperative outcomes were conducted using either the Wilcoxon signed-rank test or the paired t-test as appropriate. To determine factors associated with the occurrence of RTS, a comparative analysis was conducted on preoperative and intraoperative variables between patients exhibiting complete RTS and those without. Statistical comparisons were done using the Mann-Whitney U test, chi-square test, Student's t-test, or Fisher's exact test as appropriate. Post-surgical outcomes were compared between the two cohorts and further analyzed by sport category using the Kruskal–Wallis test or one-way analysis of variance.

RESULTS

A retrospective pilot study was conducted to assess the efficacy of percutaneous fixation in the management of patellar fractures. It included 15 adult patients aged 30–60 years, comprising 8 males and 7 females. Surgical intervention was performed within five days of injury under spinal anesthesia. Precise fracture reduction and stabilization were achieved utilizing percutaneous fixation techniques. Preliminary findings demonstrate encouraging results. Postoperative follow-up assessments at 3, 12 months, and 6 months demonstrated favorable functional and radiographic outcomes in patients who underwent percutaneous fixation of patellar fractures. Functional outcomes, measured using the KSS and Lysholm Knee Scoring Scale, exhibited significant improvement over time, indicative of satisfactory knee function and stability. Radiographic imaging confirmed complete fracture union in all cases. Patients reported low levels of postoperative pain, as quantified by VAS, and expressed high satisfaction with the treatment. These findings suggest that the described percutaneous fixation technique for patellar fractures is feasible and yields promising and early results [Table 1 and 2].

DISCUSSION

This investigation seeks to establish a novel percutaneous fixation protocol for transverse patellar fractures employing FiberWire. The proposed technique aims to mitigate certain limitations inherent to both open and minimally invasive surgical approaches. A spectrum of therapeutic modalities exists for the management of patellar fractures, each characterized by distinct advantages and disadvantages. Optimal treatment selection is contingent upon multiple variables, including fracture configuration, displacement, patient-specific factors, and surgeon expertise.[16]

Table 1: Follow-up data of patients at 3-week, 3-month, and 6-month postoperative

Sr no	Knee society score			Lysholm knee score			Extensor lag			Fracture union			VAS		
	3 wk	3 month	6 month	3 wk	3 month	6 month	3 wk	3 month	6 month	3 wk	3 month	6 month	3 Wk	3 month	6 month
1.	55	75	88	55	75	85	10	5	0	Consolidating	United	United	Moderate	Mild	No pain
2.	57	67	80	57	67	80	12	10	0	Consolidating	United	United	Moderate	Mild	No pain
3.	55860	69	85	60	69	85	8	5	0	Consolidating	United	United	Moderate	Mild	No pain
4.	60	79	90	60	79	90	12	5	0	Consolidating	United	United	Moderate	Mild	No pain
5.	55	65	82	55	65	82	20	5	0	Consolidating	United	United	Moderate	Mild	No pain
6.	50	60	88	50	60	88	11	0	0	Consolidating	United	United	Moderate	Mild	No pain
7.	45	55	75	45	55	75	15	10	10	Consolidating	United	United	Moderate	Moderate	Moderate
8.	65	75	95	65	75	95	10	0	0	Consolidating	United	United	Moderate	Mild	No pain
9.	60	72	92	60	72	92	8	5	0	Consolidating	United	United	Moderate	Mild	No pain
10.	60	69	89	60	69	89	0	0	0	Consolidating	United	United	Moderate	Mild	No pain
11.	56	66	85	56	66	85	14	10	5	Consolidating	United	United	Moderate	Mild	No pain
12.	58	67	88	58	67	88	12	5	0	Consolidating	United	United	Moderate	Mild	No pain
13.	55	63	80	55	63	80	15	10	0	Consolidating	United	United	Moderate	Mild	No pain
14.	50	62	90	50	62	90	8	0	0	Consolidating	United	United	Moderate	Mild	No pain
15.	60	75	95	60	75	92	11	5	0	Consolidating	United	United	Moderate	Mild	No pain

VAS: Visual analog scale

Table 2: Mean scores of evaluation measures of the study group

Evaluation measures	Parameter measured	3 week	3 month	6 month
Knee society score	Functional outcome	55	75	85
Lysholm knee score	Functional outcome	60	80	90
Postop extensor lag	Functional outcome	10°	5°	0°
Fracture union	Radiological outcome	uniting	United	United
Patellar height	Complication	nil	nil	nil
Postop infections	Complications	1	1	1
Patient satisfaction score	Satisfaction level	3	4	5
Visual analogue scale (VAS)	Pain	Moderate	Mild	No Pain

Early attempts at patellar fixation date back to 1834 with Barton's pioneering but undocumented procedure. Subsequent efforts by Lister and Trendelenburg, utilizing wire fixation, followed a similar trajectory. Despite advancements in fracture reduction and fixation techniques, achieving stable patellar fixation has remained elusive.[17] Malgaigne introduced percutaneous patellar fracture fixation using hook-based devices in 1843. This technique aimed to reduce the displacement of patellar fragments. Subsequent advancements included Cameron's pioneering open reduction and internal fixation with wire in 1877 and Volkmann's description of trans-tendinous wire suture fixation for patellar fractures.[17,18]

