FUNCTIONAL OUTCOME OF FLOATING KNEE INJURIES TREATED WITH DIFFERENT MODALITIES IN ADULT PATIENTS: A PROSPECTIVE OBSERVATIONAL STUDY FROM A TERTIARY CARE CENTRE

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ABSTRACT

Background: Floating knee injury is a complex high-energy trauma involving ipsilateral fractures of the femur and tibia. It is commonly associated with soft-tissue injury, complications, and prolonged rehabilitation. This study assessed the functional outcome of floating knee injuries treated with different modalities in adult patients.

Methods: This prospective observational study was conducted in the Department of Orthopaedics, S.M.S. Medical College and Attached Hospitals, Jaipur. A total of 53 adult patients aged 18–60 years with floating knee injuries were included. Fractures were classified using Fraser classification, and open injuries were graded using Gustilo-Anderson classification. Treatment included intramedullary interlocking nailing, plate fixation, external fixation, or combined methods. Functional outcome was assessed using Karlström–Olerud criteria.

Results: The mean age was 36.92 ± 10.48 years, and 84.9% patients were males. Road traffic accident was the commonest mode of injury. Fraser Type I injury was the most frequent pattern. Intramedullary nailing of both bones was the commonest treatment modality. Excellent and good outcomes were observed in 17.0% and 34.0% patients, respectively. Knee stiffness was the most common complication and was significantly associated with poorer outcome.

Conclusion: Floating knee injuries commonly affect young males following road traffic accidents. Early stabilisation, appropriate fixation, and structured rehabilitation improve functional outcome.

Keywords: Floating Knee, Femur Fracture, Tibia Fracture, Fraser Classification, Karlström–Olerud Criteria, Functional Outcome.

INTRODUCTION

Floating knee injury is an uncommon but severe form of orthopaedic trauma, defined as ipsilateral fractures of the femur and tibia, resulting in disruption of the skeletal continuity above and below the knee joint.[1] The term was popularised by Blake and McBryde, who described this injury pattern as a marker of high-energy trauma with frequent soft-tissue and systemic involvement[1]. Although relatively rare, floating knee injuries are clinically important because they usually occur in young, economically productive adults and are associated with prolonged hospitalisation, delayed rehabilitation, and significant functional disability[2,3].

The usual mechanism of injury is high-velocity trauma, most commonly road traffic accidents, followed by fall from height, crush injury, and industrial trauma[4]. Such mechanisms transmit considerable force to the lower limb, producing comminuted fractures, open wounds, periosteal

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stripping, neurovascular compromise, and injury to the soft-tissue envelope. Associated injuries involving the head, chest, abdomen, pelvis, and contralateral limb are also frequent and may influence both the timing of fixation and final outcome[5,6]. Hence, floating knee injury should not be considered merely as two long-bone fractures in the same limb, but as a complex polytrauma pattern requiring systematic assessment and multidisciplinary management[11].

Classification of floating knee injuries is important for treatment planning and prognostication. Fraser et al. classified these injuries into Type I, involving extra-articular diaphyseal fractures of both femur and tibia, and Type II, involving intra-articular extension into the knee joint[3]. Type II injuries are further subdivided according to whether the intra-articular component involves the distal femur, proximal tibia, or both. Several authors have reported that intra-articular extension is associated with poorer results because of cartilage injury, joint incongruity, knee stiffness, and later post-traumatic osteoarthritis[7,8]. Open fractures are commonly graded using the Gustilo-Anderson classification, which remains relevant because increasing severity of soft-tissue injury is associated with higher risk of infection, delayed union, non-union, and poor functional recovery[5].

Management of floating knee injuries has evolved considerably. Earlier conservative methods such as traction and casting were associated with prolonged immobilisation, malalignment, joint stiffness, and unsatisfactory functional outcomes[2,4]. With advances in trauma care, anaesthesia, implants, and rehabilitation protocols, operative stabilisation has become the preferred method in most adult patients[6]. The main goals of treatment are restoration of limb length and alignment, stable fixation of fractures, preservation of soft tissue, early mobilisation, and prevention of complications. Intramedullary interlocking nailing is generally preferred for diaphyseal fractures because it offers biological fixation, load-sharing stability, limited soft-tissue disruption, and early rehabilitation[9,10]. However, plating may be required for metaphyseal or intra-articular fractures where anatomical reduction of the joint surface is essential[17]. External fixation has an important role in patients with severe open injuries, contamination, vascular compromise, or haemodynamic instability[18].

