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Original Article

Comparison of functional outcomes among subtypes of Fraser's type II floating knee

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ABSTRACT

Purpose: The poor prognosis in patients with floating knee injuries is mainly contributed to articular involvement (Fraser's type II). This study aims to evaluate and compare the functional outcomes among different Fraser's type II floating knee injuries after surgical management.

Methods: Twenty-seven patients with Fraser's type II floating knee injuries (54 fractures) between September 2014 and December 2015 were enrolled prospectively in this study and were distributed according to Fraser's floating knee classification into three different groups as type IIA (ipsilateral femoral shaft and tibial intra-articular involvement, $n = 11$), type IIB (ipsilateral tibial shaft and femoral intra-articular involvement, $n = 9$) and type IIC (both femoral and tibial intra-articular involvement, $n = 7$). The differences among the groups were evaluated and compared. The functional outcomes of these injuries at one year were analyzed using Knee Injury and Osteoarthritis Outcome Score (KOOS) which covers 5 subscales of pain, other symptoms, activities of daily living, sports and recreation, and quality of life. The result was also compared with standardized age-sex matched healthy population using paired samples *t*-test.

Results: All the patients were male, and the injury mechanism was solely roadside accident. The mean age was 29.8 years and injury severity score 17.9 (comparable in all the three groups). Most injuries were observed on the right side (20 cases, 74.1%). Based on paired samples *t*-test, the KOOS score of patients with Fraser's type IIA was found to be better than that of type IIB and type IIC. Compared with the reference age-sex matched control group, patients with Fraser's type IIB and IIC fractures had significantly lower mean score in all KOOS subscales (all $p < 0.01$). However, Fraser's type IIA only revealed significant difference regarding the subscales of activities of daily living ($p < 0.0001$), sports and recreation ($p < 0.0001$), and quality of life ($p < 0.0001$).

Conclusion: The results of this study show that patients with Fraser's type IIA fractures had a better functional outcome as compared to those with type IIB and IIC fractures. This might be due to the open intra-articular involvement of the distal femur of the latter two fracture types.

Introduction

Floating knee is the term applied for the flail knee joint-segment resulting from an ipsilateral fracture of the femur and tibia. This type of injury gives an appearance as if the knee is floating. This term includes injuries which have a combination of the diaphyseal, metaphyseal, and/or intra-articular fractures, and therefore the knee becomes "disconnected" from the rest of the limb.[1,2]

Blake and McBryde[3] initially described this injury, which is generally caused by high-energy trauma. Fraser et al.[4] classified this injury into type I for ipsilateral femur and tibia diaphyseal fractures, type IIA for intra-articular tibia and diaphyseal femur fractures, type IIB for intra-articular femur and diaphyseal tibia fracture and type IIC if both fractures having intra-articular component.

Being almost always caused by high energy trauma, the floating knee is commonly encountered in patients who might have severe injuries to the chest, head, abdomen, and/or limbs. These associated injuries might be sometimes life-threatening. Floating knee injuries can also be associated with soft-tissue injuries including ligamentous and vascular injuries.[5] There are few earlier studies available

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on the subject of ipsilateral fractures of the femur and tibia. Most of the previous papers are restricted to diaphyseal fractures of both bones, which also included the ipsilateral hip, foot, or ankle injuries. However, the function of the knee has received little attention in the past and hence we aimed to describe it in a more comprehensive manner. This study aimed to evaluate the differences and compare the functional outcomes of floating knee injuries after surgical management among the three Fraser's type II floating knee injuries, namely IIA, IIB and IIC.

Methods

The present study is a single center prospective study conducted at a tertiary level teaching hospital in India after obtaining institutional ethics approval (NK/1587/MS/10689–90). Patient enrollment involved satisfaction of the inclusion and exclusion criteria and their informed consent.

Inclusion and exclusion criteria

Between 2014 and 2015, seventy patients with ipsilateral fractures of the femur and tibia with at least one of the bone fracture consisting of an intra-articular extension (Fraser's type II floating knee) presented to our hospital. The inclusion criteria were Fraser's type II fractures in those skeletally mature patients who consented to be part of this study. Patients with (1) Fraser's type I fractures, (2) ipsilateral fractures of the hip, foot or ankle, (3) pathological fractures, (4) periprosthetic fractures, (5) neurological deficits resulting from head or spine injury, (6) co-morbidities resulting in undue delay in surgery, and (7) crushed or mangled extremities were excluded. Details of patients with ipsilateral femur and tibia fractures and those finally included for analysis are presented in Fig. 1.