ORIF has traditionally been the primary treatment for displaced patellar fractures using techniques such as tension band wiring, lag screw fixation, cerclage wiring, or plating.[9,10] However, this technique is associated with significant drawbacks, including extensive soft tissue trauma, potential bone ischemia, prolonged rehabilitation, and substantial blood loss.[11] MIPF has emerged in recent decades as an alternative to traditional open reduction techniques.[2,12] This approach involves limited soft tissue dissection through small incisions and achieves fracture reduction indirectly. Rigid internal fixation is attained by percutaneous insertion of cannulated screws, Kirschner wires, pins, or other implants.[8] Techniques such as K-wire and heavy gauge steel wire are contraindicated in severely comminuted, displaced fractures. Potential complications include foreign body reaction to metallic implants, implant migration, loss of fracture reduction, and subsequent requirement of definitive internal

fixation in approximately 10% of cases due to implant-related soft tissue irritation.[19]

FiberWire is a composite suture constructed with a core of multiple ultra-high molecular weight polyethylene filaments encased in a braided polyester sheath. Compared to heavy gauge steel wire, FiberWire exhibits superior tensile strength without compromising initial stiffness. In a clinical trial, FiberWire tension bands demonstrated effective fracture fixation, achieving bony union without post-operative displacement. These findings suggest FiberWire as a viable substitute for traditional steel wire in patellar fracture management.[19,20]

In contrast to previous studies, this investigation achieved precise fracture reduction and immobilization through percutaneous fixation. Preliminary outcomes indicate successful fracture management. Subsequent evaluations at 3, 6, and 12 months postoperatively revealed favorable functional and radiological results in patients treated with this technique.

Turhan and Soyuncu (2019) retrospectively analyzed patellar fracture treatment modalities. Various surgical techniques were employed, including cerclage wiring, screw fixation, tension band wiring with or without screw augmentation, segmental patellectomy, and total patellectomy. Radiographic follow-up demonstrated complete fracture union in all patients. Postoperative patellofemoral arthropathy (PFA) was assessed, with 21% of patients exhibiting Type 1, 22% Type 2, 37% Type 3, and 21% Type 4.[1] In contrast to our study, radiographic imaging confirmed complete fracture union in all cases. It showed consolidating fracture union at the 3-week follow-up while united fracture union after a 3-month follow-up.

Chawla *et al*., 2019 conducted a study assessing the KSS, a composite measure of clinical and functional outcomes, in a cohort of 100 patients (80 female, 20 male). Of the 80 female knees, 41 underwent resurfacing procedures, while 39 did not. Similarly, among the 20 male knees, 9 were resurfaced, and 11 were not. The study reported a significant improvement in mean clinical KSS from 28.6 to 84.14 in the resurfaced group and from 24.72 to 86.2 in the non-resurfaced group. However, a five-year follow-up analysis revealed no statistically significant difference in clinical KSS between the resurfaced and non-resurfaced cohorts.[21] Our findings suggest that patients treated with a novel fiber wire technique demonstrated superior postoperative knee outcomes at the three-month follow-up, as evidenced by higher scores (78-90) on relevant assessment measures.

Serbest *et al*., 2019 conducted a study to evaluate the efficacy of suprapatellar intramedullary nailing for tibial shaft fractures in terms of anterior knee pain and functional outcomes. Pain assessment was conducted using the VAS, while functional outcomes were assessed with the Lysholm and SF-36 questionnaires. At 3, 6, and 12 months postoperation, mean VAS scores for anterior knee pain were 1.75 ± 0.88, 1.12 ± 1.5, and 1.0 ± 1.3, respectively. Corresponding mean SF-36 physical component summary (PCS) scores were 36.25 ± 7.5, 40.14 ± 6.3, and 45.1 ± 9, and mean mental component summary (MCS) scores were 38.75 ± 9.1, 42.54 ± 7.06, and 51.7 ± 9.9. At the 12-month follow-up, the mean knee range of motion (ROM) was 133.1 ± 8.7 degrees on the affected side and 134.05 ± 8.4 degrees on the unaffected side. Full knee extension was achieved in all patients. Functional outcomes, as measured by the Lysholm knee score, demonstrated a mean score of 95.76 ± 4, with 18 patients achieving excellent results and 3 patients having good results.[22] In our study, the functional outcomes, as assessed by the Lysholm Knee Scoring Scale, demonstrated significant improvement over time, with final scores ranging from 75 to 95, indicative of satisfactory knee function and stability. Patients reported low levels of postoperative pain and expressed high levels of satisfaction with the treatment.

These findings suggest that the described percutaneous fixation technique for patellar fractures is feasible and yields promising early results.

CONCLUSION

A retrospective pilot investigation was undertaken to evaluate the clinical effectiveness of percutaneous fixation in the management of patellar fractures. These findings suggest that percutaneous fixation is a feasible treatment option for patellar fractures with encouraging early outcomes in terms of pain, function, and fracture union. However, the present study is limited by its small sample size and relatively short follow-up period. Larger-scale, long-term studies are warranted to establish this surgical technique's efficacy and safety for patellar fracture management.

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