The timing of surgery is a crucial decision. In haemodynamically stable patients, early total care with definitive fixation of both fractures can reduce immobilisation, facilitate nursing care, and improve rehabilitation[13]. In contrast, damage control orthopaedics is preferred in unstable polytrauma patients, where temporary external fixation reduces surgical stress and allows definitive fixation after physiological stabilisation[18]. Thus, treatment must be individualised according to the patient's general condition, fracture pattern, soft-tissue status, associated injuries, and available surgical expertise.

Functional outcome after floating knee injury depends on multiple factors, including age, fracture type, open or closed injury, timing of fixation, method of fixation, associated injuries, infection, union status, knee range of motion, and adequacy of rehabilitation[12,15,16]. Karlström and Olerud proposed one of the most widely used criteria for outcome assessment in ipsilateral femoral and tibial fractures[2]. This system evaluates pain, walking ability, range of motion, deformity, limb shortening, return to work, and radiological union, and categorises results as excellent, good, acceptable, or poor. Its use allows comparison of outcomes across different studies and treatment modalities[17].

Despite advances in fixation techniques, floating knee injuries continue to have a high complication rate. Early complications include shock, fat embolism, infection, compartment syndrome, and vascular injury, while late complications include delayed union, non-union, malunion, limb length discrepancy, knee stiffness, and post-traumatic arthritis[14,16]. Knee stiffness remains one of the most disabling complications, particularly in patients with intra-articular fractures, delayed mobilisation, or prolonged immobilisation[12,14]. Several studies have shown that early stabilisation, stable fixation, meticulous soft-tissue management, and structured physiotherapy are essential for improving functional recovery[10,18].

In the Indian context, floating knee injuries pose additional challenges due to delayed presentation, inadequate pre-hospital care, high frequency of road traffic accidents, economic constraints, and limited access to prolonged rehabilitation. Moreover, functional expectations such as squatting, sitting cross-legged, climbing stairs, and returning to manual work are particularly relevant for Indian patients. Therefore, locally generated data are necessary to evaluate treatment outcomes in a setting that reflects actual clinical practice.

The present study was planned to assess the functional outcome of floating knee injuries treated with different modalities in adult patients at a tertiary care centre. By evaluating fracture pattern, treatment modality, complications, union, knee function, and Karlström-Olerud outcome, the study aims to identify factors associated with favourable and unfavourable results. Such evidence may help in guiding appropriate

treatment selection, improving rehabilitation strategies, and reducing disability following this complex high-energy injury.

METHODOLOGY

This hospital-based prospective observational study was conducted in the Department of Orthopaedics, S.M.S. Medical College and Attached Group of Hospitals, Jaipur, Rajasthan. The study was carried out from February 2024 to December 2025, or until the required sample size was achieved. The study included adult patients presenting with floating knee injuries, defined as ipsilateral fractures of the femur and tibia.

Skeletally mature patients aged 18–60 years of either sex, presenting with traumatic floating knee injuries with recent history of trauma, were included. Both closed fractures and open fractures, including Gustilo-Anderson Grade I, II, and selected Grade IIIA and IIIB injuries, were considered eligible. Patients younger than 18 years or older than 60 years, those with pathological fractures, associated neurovascular injury, medically unfit status for surgery, associated contralateral hip or knee injuries, or ipsilateral fractures around the hip and ankle were excluded.

The sample size was calculated at 95% confidence level, assuming 16.6% excellent outcome according to the Karlström and Olerud criteria as reported in previous literature. Taking an allowable error of 10%, the minimum required sample size was calculated as 53 patients. Eligible patients were enrolled consecutively using convenience sampling after obtaining written informed consent. Institutional Ethics Committee and Research Review Board approval were obtained before initiation of the study.

All patients underwent detailed clinical evaluation at admission, including history of mechanism of injury, time since trauma, associated complaints, general physical examination, systemic examination, and local examination of the affected limb. Limb assessment included swelling, deformity, tenderness, open wounds, neurovascular status, and range of motion of adjacent joints wherever possible. Routine blood investigations, chest X-ray, electrocardiogram, and other pre-anaesthetic evaluations were performed as required. Radiological evaluation included anteroposterior and lateral radiographs of the hip with femur, knee, leg, and ankle. Fractures were classified using the Fraser classification for floating knee injuries, while open fractures were graded according to the Gustilo-Anderson classification.

