



International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2017; 3(1): 700-705
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www.orthopaper.com
Received: 11-11-2016
Accepted: 12-12-2016

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Malunion in floating knee injuries – An analysis in 30 patients presenting to a tertiary care facility and are surgically treated

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DOI: <http://dx.doi.org/10.22271/ortho.2017.v3.i1k.101>

Abstract

Floating Knee is the term applied to the flail knee joint segment resulting from a fracture of the shaft or adjacent metaphysis of the ipsilateral femur and tibia. The fractures range from simple diaphyseal to complex articular types. The word floating knee was introduced for the first time by Mc Bryde in 1965.

The incidence of these injuries is increasing. They are associated with potentially life threatening injuries of the head, chest, and abdomen. Not less frequently these injuries cause infection, excessive blood loss, fat embolism, mal union, delayed or non-union, knee stiffness, prolonged hospitalization, and inability to bear weight.

Malunion is one complication which drastically affects the functional outcome. Hence we tried to find the factors that may result in malunion more often than not which will help to prepare us in a more suitable manner in treating these injuries.

We analysed 30 cases of floating knee which were surgically treated regarding the pattern of injuries, type of injuries, closed/open, fixation methods, associated injuries, union rates, malunion and functional outcome. All cases were followed up to a minimum of 1 year. We found that malunion in a floating knee injury which was surgically treated drastically affected functional outcome.

The mechanism of injury, type of fracture, open/closed injury, level of fracture whether diaphyseal or juxta articular or intraarticular, type of initial fixation all had a significant correlation with occurrence of malunion.

Keywords: Floating knee, malunion, correlating factors, functional outcome

Introduction

With modernization and advances in motorized technology, the pattern and problems associated with trauma are also changing. The 'floating knee' is one such injury, the incidence of which appears to be increasing.

It is described as an ipsilateral concurrent break in the femur and tibia.

Most of the patients are in their third decade with a preponderance of males^[1]. Road traffic accidents account for majority of cases and is followed by fall from height. The word floating knee was introduced for the first time by Mc Bryde^[2] in 1965.

Ipsilateral fractures of the femur and tibia in the adult are serious injuries with a high rate of complications. Besides being caused by high energy trauma with extensive skeletal and soft tissue damage, they are also associated with potentially life threatening injuries of the head, chest, and abdomen. Some other complications attributable to floating knee injuries include infection, excessive blood loss, fat embolism, mal union, delayed or non-union, knee stiffness, prolonged hospitalization, and inability to bear weight.

Malunion is one complication which drastically affects the functional outcome. Hee H *et al*^[3] studied prognostic factors determining outcome in these injuries. They identified that malunion is an important prognostic factor and degree of comminution and habit of smoking contribute to the cause of malunion. There are no studies which focussed on one complication of these injuries. We tried to find the factors that may result in malunion more often than not which will help to prepare us in a more suitable manner in treating these injuries.

Aim of the study

To analyse the floating knee injuries and to find a correlation between the occurrence of malunion and various factors which can guide the attending orthopaedic surgeon to treat these complex injuries in a better manner.

Objectives

- To estimate the chance of malunion in floating knee injuries
- To identify the factors that cause malunion
- To try to establish a correlation between these factors and the occurrence of malunion
- To study the effect of malunion on functional outcome of these injuries

Materials and Methods

Before persuading the study approval from institutional ethical committee was obtained. Patients with floating knee injuries who are aged more than 18 years irrespective of sex are included in this study. Those patients who were less than 18 years of age, who were on drugs affecting bone metabolism, had metabolic disorders and malignancies were excluded. Total number of patients studied was 30. The patients were followed up for minimum period of one year.

When the patients presented in to emergency room primary survey of airway breathing and circulation was done. The patients were resuscitated accordingly. Once the patients were hemodynamically stabilized necessary primary investigations were done. All fractures were splinted in Thomas splint or plaster of Paris slab.

Open fractures and wounds were documented properly. Cultures were sent. Adequate wound wash and irrigation was done with minimum of 8 L of sterile normal saline. Appropriate antibiotics and tetanus immunoglobulin were given. Type II, Type IIIA and Type IIIB fractures were stabilized with external fixators and if needed articular fragments are reduced and reduction held with K wires.

Floating knee was classified according to Blake and McBryde's Classification. Open fractures were classified according to Gustilo and Anderson classification. The plan of management for the given patient was made depending on the nature of fracture, location of fracture, associated soft tissue injuries. A primary survey was made and x-rays were taken to image the entire femur and tibia with the adjacent articulations of the knee hip and ankle.