Grouping

As per Fraser's classification of the floating knee, patients were divided into three groups depending on the intra-articular involvement: type IIA with ipsilateral femoral shaft and tibial intra-articular involvement, type IIB with ipsilateral tibial shaft and femoral intra-articular involvement, and type IIC with both femoral and tibial intra-articular fractures.

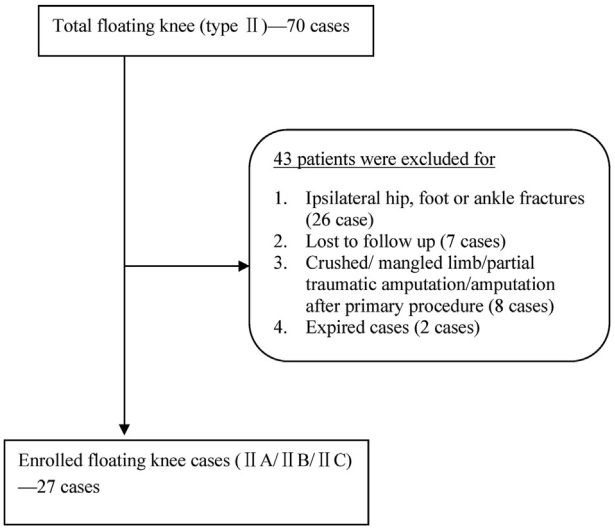

Fig. 1. Process of enrollment of Fraser's type II knees for analysis.

Treatment

On admission all the patients were managed as per the advanced trauma life support protocol: primary survey, resuscitation, secondary survey, and definitive treatment. The severity of injuries was graded according to the injury severity score (ISS).[6]

Initial wound toilet, tetanus immunization, and prophylactic antibiotic therapy was initiated for all the open fractures. Surgical stabilization of the fractures was planned based on the severity of the open injury, local damage to the soft tissues, loss of local biology, and duration of the injury. Higher grades of open fracture (all grade III) underwent temporizing phase using knee spanning external fixator as soon as possible unless the associated injuries dictate unfit for emergency orthopedics surgical intervention. Open wounds were debrided and treated with perioperative antibiotics until the wound was adequately closed. For cases with severe open injury and unable to achieve primary wound closure, intervention was done by plastic surgeons and included vacuum-assisted wound care, local flap, or split-thickness skin graft. Definitive fixation with various modalities was performed at a later stage after the soft tissues had recovered and the patient became systemically stable. Rehabilitation and mobilization were started as soon as possible after surgery or as dictated by the associated injuries and general condition of the patients.

Outcome measurement

All the patients were followed up regularly after definitive surgery at 6 weeks, 3 months, 6 months and 1 year. The Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to assess functional outcomes. The KOOS is a self-administered questionnaire which includes 42 items in 5 separately scored subscales: pain (9 items), other symptoms (7 items), function in activities of daily living (ADL) (17 items), sports and recreational activities (5 items) and quality of life (QOL) (4 items).[7] A Likert scale is used and all items have five possible answer options scored from 0 (no problems) to 4 (extreme problems) and each of the five scores is calculated as the sum of the items included. Scores are transformed to a 0–100 scale. A total score of 100 indicates no knee problems and 0 indicate extreme knee problems.

Statistical analysis

Statistical evaluation of all data was performed using IBMSPSS 22.0. One-way analysis of variance was used to compare continuous variables and a Chi-square test was used to compare categorical variables. The final KOOS subscales scores of all Fraser's type II floating knee groups were compared to the standardized age and sex-matched scores given of the healthy population by paired sample *t*-test.[8,9] A significance level of $p < 0.05$ was set for all tests.

Results

A total of 27 patients were included for analysis. All the patients were male, and the mode of injury was roadside accident in all of them. Most injuries were observed on the right side (20 cases, 74.1%) and were predominantly seen in young patients (mean 29.8 years old). Of the 27 cases, 11 were classified as type IIA, 9 as type IIB and 7 as type IIC. The demographic and injury characteristics are shown in Table 1. Out of 54 fractures (27 femur and 27 tibia), 41 (75%) were of open type, including open femur fractures in 24 cases and open tibia fractures in 17 cases. Detailed distribution based on Gustilo Anderson classification is shown in Table 1. The mean ISS was 17.9 and was comparable in all the three groups. All patients were followed up to one year.

Table 1
Pre-operative demographic and injury characteristics of the 27 patients with Fraser's type II floating knees.