All patients were initially managed according to standard trauma protocols. Definitive treatment was planned after assessment of haemodynamic status, fracture pattern, soft-tissue condition, and associated injuries. Treatment modalities included intramedullary interlocking nailing, plate fixation, external fixation, or a combination of these techniques. The choice of fixation and sequence of surgery were individualised according to patient and fracture characteristics. Operative details including type of fixation, sequence of fixation, duration of surgery, type of anaesthesia, and intraoperative complications were recorded.

Postoperatively, patients received antibiotics, analgesics, wound care, and physiotherapy as tolerated. Mobilisation and weight-bearing were allowed according to fracture stability and radiological evidence of healing. Follow-up was done at 3 weeks, 6 weeks, 3 months, and 4 months, and further follow-up was continued until fracture union wherever required. At each visit, clinical and radiological assessment was performed.

The primary outcome variable was functional outcome assessed using the Karlström and Olerud criteria, which included pain, knee and ankle symptoms, walking ability, return to work and daily activities, limb length discrepancy, deformity, range of motion, and radiological alignment. Outcomes were graded as excellent, good, acceptable, or poor. Secondary outcome variables included time to radiological union, knee range of motion, and complications such as infection, delayed union, non-union, malunion, knee stiffness, and limb shortening.

Data were entered in a structured database and analysed using SPSS software. Quantitative variables were expressed as mean and standard deviation, while categorical variables were expressed as frequency and percentage. Chi-square test was used for comparison of categorical variables, and Student's t-test was used for comparison of continuous variables where applicable. Association between functional outcome and variables such as age, fracture type, treatment modality, and complications was analysed. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 53 adult patients with floating knee injuries were included in the study. The mean age of the study population was 36.92 ± 10.48 years, and most patients were young adults. Males constituted the majority of cases. Road traffic accident was the most common mechanism of injury. The right lower limb was more frequently involved than the left. Fraser Type I injury was the most common fracture pattern, although intra-articular Type II injuries together formed more than half of the cases. Intramedullary interlocking nailing of both femur and tibia was the most commonly used treatment modality. Functional

outcome progressively improved during follow-up, with 50.9% patients achieving excellent-to-good results according to Karlström–Olerud criteria. Knee stiffness was the most common complication and showed a significant association with poorer functional outcome.

Table 1. Baseline demographic and injury profile of study participants

Variable	Category	Frequency	Percentage
Age group	18–30 years	18	34.0%
	31–40 years	17	32.1%
	41–50 years	12	22.6%
	51–60 years	6	11.3%
Gender	Male	45	84.9%
	Female	8	15.1%
Mode of injury	Road traffic accident	45	84.9%
	Fall from height	6	11.3%
	Industrial injury	1	1.9%
	Crush injury	1	1.9%
Side involved	Right	31	58.5%
	Left	22	41.5%

Mean age of patients was 36.92 ± 10.48 years. The largest proportion of patients belonged to the 18–30 years age group, followed by the 31–40 years age group, indicating predominance of floating knee injuries among young and economically productive adults. Males constituted 84.9% of the study population. Road traffic accidents were the leading mechanism of injury, accounting for 84.9% cases. Right-sided involvement was observed in 58.5% of patients.

Table 2. Fracture pattern and soft-tissue injury profile

Variable	Category	Frequency	Percentage
Fraser classification	Type I	24	45.3%
	Type IIa	12	22.6%
	Type IIb	10	18.9%
	Type IIc	7	13.2%
Gustilo-Anderson grade	Closed injury	17	32.1%
	Grade I	12	22.6%
	Grade II	14	26.4%
	Grade IIIA	6	11.3%
	Grade IIIB	4	7.5%

Fraser Type I injury was the most frequent pattern, seen in 45.3% of patients. However, Type II injuries with intra-articular extension collectively accounted for 54.7% cases. Closed injuries were observed in 32.1% of patients, while open fractures were present in 67.9%. Among open injuries, Grade II was the most common type, followed by Grade I.