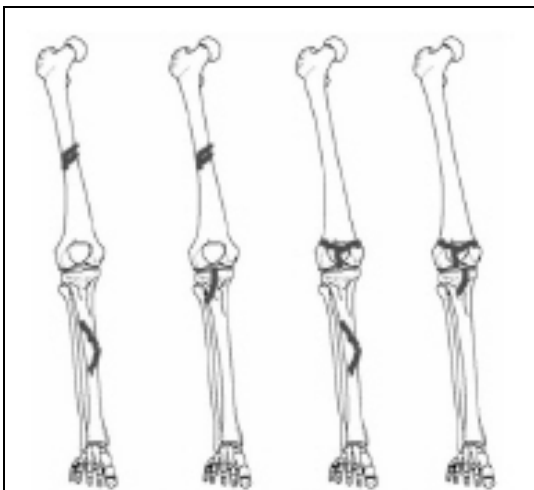


Fig 1: Blake & Mc Bryde Classification of Floating knee

Primary care was given to all these patients and then they were operated. The average waiting period was between 7-10 days as ours is a state run institution where there are problems of manpower and material availability. The patient was subjected to mobilization schedule according to associated injuries and general condition. Follow up study was done at 6 weeks, 12 weeks, 6 months and 1year. Serial x-rays and functional assessment were carried out at each visit in outpatient clinic itself using the Karlstrom and Olerud's⁴ criteria and the results were recorded.

Results

The age of our patients ranged from 18 to 75 years. Most of them were between late twenties to early thirties and all the patients in our series were males. The 30 patients were classified according to Blake and McBryde's classification. Of these 11 were types 1, 14 were type 2A and 5 were type 2B.

Table 1: Blake and mcbryde classification

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Type 1	11	36.7	36.7	36.7
Type 2A	14	46.7	46.7	83.3
Type 2B	5	16.7	16.7	100.0
Total	30	100.0	100.0	

All the patients in our series sustained injury due to road traffic accidents mostly involving four wheelers. Of the thirty patients twenty one were open fractures. Out of the 21 open fractures. There were 10 femur and 11 tibial open fractures. The fractures were classified according to Gustilo –Anderson classification. Among the total open fractures grade I accounted to five (23.8%) fractures, grade II accounted to three (14.2%) fractures, grade III-A accounted to nine (42.8%) fractures, grade III-B accounted to four (19.04%) fractures and grade III-C accounted to zero.

The pattern of fractures varied from simple transverse to comminuted intra articular with combination of these patterns. Out of the femur fractures, 19 (63.3%) were transverse, 10 (33.3%) were Comminuted and 1 (3.3%) were segmental. Among the thirty femur fractures, 7 (23.3 %) were intra articular and 23(76.7%) were extra articular. The 7 intra articular cases were confined to the knee joint. Two (6.7%) were intertrochanteric fractures. Diaphyseal and diaphyseal metaphyseal junction fractures accounted for 21 fractures (70%). Of the thirty tibia fractures 17(56.7%) were transverse fractures, 13(43.3%) were comminuted. Among the thirty fractures of tibia, nineteen were diaphyseal (63.3%), seven (23.3%) were in the diaphyseal-metaphyseal junction, four were intraarticular of which two (6.7%) involved knee and other two (6.7%) involved ankle joint.

The original deformity at the fracture site was also recorded. Among the thirty patients deformity was seen in 15 (50%) patients, of which both femur and tibia were involved in 5 (16.7%) patients. In four patients (13.3%) tibia only was involved and in six (20.0%) patients femur alone was involved. Among the five patients with both femur and tibia involved in three patients had varus deformity of femur and valgus deformity of tibia, two patients had external rotation deformity of femur and varus deformity of tibia. Of the six patients which involved femur alone there was varus deformity in four patients and external rotation in two patients. In patients where tibia was alone involved two had varus and two had valgus deformity.

The Associated other injuries were seen in five cases (16.6%) Contralateral lower limb injuries were one, (3.3%) that patient

had grade II tibia I fracture for which an external fixator was applied later managed with interlocking tibia nail. One patient (3.3%) had head injury which was managed appropriately. One patient had a pubic diastasis for which recon plate was applied. Two (6.6%) had crush injury foot.