Variables	Fraser's type II floating knees			Statistics	*p* value
	A ($n = 11$)	B ($n = 9$)	C ($n = 7$)		
Age (years)[b]	34.7 ± 10.7	28.2 ± 13.6	24.2 ± 8.3	1.96	0.26
Injury severity score[b]	17.9 ± 7.4	18.1 ± 8.0	16.2 ± 7.8	0.12	0.88
Tibial fracture					
Closed	3 (11.1)	4 (14.8)	3 (11.1)		
Open[a,b]				11.65	0.30
Grade I	3 (11.1)	0	0		
Grade II	2 (7.4)	0	0		
Grade IIIA	1 (3.7)	2 (7.4)	2 (7.4)		
Grade IIIB	1 (3.7)	3 (11.1)	2 (7.4)		
Grade IIIC	1 (3.7)	0	0		
Femoral fracture					
Closed	3 (11.1)	0	0		
Open[a,b]				17.79	0.03
Grade I	3 (11.1)	0	0		
Grade II	2 (7.4)	1 (3.7)	0		
Grade IIIA	2 (7.4)	6 (22.2)	5 (18.5)		
Grade IIIB	0	2 (7.4)	2 (7.4)		
Grade IIIC	1 (3.7)	0	0		
Associated orthopedic injuries	4 (22.2)	7 (38.8)	7 (38.8)	0.79	0.42
Associated non-orthopedic injuries	3 (33.3)	6 (66.6)	–	2.44	0.19
Time from injury to hospital presentation (h)	22.4 ± 28.6	5.6 ± 3.2	7.3 ± 5.7	2.37	0.11
Duration between injury and surgery (h)	18 ± 13.9	13.5 ± 5.8	11.4 ± 4.7	1.05	0.36
Duration of hospitalization (days)	15.2 ± 12.4	17.5 ± 13.6	17.1 ± 14.7	0.08	0.92
Knee Injury and Osteoarthritis Outcome Score					
Pain				3.90	0.03
Symptoms				0.35	0.70
Activities of daily living				0.34	0.71
Sports and recreation				0.18	0.84
Quality of life				0.03	0.96

Data are presented as mean ± standard deviation or *n* (%).
[a] Open fractures are classified based on Gustilo Anderson classification.
[b] variables are analyzed by using Chi-squared test among the Fraser's type II floating knees and expressed as χ^2 values and *p* values, otherwise compared by analysis of variance and expressed as *F* values and *p* values.

The mean duration of hospitalization was maximum in Fraser's type IIB group (17 days), followed by type IIC (16 days) and type IIA (14 days). There were significant differences in the severity of open femoral fracture grading between IIA and IIC ($p = 0.02$), IIA and IIB ($p = 0.03$) and among all three subtypes of Fraser's type II ($p = 0.02$). However, there were no differences in femoral fracture grading between type IIB and IIC. The type IIB and type IIC had more severe grades of open femoral fractures with intra-articular involvement as compared to type IIA. No significant differences in age, ISS, open tibia fracture grading, associated injuries, delay in primary surgery, duration of injury, and hospitalization were found among three subtypes. Detailed data among floating knee subtypes are shown in Table 1.

Eighteen (66.7%) patients had 27 associated injuries; 9 were non-orthopedic and 18 were orthopedic injuries involving the upper limbs or contralateral lower limb. Among the 9 cases of non-orthopedic injuries, 3 were in type IIA group: 1 had fracture with vascular injury and achieved successful repair and 2 had head injuries; the rest 6 cases were in type IIB group: 2 had head injuries, 2 had maxillofacial injuries, 1 had blunt abdominal trauma, and 1 had peroneal nerve palsy.

Comparison between healthy counterparts

Paired samples *t*-test showed that the mean KOOS subscale scores of all the patients with Fraser's type II floating knees were lower as compared to the reference healthy group (Fig. 2). Both type IIB and type IIC revealed statistically significant differences in all the 5 KOOS subscales. However, type IIA only showed significantly poorer results in ADL, sports and recreation, and QOL (Table 2). Comparable KOOS in subscales pain and with healthy counterparts indicated that Fraser's type IIA patient reached a normalized population level, implying a better functional outcome than types IIB and IIC. The poorer outcomes in type IIB and IIC might be due to the involvement of the femoral articular surface in these two groups.

Complications

Out of the 27 patients, 7 developed infections (4 deep soft tissue and 3 osteomyelitis). One patient with Fraser's type IIC fracture developed chronic discharging sinus and required implant removal at 6 months, however, the fracture achieved union. One patient in Fraser's type IIC developed an early infection and required radical debridement of the distal femur within 2 weeks of definitive surgery. Knee stiffness was the most common complication, i.e. 3 cases in type IIA, 4 in type IIB, and 3 in type IIC, 10 in total. Three patients had ligament injuries, including two medial collateral ligament injuries in Fraser's type IIC and another anterior cruciate ligament injury in Fraser's type IIA.