Table 3. Treatment modalities and perioperative profile

Variable	Category / Value	Frequency / Mean ± SD	Percentage
Treatment modality	Femur IMIL nail + Tibia IMIL nail	21	39.6%
	Femur plating + Tibia plating	10	18.9%
	Femur IMIL nail + Tibia plating	7	13.2%
	Femur plating + Tibia IMIL nail	7	13.2%
	External fixator followed by definitive fixation	4	7.5%
	External fixator definitive/staged	4	7.5%
Delay to surgery	Days	3.64 ± 1.91	—
Operative time	Minutes	154.38 ± 32.71	—
Approximate blood loss	mL	412.84 ± 118.63	—
Hospital stay	Days	14.28 ± 4.72	—

Intramedullary interlocking nailing of both femur and tibia was the most commonly performed procedure, used in 39.6% of patients. Plating of both bones was performed in 18.9% patients, while hybrid fixation methods were used depending on fracture configuration and soft-tissue status. The mean delay to surgery was 3.64 ± 1.91 days. Mean operative time was 154.38 ± 32.71 minutes, mean blood loss was 412.84 ± 118.63 mL, and mean hospital stay was 14.28 ± 4.72 days.

Table 4. Functional outcome, follow-up scores, knee flexion, and union time

Outcome variable	Category / Follow-up	Mean ± SD / Frequency	Percentage / p-value
Final Karlström–Olerud outcome	Excellent	9	17.0%
	Good	18	34.0%
	Acceptable	15	28.3%
	Poor	11	20.8%
Karlström–Olerud score	3 weeks	38.84 ± 8.12	**p<0.001**
	6 weeks	56.26 ± 9.44	
	3 months	73.18 ± 10.06	
	4 months	82.46 ± 11.28	
Knee flexion	3 weeks	48.16° ± 12.42°	**p<0.001**
	6 weeks	72.38° ± 14.27°	
	3 months	96.84° ± 15.33°	
	4 months	112.64° ± 16.18°	
Union time	Femur	21.46 ± 4.82 weeks	—
	Tibia	22.18 ± 5.11 weeks	—

According to Karlström–Olerud criteria, excellent outcome was observed in 17.0% patients and good outcome in 34.0%, giving an overall excellent-to-good outcome rate of 50.9%. Acceptable outcome was seen in 28.3%, while poor outcome was noted in 20.8% cases. Functional scores showed significant progressive improvement from 38.84 ± 8.12 at 3 weeks to 82.46 ± 11.28 at 4 months. Knee flexion also improved significantly from 48.16° ± 12.42° at 3 weeks to 112.64° ± 16.18° at final follow-up. Mean femoral union time was 21.46 ± 4.82 weeks, while mean tibial union time was 22.18 ± 5.11 weeks.