Case illustrations 1



Case illustration 2



Case illustration 3



Table 2: Deformity at the fracture site

Bone Site	No. Of Patients	Deformity	Distribution (Nos.)
		Femur-varus Angulation(>10 ⁰)	3
		Tibia-valgus Angulation(>20 ⁰)	
Femur And Tibia	5	Femur-external Rotation(>10 ⁰)	2
		Tibia-varus Angulation(>10 ⁰)	
		Varus Angulation(>20 ⁰)	2
Tibia Only	4	Valgus Angulation(>10 ⁰)	2
Femur only	6	Varus angulation (> 10°)	4
		External rotation(>10°)	2

These patients were operated and method of internal fixation was decided by the fracture pattern, level of fracture and whether the fracture was open or closed. Some of the fractures were converted to Type I open fracture from Type II or Type III. As many as 19 fractures (63.3%) were fixed with ante grade intramedullary nail, 1 fracture (3.3%) with retrograde intramedullary nail, 2 fractures (6.7%) fixed with Locking plates, 3 fractures (10%) with DCS and 2 Fractures (6.7%) with DCP. In 3 fractures AO external fixator was used as a definitive fixation in 2 fractures (6.7%) and in 1(3.3%) Ilizarov was used as definitive fixation. Of the thirty patients 16 fractures (53.3%) were fixed with intramedullary nail, 5

fractures (16.7%) were fixed with locking plates, 4 fractures (13.3%) were fixed with DCP, in three fractures (10%) AO external fixator was used as definitive fixation and in one (3.3%) Ilizarov fixator was used as definitive fixation. One was managed conservatively with femur fracture was being managed with Orthofix. In all our cases femur was fixed followed by tibia and duration of surgery ranged from 2 ½ hrs to 4 hrs.

In our series bony union occurred over a period of 3 months to more than a year. The femur bony union ranged from twelve to more than a year. At twelve weeks, two (6.7%) patients had union, at twenty four weeks twenty three (76.7%) patients had union and at one year, three patients (10.0%) had union and two patients (6.7%) need more than a year for union. The average period being twenty eight weeks.

Table 3: Bony union femur

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 12 weeks	2	6.7	6.7	6.7
24 weeks	23	76.7	76.7	83.3
1 year	3	10.0	10.0	93.3
More than 1 ye	2	6.7	6.7	100.0
Total	30	100.0	100.0	

The tibial bony union ranged from twelve weeks to more than a year. At twelve weeks, ten (33.3%) patients had union, at twenty four weeks eighteen (60%) patients had union and at one year one patient (3.3%) had union. One patient needed more than a year for union. The average duration being 22 weeks.

Table 4: Bony union tibia

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 12 weeks	10	33.3	33.3	33.3
24 weeks	18	60.0	60.0	93.3
1 year	1	3.3	3.3	96.7
More than 1 y	1	3.3	3.3	100.0
Total	30	100.0	100.0	

We analysed these results with functional outcome using Karlstrom-Oleurd’s criteria⁴.

Table 5: Karlstrom-oleurd criteria

Criterion	Excellent	Good	Acceptable	Poor
Subjective complaints from thigh or leg	0	Intermittent slight symptoms	More severe symptoms impairing function	Considerable functional impairment; pain at rest
Subjective symptoms from knee or ankle joint	0	Same as above	Same as above	Same as above
Walking ability	Unimpaired	Same as above	Walking distance restricted	Use cane, crutch, or other support
Work and sports	Same as before accident	Given up sport; work same as before accident	Change to less strenuous work	Permanent disability
Angulation, rotational deformity, or both	0	<10°	10-20°	>20°
Shortening	0	<1 cm	1-3 cm	>3 cm
Restricted joint mobility (hip, knee or ankle)	0	<10° at ankle; <20° at hip, knee or both	10-20° at ankle; 20-40° at hip, knee or both	>20° at ankle; >40° at hip, knee or both

The results show five patients (16.7%) with excellent, thirteen patients (30.0%) with GOOD, eight patients (26.7%) with acceptable and four patients (13.3%) with POOR outcome.

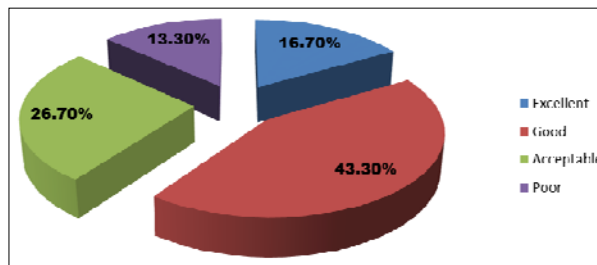


Fig 2: Functional outcome

Excellent Outcomes

There were five patients (16.7%) with excellent outcome. All patients had both femur and tibia nailing done. All these patients had no pain or any deformity. After an average period of 6 months these patients returned back to their work as before accident. This probably because these are Type I injury with knee is not involved. They had a good knee range of motion in the range of 90-100°.