Discussion

In the present study, Fraser's type I fractures were excluded, as we believe that the diaphyseal fractures would preclude an efficient knee score assessment. Moreover, Fraser's type II cannot be compared to type I as their outcomes are universally poor.[10] Most of the previous series focused on ipsilateral diaphyseal fractures (Fraser's type I) and its management; only a few studies specifically showed the results about Fraser's type II. Hung et al.[10] had reported the outcomes in type IIA floating knee (intra-articular knee involvement) and type IIB (without intra-articular knee involvement, but hip or ankle joints involved) as per Blake and McBryde's

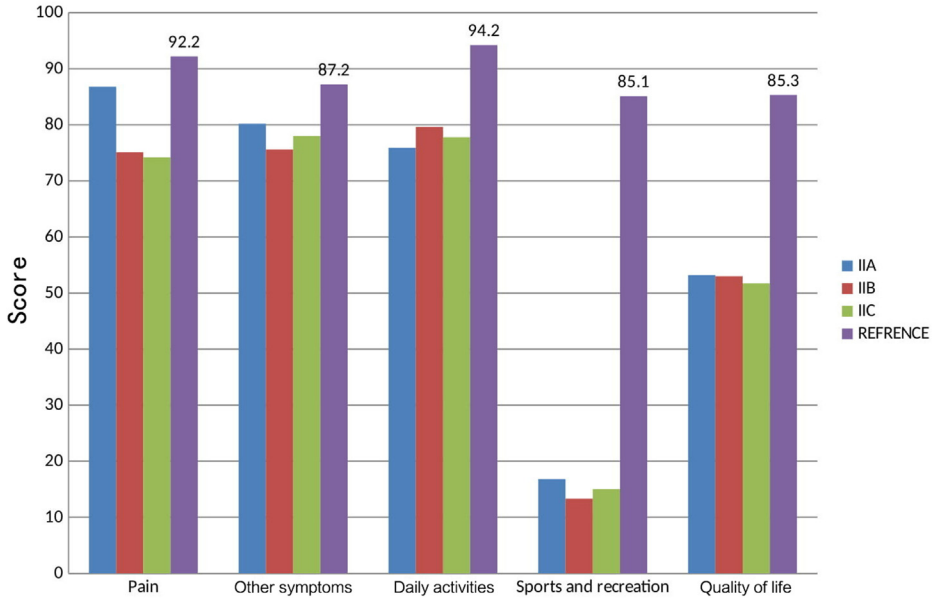

Fig. 2. Knee Injury and Osteoarthritis Outcome Score subscores at final follow-up among Fraser's floating knee subtypes.

Table 2
Assessment and comparison of KOOS to health age and sex matched counterparts.

Group	KOOS				
	Pain	Other symptoms	Activities of daily living	Sports and recreation	Quality of life
IIA	86.8 ± 10.6	80.2 ± 15.8	75.9 ± 10.9	16.8 ± 14.3	53.2 ± 13.7
t value	1.67	1.44	5.55	15.76	7.69
p value	0.125	0.179	<0.0001	<0.0001	<0.0001
IIB	75.1 ± 12.9	75.6 ± 9.4	79.6 ± 10.0	13.3 ± 13.4	53.0 ± 11.1
t value	3.97	3.68	4.32	15.99	8.67
p value	0.004	0.006	0.003	<0.0001	<0.0001
IIC	74.2 ± 8.7	78.0 ± 7.8	77.8 ± 8.5	15.0 ± 8.6	51.7 ± 9.0
t value	5.41	3.08	5.03	21.41	9.79
p value	0.002	0.022	0.002	<0.0001	<0.0001

Comparison of the mean KOOS between floating knee Fraser's subtypes and referencing age group scores using paired-*t* test. The KOOS values are presented as mean ± standard deviation with *p* value and *t* value.
KOOS: knee Injury and Osteoarthritis Outcome Score.

previous classification and found poor functional outcome in type II floating knee injury due to the contribution of intra-articular fractures (type IIA). Because of our strict inclusion criteria, we have excluded the cases with ipsilateral hip, foot, or ankle fractures. Patients requiring amputation and those with crushed injuries of the limb were also excluded. This limited inclusion criteria had the advantage of knowing the true relevance of the floating knee injury to the knee function.