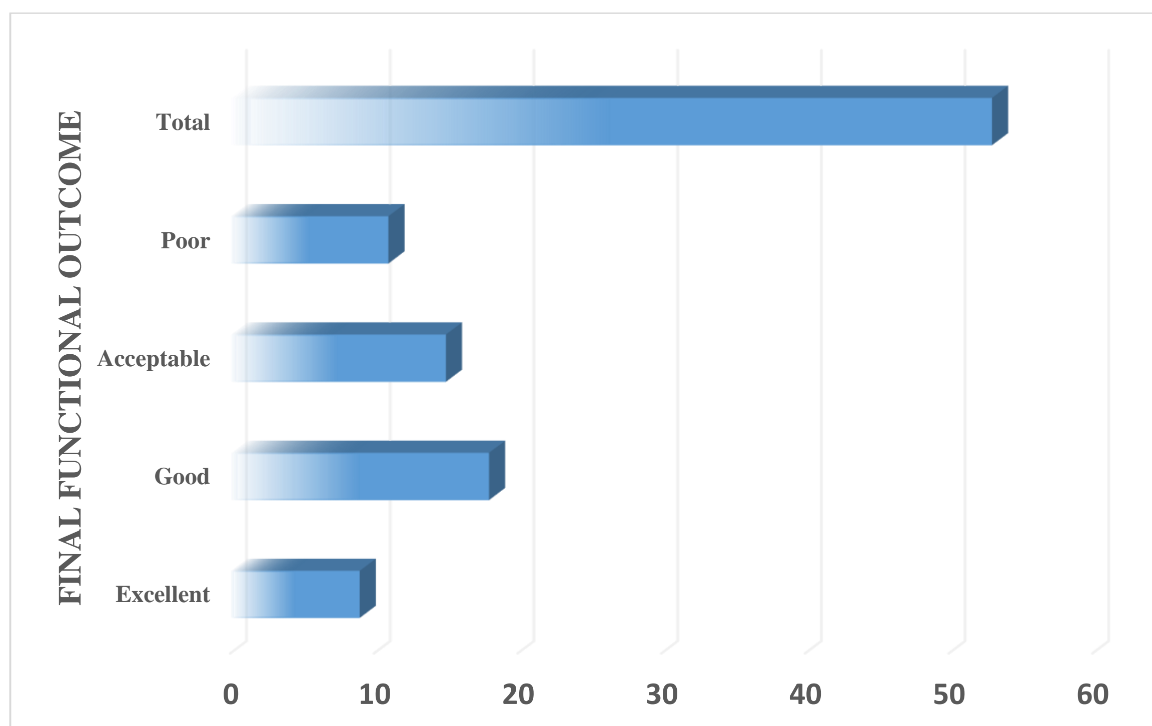


Figure 1. Distribution of final functional outcome according to Karlström–Olerud criteria.

Table 5. Postoperative complications

Complication	Frequency	Percentage
Knee stiffness	14	26.4%
Delayed union	9	17.0%
Postoperative infection	7	13.2%
Re-operation required	6	11.3%
Malunion	5	9.4%
Non-union	4	7.5%
Implant failure	3	5.7%
Fat embolism syndrome	2	3.8%

Knee stiffness was the most common postoperative complication, affecting 26.4% of patients. Delayed union was observed in 17.0% and postoperative infection in 13.2% cases. Re-operation was required in 11.3% patients. Malunion, non-union, implant failure, and fat embolism syndrome were less common but clinically important complications.

Table 6. Factors associated with final functional outcome

Variable	Category	Excellent/Good	Acceptable/Poor	p-value
Knee stiffness	Present	3	11	**<0.001**
	Absent	24	15	
Fraser classification	Type I	18	6	0.041
	Type IIa	5	7	
	Type IIb	3	7	
	Type IIc	1	6	
Treatment modality	Femur IMIL nail + Tibia IMIL nail	15	6	0.048
	Femur plating + Tibia plating	4	6	
	Hybrid fixation methods	6	8	
	External fixation-based methods	2	6	
Final knee flexion vs final Karlström–Olerud score	Pearson r	0.742	—	<0.001
Hospital stay vs final functional score	Pearson r	-0.428	—	0.002

Knee stiffness showed a highly significant association with poorer functional outcome. Patients without knee stiffness had better excellent-to-good recovery. Fraser Type I injuries were associated with better outcomes compared to Type II injuries, especially Type IIc injuries. Treatment modality also showed a significant association with outcome, with femur IMIL nail and tibia IMIL nail demonstrating comparatively better functional recovery. Final knee flexion showed a strong positive correlation with final Karlström–Olerud score, while duration of hospital stay showed a moderate negative correlation with final functional score.

