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A retrospective study of floating knee injuries and various modalities of operative intervention with outcomes

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Abstract
Background: floating knee injuries refers to ipsilateral tibial and femoral shaft fractures with or without involving knee joints articular surface to various extent. This is a high impact injury usually occurs from high velocity RTA. Multiple life-threatening injury to head, chest and abdomen involving multiple soft tissues is a common occurrence with floating knee. Involvement of tibia and femur to variable extent results in huge diversification of fracture patterns and treatment. This study aims at analysis of need for various modes of operative interventions with combination of multiple fixation techniques and their outcome.
Methods: This is a retrospective study of 30 cases conducted between 2018 to 2020 with follow-up of 2 years. Study conducted at a tertiary care private hospital. Patients were treated with combination of various implants like external fixator, femoral and tibial plate osteosynthesis, and intramedullary nail as per the fracture pattern. Outcome analysed at the end of study taking in to consideration of type of fracture and implants used in terms of time to union, complications and need for reoperation. Objectively assessed after a 2 year with Karlstrom and Olerud criteria.
Results: The mean age of our study population was 32.4 years. The average time for union of femur was 7.5 months, and for tibia is 9.7 months. All thirty patients were involved in road traffic accident. The right side was involved in 24 (80%) patients and left side in 6 (20%) patients. There were 14 Type-I (46.66), 3 Type-IIA (10%), 9 Type-IIB (30%) and 4 Type-IIC (13.33%) Floating knee injuries according to Fraser classification. There were 21 (70%) open in which all patients were with tibia open fractures and 9 (30%) were with closed fractures. Functional assessment was done using Karlstrom and Olerud criteria after complete bony union, which showed excellent results in 8(26.66) patients, good in 10(33.33%), fair in 8 (26.66%) and 4 patients with poor results (13.33%).
Conclusions: Floating knee injuries are complex fracture. Needs initial thorough evaluation to roll out other injuries. Early diagnosing and addressing of popliteal artery injuries are limb saving. Initial stabilisation of fractures with external fixator to control damage may follows multiple operative procedures as definitive fixation in many. Anatomical reduction and fixation irrespective of implant with minimal soft tissue insult were proved to be critical. Aggressive rehabilitation process and early joint mobilisation are key to good outcome.

Keywords: Floating knee, fraser classification, karlstrom, olerud

Introduction
Floating knee injuries refers to ipsilateral tibial and femoral shaft fractures with or without involving knee joints articular surface to various extent [1]. The term floating knee was described by Blake and McBride and Blake in 1975 [2]. These are rare but dangerous injuries. Majority of the floating knee injuries are due to road traffic accidents high velocity and hard impacts are required to cause this kind of trauma. Incidence of vascular injury ranges from 7% to 29% in some studies [3, 4]. Severity of injury warrants evaluation of patient according to ATLS protocol. It is prudent from previous studies that life-threatening injuries to head, chest and abdomen are not uncommon. Kao *et al*. reported injuries to head, chest, pelvis and contralateral extremity to various extent [5].
Patients Involvement of tibia and femur to variable extent results in huge diversification of fracture patterns and treatment. Fraser classification was used to classify FKI.[4] Open fracture were classified according to Gustilo and Anderson'sclassification [6].

Multiple adverse events were reported throughout the course of the injury and treatment. early complications such as fat embolism, excessive blood loss, associated pelvic and urethral injuries, popliteal artery occlusion and many delayed complications such as delayed or non-union, malunion, stiff joint, popliteal aneurysm, infection and amputation [5].
Recent advances in fracture fixation methods and operative techniques and efficient management at causality showed improved outcome results of floating knee injuries. This study aims at analysis of need for various modes of operative interventions with combination of multiple fixation techniques and their outcome.

Methods

This is a retrospective study of 30 cases of floating knee classified according to Fraser classification, open injuries are classified according to Gustilo Anderson classification. Patients admitted to our institution between 2018-2020 were selected. patients with floating knee due to RTA attending to causality and outpatient department were primarily evaluated to exclude neurovascular injury and head and abdomen injury. Finally, patient was evaluated with radiography and arterial doppler or CT angiography of lower limb to roll out popliteal artery injury if in doubt. Patients are selected for the study depending on the inclusion and exclusion criteria. AO external fixator was used as External fixation of some cases. Distal femur locking plate, proximal tibia locking plate, intramedullary nail was used as definitive mode of management. Post-operative Evaluation of the patient`s clinical and functional outcome regarding union rate, time taken to unite, knee movements and complications were analysed with respect to fracture type as per classification. Objectively assessed after a 2 year with Karlstrom and Olerud criteria. Follow up carried at regular intervals of 6 weeks, 3 months, 6 months, 12 months, 18 months and 24 months intervals and same recorded in a specialised case form.