In the present study, the incidence of associated injuries were 66.7%, which is comparable to that reported in the literature, 50%–91%.[4,5,10,12,13,15] However, the number of associated systemic injuries were relatively small as compare to the non-orthopedic injuries in our study. In a study of type II floating knee, Hung et al.[10] reported half associated non-orthopedic systemic injuries (12/24). In our study, the rate was only 33.3% (9/27). As per our observations, we believe that patients having floating knee injuries with the concomitant ipsilateral hip, foot, or ankle fractures probably had associated systemic injuries too. As we have excluded the cases with associated ipsilateral hip or ankle injuries, subsequently, most of the severe systemic injuries have probably been excluded. It can be inferred that in the present study, the impact of associated

Table 3
Analysis of the available literature, comparing the results of previous reports on Fraser's injury subtypes.

Literature	Functional outcome according to Karlström and Olerud criteria			
	Excellent	Good	Fair	Poor
Adamson et al.[15]				
Type IIA ($n = 15$)	2 (13.3)	3 (20.0)	2 (13.3)	8 (53.3)
Type IIB ($n = 12$)	–	1 (8.3)	3 (25.0)	8 (66.6)
Type IIC ($n = 7$)	–	2 (28.0)	2 (28.0)	3 (42.0)
Hung et al.[10]				
Type IIA ($n = 9$)	1 (11.1)	2 (22.2)	3 (33.3)	3 (33.3)
Type IIB ($n = 10$)	–	1 (10.0)	2 (20.0)	7 (70.0)
Type IIC ($n = 2$)	–	1 (50.0)	–	1 (50.0)
Oñorbe et al.[16]				
Type IIA ($n = 2$)	–	1 (50.0)	1 (50.0)	–
Type IIB ($n = 1$)	–	1 (100)	–	–
Type IIC ($n = 2$)	–	1 (50.0)	–	1 (50.0)
Marco et al.[17]				
Type IIA ($n = 2$)	–	–	–	2 (100)
Type IIB ($n = 2$)	–	–	–	2 (100)
Type IIC ($n = 3$)	–	–	–	3 (100)

systemic injuries on isolated floating knee injuries was probably relatively less as compared to associated orthopedic injuries.

We reviewed the available data pertaining to type II floating knee injuries in previous studies and have compared the results among subtypes (Table 3). The majority of excellent or good results were seen in type IIA and poor results were mainly in type IIB/IIC fracture types.

Assessment of the functional outcomes following floating knee injuries in most previous studies were according to Karlström and Olerud criteria which contains seven factors.[10–14] This criterion has many shortcomings but no other assessment methods are available.[14] To the best of our knowledge, there is no study available detailing how this injury affects the functional status of the injured knee in terms of daily life activities and quality of life. In other words, there should be a broad self-measured health status questionnaire scoring systems, which are often used in different fields of orthopedic injuries. In the present study, we have used the KOOS scoring system to delineate various aspects of the knee-related functional status in terms of pain, symptoms, ADL, sports and recreation function, and most importantly, the QOL. The mean KOOS in patients of Fraser's type IIA were close to that of normal population in all subscales, better than type IIB and type IIC. This indicates a superior functional outcome in patients with ipsilateral proximal tibial and femoral shaft fractures. In other words, poorer outcomes in type IIB and type IIC may be contributed to the open intra-articular involvement of the distal femur.

Strengths of our study

To the best of our knowledge, it is the first prospective observational study of functional outcome in floating knee injuries using KOOS scoring. Following of strict inclusion and exclusion criteria meant that direct effect of a floating injury on the knee function could be evaluated better in this study as compared to the existing ones.

Limitation

Only 27 of 70 floating knees were included for evaluation in the present study thus the exact numbers were less. The outcome from our preliminary study helps in orthopedic surgeons to prognosticate floating knee injuries at the time of presentation and thereby treatment can be individualized according to the characteristics of the fracture. Aggressive measures might be required for possibly poor outcomes in an endeavor to change their outcomes.

Conclusion

Floating knee injury is a heterogeneous group of injury patterns involving the femur and tibia. After the analysis of functional outcomes using KOOS scoring the open intra-articular distal femur involvement was found to be a significant contributing factor to poor outcomes of type II floating knee. Strategies should be made targeting these factors to reduce complications and improve the outcomes in floating knee injuries.

Funding

Nil.

Ethics statement

Study was approved by Institutional Ethics Committee, PGIMER Chandigarh (NK/1587/MS/10689–90). All personal data were obtained by the investigators after obtaining consent from patients. Consent for publication was obtained from all patients.

Declaration of competing interest

All named authors hereby declare that they have no conflicts of interest to disclose.

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