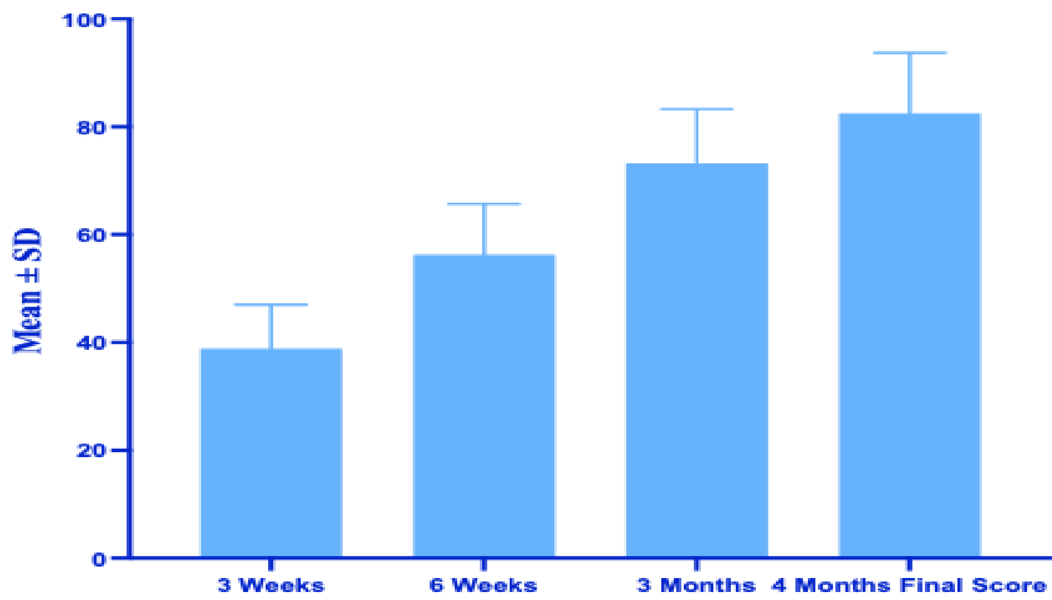
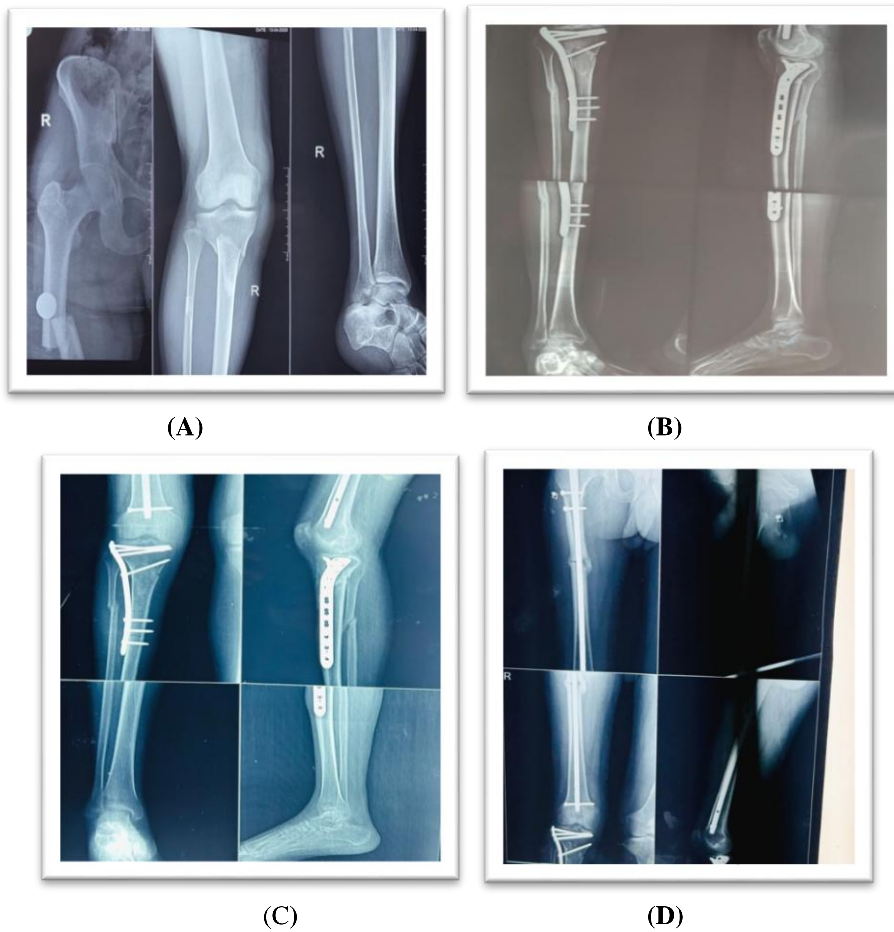
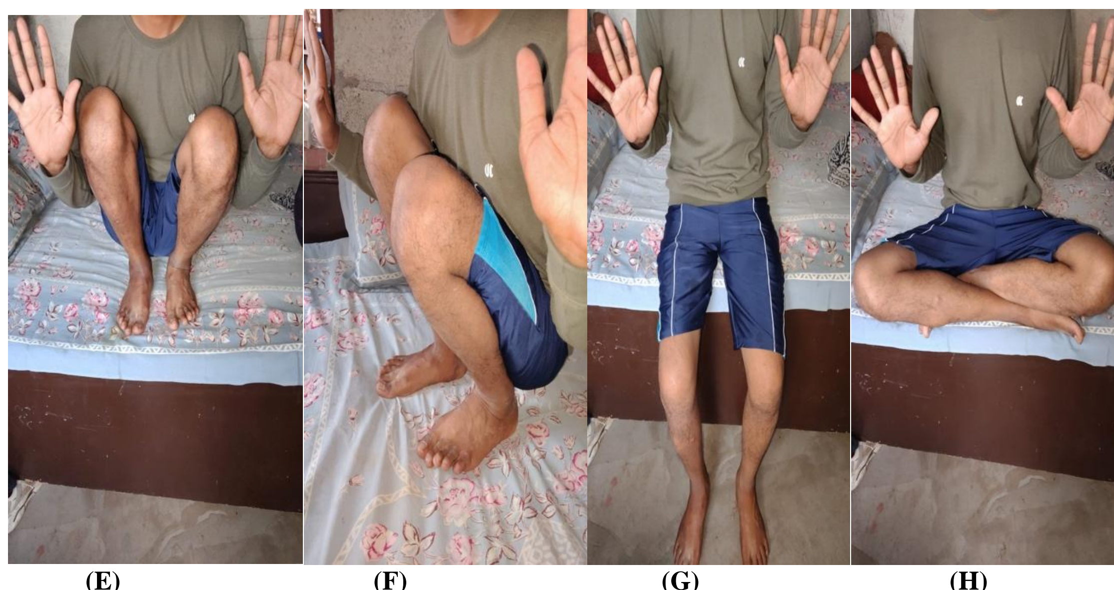