Results

The mean age of our study population was 32.4 years. The average mean time for femur union was 7.5 months and for tibia 9.7 months. All 30 patients were involved in road traffic accident. The right side was involved in 24 (80%) patients and left side in 6 (20%) patients. There were 14 Type-I (46.66%), 3 Type-IIA (10%), 9Type-IIB (30%) and 4Type-IIC (13.33%) FKI according to Fraser classification. There were 21 (70%) open Floating knee injuries, in which all patients were with open tibia fractures and 9 (30%) were with closed fractures .7 patients had head injury and was evaluated with CT scans, 3 patients had chest injury and 2 patients needed intercostal chest drain for hemothorax. 2 patients had pelvic injury and 1 patient required internal fixation. 7 patients had other associated extremities injury. None of the patients had vascular injury in extremities. The complications encountered were knee stiffness in 11(36.66%) patients. Delayed union was noted in 20 tibia (66.66%) and 12 femur (40%) fractures. 1(3%) femur and 1(3%) tibia fracture required dynamization after three months of surgery in view of no callus and went on to unite at 8 month and 6 months respectively. 1(3%) patient developed early superficial infection over the surgical site in tibia which resolved with secondary debridement and antibiotics. 2(6%) patients had wound defect over leg which were managed with split skin graft and three patients with gastrocnemius flap coverage. Functional assessment was done using Karlstrom and Olerud criteria after complete bony union, which showed excellent results in 8 (26.66%) patients, good in 10 (33.33%), fair in 8 (26.66%) and 4 (13.33%) patients with poor results.

Table 1: Age distribution

	Frequency	Percent
18 - 27	14	46.7
28 - 37	9	30.0
38 - 47	2	6.7
48 - 57	3	10.0
>58	2	6.7
Total	30	100.0

Table 2: cases as per Fraser classification

S. No	Types	No. of Cases
1	Type I	14 (46.66%)
2	Type II A	3 (10%)
3	Type II B	9 (30%)
4	Type II C	4 (13.33%)

Table 3: Percentage of open fractures (Gustilo Anderson classification)

		Frequency	Percent
Valid	Type 1	14	46.7
	Type 2a	3	10.0
	Type 2b	9	30.0
	Type 2c	4	13.3
	Total	30	100.0

Table 4: scoring as per karlstrom and olerud criteria

	Frequency	Percent
Poor	4	13.3
Fair	8	26.7
Good	10	33.3
Excellent	8	26.7
Total	30	100.0

Discussion

The term floating knee was described by Blake and McBride in 1975. Floating knee involves fracture of tibia and femur to variable extent. Fraser classified the injuries accordingly. Floating knee injuries signifies high energy impact and high velocity road traffic accidents. In general, the reported incidents are rare though the incidence of floating knee injuries was reported as 2.6% of all fractures by Letts *et al*. [7]. Study done by Fraser *et al*. in 1978 involving 222 cases of floating knee showed majority of injuries were sustained due to road traffic accidents [4]. In the present study also, road traffic accidents was the cause in all 30 patients (100%). Mechanism of injury, sustained by passengers of 4-wheeler has been explained by Hayes JT *et al*. In their studies, passengers with floating knee injuries were placing their feet firmly against the sloping floor of the front seat and dash board just prior to the collision. Their legs getting crashed during sudden and immense decelerating forces produced by the impact [8]. Dissipation of energy occurs via giving way of tibia and femoral fractures around knee. Similar mechanism is seen in the bike riders too but impact to knee is taken against the ground with sudden deceleration.
In our study we found 70% (21) patients sustained associated injuries and this is similar to studies conducted by O norbe *et al*. and Adamson *et al*. [9, 10]. Hee *et al*. described similar results in their study [11]. Age of our study population ranges between 18 to 60 years with mean age being 32.4 years. Gender wise predominantly 93.3% (27) male community was involved which is in par with many other studies. Young age and male predominance can be justified with increased outdoor activity and travel. we noticed that 14 (46.7%) of the patients had Fraser's type I fracture, 3(10%) had type IIA fracture and 9(30%) had type IIB fracture and 4(13.3%) had type IIC

fracture. 21 out of 30 patients (70%) sustained open fractures and the rest 30% were closed fractures. Open fractures were further classified with Gustilo Andersons classification. 13.3% (4) were type I open fractures and 16.7% (5) patients sustained type IIB open fracture and rest of the 40% (12) patients suffered with type IIIB open fracture. 7 patients had head injury and was evaluated with CT scans, 3 patients had chest injury and 2 patients needed intercostal chest drain for hemothorax. 2 patients had pelvic injury and 1 patient required internal fixation. 7 patients had other associated extremities injury one 1 patient had complete transaction of the spinal cord and ended with quadriplegia eventually expired during the course of the study.