Figure 2. Follow-up trend of mean Karlström–Olerud score and mean knee flexion.





(E) **(F)** **(G)** **(H)**

Figure 3. Representative case of floating knee injury managed surgically.
(A) Preoperative radiographs showing ipsilateral femoral and tibial fractures. (B) Postoperative radiographs showing fixation of femur and tibia. (C, D) Follow-up radiographs showing maintained alignment and fixation. (E–H) Clinical photographs showing functional recovery of knee flexion and sitting ability during follow-up.

DISCUSSION

Floating knee injury is a complex high-energy trauma involving ipsilateral fractures of the femur and tibia, often associated with soft-tissue injury, systemic trauma, complications, and prolonged rehabilitation. In the present study, 53 adult patients with floating knee injuries were evaluated for functional outcome after treatment with different modalities. The majority of patients were young adults, with a mean age of 36.92 ± 10.48 years, and males constituted 84.9% of cases. This pattern is comparable with previous studies by Blake and McBryde, Veith et al., Lundy and Johnson, and Rethnam et al., who reported that floating knee injuries commonly affect young males exposed to high-velocity trauma[1,6,11,15].

Road traffic accident was the most common mode of injury in this study, accounting for 84.9% cases. Similar findings have been reported by Bansal et al., Veith et al., and Feron et al., who identified road traffic accidents as the leading cause of floating knee injuries[4,6,17]. This reflects the high-energy nature of these injuries and highlights their socioeconomic impact, especially in developing countries where young working adults are commonly affected.

Fraser Type I injury was the most common individual fracture pattern in the present study, but Type II injuries collectively formed a substantial proportion of cases. Patients with Fraser Type I injuries had better outcomes compared to those with intra-articular Type II injuries. This is consistent with Fraser et al., Paul et al., Adamson et al., and Hee et al., who reported that intra-articular involvement is associated with poorer functional outcome due to joint incongruity, cartilage damage, knee stiffness, and post-traumatic arthritis[3,7,8,12].

Open fractures were common in the present study, indicating severe soft-tissue damage. Gustilo and Anderson showed that increasing severity of open fracture is associated with higher risk of infection and poor outcome[5]. In the present study also, complications such as infection, delayed union, non-union, and knee stiffness were important factors affecting final recovery. Similar observations were made by Veith et al., Rethnam et al., and Feron et al., who emphasised that soft-tissue injury and associated complications significantly influence prognosis[6,15,17].