Some studies advised early total care (ETC) in all patients except in more critical patients and some advised damage control (DCO) and delayed skeleton stabilization [12, 13]. Principles of Early total care is followed for the stable patient. Damage control orthopaedics is required for unstable patients. However, Ther is no uniform consensus about the treatment protocol for border line patients. It is appropriate for the patient to individualise the management after assessing the benefit of early definitive fracture fixation versus addressing the life-threatening injuries and systemic complications such as fat embolism, massive blood loss, acute lung injury, multi organ failure [14].

There are no studies in literature which shows specific protocol for managing floating knee injuries. Ul-Haque et al. in 1983 described non operative management in his case series [15]. In 1984 Katada *et al*. described the need for rigid fixation of both tibia and femur [16]. In 1986 Letts *et al*. described that at least one fracture should be fixed rigidly either internally or externally, usually the femur [7]. Bansal *et al*. in 1984 proposed Femoral fixation and non-operative management for ipsilateral tibial fractures by plaster of paris [17]. Flexible intramedullary nails were described by Behr *et al*. in 1987 [18]. Lobenhoffer in 1996 described percutaneous plating with minimal soft tissue injuries [19]. Rethnam *et al*. in 2006 described Single incision nailing for both tibia and femur [20]. Dwyer *et al*. 2005 preferred intramedullary nailing for fixation in both femoral and tibial diaphyseal fracture [21]. In 1996 study by Gregory *et al*. introduced retrograde nailing of the femur and un reamed nailing for the tibia [22].

Various studies documented good result after operative treatment [23, 26]. In our study all fractures were fixed rigidly, 23 Tibia (76%) fractures and 17 femur (56%) were treated with intramedullary nail, the outcome of which were better than plating. 6 Tibia (20%) and 13 femur (43%) fractures fixed with locked plates. 1 (3%) tibial fracture was managed with Ilizaro ring external fixator.

Fig 1: Type 2B Floating knee injury with 2-year follow-up

Fig 2: Type 3 floating knee injury and associated acetabular fracture

A comparison of four treatment modality for FKI was done by Dwyer *et al*. [21] which showed that excellent to good result were obtained when shaft femur and tibia fracture, which were treated with intramedullary nail or combined modality (intramedullary nail for femur fracture and cast brace for tibia fracture), and poor result when both fractures treated with external fixator.

Table 5: Comparison of functional outcome of this study with other studies

Name of Study	n	Excellent	Good	Acceptable	Poor
Fraser *et al*. 1978	63	3	15	30	15
Schiedts *et al*. 1994	18	4	7	-	7
Hee *et al*. 2001	89	6	53	25	4
Anoop Kumar *et al*. 2006	42	7	14	14	7
Ulfin Rethnam *et al*. 2007	29	15	9	2	3
Aher d *et al*. 2016 [27]	30	3	9	10	8
This Study	30	8	10	8	4

Fig 3: functional status at the end of 2 year

As per the literature intramedullary nailing is the procedure of choice for floating knee injuries. Better functional outcomes were seen with intramedullary nailing than with any other methods [28, 29]. Fraser found that poor functional outcome was seen in intraarticular fractures [4]. Hee *et al*. had described that comminuted and segmental fractures were poor predictors of the functional outcome [11]. Similar results were shown by Bansal *et al*. [17] Similar results were seen in our study too. Fractures which are extra articular managed with nailing and resulted in good outcome compared to intra articular fractures managed with locked plate and other fractures managed with external fixators. No cases were bad enough to get amputated in our series. Study conducted by Dwayer. *et al*. reported up to 27% incidence of amputation in FKI [21]. All of these cases had massive soft tissue crushing, severe infection and neurovascular injuries. In various literature vascular insult associated with FKI ranges from 7% to 29% [3, 4]. Rios *et al*. [30] and O˜norbe *et al*. [9] Reported neurological injury associated with FKI were 5% and 27% in their study respectively. In our series no patient had any vascular and neurological injuries.

Conclusion

Floating knee injuries requires treatment prioritization of life over limb. Fixation of fracture carried out after hemodynamic stabilisation patients in general Intramedullary nailing used in diaphysis and extra articular fractures tends to have better outcome. Intraarticular fractures need open reduction and locked plate fixation. Both intra articular nature of the fracture and fixation method contributes to relatively poor outcome. Aggressive rehabilitation and physiotherapy are a must to overcome joint stiffness.

Declarations

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Conflict of interest: None

Ethical approval: The study was approved by the institutional ethics committee.

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