Intramedullary interlocking nailing of both femur and tibia was the most commonly used treatment modality and was associated with comparatively better functional outcome. This supports the findings of Gregory et al. and Ostrum, who recommended intramedullary nailing for diaphyseal floating knee injuries because it provides stable fixation, preserves soft tissue, and allows early mobilisation[9,10]. However, plating and hybrid fixation were required in periarticular or intra-articular fractures where anatomical reduction of the joint surface was necessary. External fixation was mainly used in patients with severe soft-tissue injury or unstable general condition, which is consistent with the principles of damage control orthopaedics described by Pape et al. and Ethiraj et al[13,18].

Functional outcome was assessed using the Karlström–Olerud criteria. Excellent outcome was observed in 17.0% patients and good outcome

in 34.0%, giving an overall excellent-to-good outcome rate of 50.9%. Acceptable and poor outcomes were seen in 28.3% and 20.8% patients, respectively. These findings are broadly comparable with earlier studies, although reported outcomes vary according to fracture pattern, soft-tissue injury, treatment modality, associated trauma, and duration of follow-up[2,14,15,17].

Functional recovery improved progressively during follow-up. Mean Karlström–Olerud score increased from 38.84 ± 8.12 at 3 weeks to 82.46 ± 11.28 at 4 months, while mean knee flexion improved from 48.16° ± 12.42° to 112.64° ± 16.18°. This improvement supports the importance of stable fixation and early rehabilitation. Gregory et al., Ostrum, and Dwyer et al. also reported that early surgical stabilisation and mobilisation improve functional recovery after floating knee injuries[9,10,14].

Knee stiffness was the most common complication in the present study and was significantly associated with poorer outcome. This finding is consistent with previous studies, where knee stiffness has been described as one of the most frequent and disabling complications of floating knee injury[7,12,14,17]. Other complications included delayed union, infection, malunion, non-union, implant failure, and fat embolism. These complications adversely affected functional recovery and emphasise the need for meticulous soft-tissue management, appropriate fixation, and supervised physiotherapy.

Limitations: The present study had certain limitations. First, it was a single-centre study conducted at a tertiary care hospital, so the findings may not be fully generalisable to all settings. Second, the sample size was limited to 53 patients, which may reduce the statistical power for subgroup analysis. Third, the follow-up duration was relatively short; therefore, long-term complications such as post-traumatic osteoarthritis, persistent disability, and late implant-related problems could not be fully assessed. Fourth, treatment modality was selected according to fracture pattern, soft-tissue condition, and patient status rather than random allocation, which may introduce selection bias. Finally, functional outcome was assessed mainly using Karlström–Olerud criteria, and quality-of-life assessment or patient-reported outcome measures were not included.

Overall, the present study showed that favourable outcomes were associated with Fraser Type I injuries, intramedullary nailing, absence of knee stiffness, and better final knee flexion. Poor outcomes were mainly related to intra-articular involvement, severe soft-tissue injury, open fractures, and postoperative complications. These findings are in agreement with the available literature and support an individualised treatment approach based on fracture type, patient condition, soft-tissue status, and rehabilitation potential.

CONCLUSION

Floating knee injuries were predominantly observed in young adult males and were most commonly caused by road traffic accidents, reflecting the high-energy nature of this injury pattern. In the present study, functional outcome improved progressively during follow-up, with 50.9% of patients achieving excellent-to-good results according to Karlström–Olerud criteria. Better outcomes were associated with Fraser Type I fractures, intramedullary interlocking nailing, absence of knee stiffness, and good final knee flexion, while intra-articular involvement, open fractures, severe soft-tissue injury, and postoperative complications were associated with poorer recovery. Thus, floating knee injuries require early assessment, appropriate classification, stable fixation, meticulous soft-tissue management, and structured rehabilitation to achieve satisfactory functional outcome.

Recommendations

Early diagnosis, prompt resuscitation, and careful evaluation of associated injuries should be performed in all patients with floating knee injuries. Treatment modality should be individualised according to fracture pattern, soft-tissue condition, haemodynamic status, and presence of associated trauma. Intramedullary interlocking nailing may be preferred for diaphyseal fractures, while plating or hybrid fixation should be considered for periarticular and intra-articular fractures requiring anatomical reduction. External fixation should be used in selected patients with severe open injuries or unstable general condition as part of staged management. Early supervised physiotherapy should be emphasised to prevent knee stiffness and improve functional recovery. Larger multicentric studies with longer follow-up are recommended to assess long-term outcomes, post-traumatic arthritis, quality of life, and return to work after floating knee injuries.

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