Good Outcomes

There were thirteen (60%) patients with Good outcome. Of them ante grade nailing of femur has been done in ten patients, locking plate for femur in two patients and one had DCS. Tibial nailing was done in six patients. In three locking plate was used and in remaining three DCP was used. In one fracture healed with external fixator. Among the Good outcomes, six patients had intermittent knee pain but not severe. These patients had changed their jobs after the accident. The knee range of motion ranged from 90 – 100 in eight patients, three patients had a range of 60-90°; two had 45-60°.

Acceptable Outcomes

Acceptable outcome were seen in eight (26.7%) patients, out of these four patients had malunion at femur fracture site. One patient had raw area which needed extensive SSG. One patient had deformity of both tibia and femur. The average range of motion at the knee for these patients was 0 – 70 degrees. The walking distance of these patients were restricted.

Poor Outcomes

Poor outcomes were seen in four (13.3%) patients, all four had worst high velocity injury. In three of these patients femur fracture was Type IIIA open fracture of which one was segmental. There were three Grade IIIB fractures of tibia. Two femur and three tibiae were comminuted. Three tibial fractures were intraarticular.

There was infection in one patient. Knee range of motion was less than 30°. All needed support in the form of cane or crutch. As many as 12 of these thirty patients had malunion which drastically affected the functional outcome in these injuries.

Table 6: Malunion Vs Functional Outcome

FUNCTIONAL OUTCOME		MAL UNION		Total
		Yes	No	
EXCELLENT	Count	0	5	5
	% of Total	.0%	16.7%	16.7%
GOOD	Count	5	8	13
	% of Total	16.7%	26.7%	43.3%
ACCEPTABLE	Count	4	4	8
	% of Total	13.3%	13.3%	26.7%
POOR	Count	4	0	4
	% of Total	13.3%	.0%	13.3%
Total	Count	13	17	30
	% of Total	43.3%	56.7%	100.0%

Malunion drastically affected the functional outcome. Hence we worked to analyse what were the variables that correlated with the occurrence of malunion and whether we can expect malunion in a particular patient. We analysed the mechanism of injury, pattern of fractures, level of fractures, method of fixation, original deformity at the fracture site, whether the fracture was open or closed and tried to find a correlation of these factors with the occurrence of malunion and to know whether it was possible to predict the occurrence of malunion in a floating knee injury.

Results

The tendency for malunion was more in high velocity injuries. Of the thirty patients 22 patients had motor vehicle accidents involving four wheelers. Of these 13(43.3%) had developed malunion which is highly significant, $p = 0.015$ which is less than 0.05. Open fractures tend to result in malunion. Of the 5 cases of Type IIIB open fractures of femur 4(13.3%) resulted in malunion and all the four Type IIIB open fractures of tibia resulted in malunion.

The pattern of fracture of femur as well as tibia with level of fracture (whether diaphyseal, articular, metaphyseal) had a definite role in the occurrence of malunion. Of the ten communitated fractures of femur 8(26.7%) developed malunion which is highly significant ($p=0.001$). Also only one segmental fracture of femur in this series malunited. Of the 13 communitated fractures of tibia 7(23.3%) went into malunion.

The level of fracture seemed to be important in deciding the occurrence of malunion. Out of the 7 intraarticular fractures of femur 5 went into malunion and out of 3 metaphyseal fractures 2 resulted into malunion, which was significant as $p=0.032$ which was less than 0.05. As for as the tibia was concerned the picture was similar. The only two articular fractures of tibia resulted in malunion. In most of these fractures articular reconstruction was not accurate because of time delay. Also most of these fractures needed bone grafting.

The type of floating knee whether Type I or IIa or IIb was a deciding factor. Of the 14 Type IIa 7 fractures malunited and of the 5 Type IIb all were malunited. This was highly significant $p=0.002$ which is less than 0.01.

The type of fixation used determined the position of union. Of the 19 cases of femur where ante grade nail was used 15 united in good position. But not much could be obtained from this result as type and level of fracture often determined the type of fixation. When there was an original deformity at the fracture site the result was often malunion. Of the 11 fractures of femur which had deformity 9 developed malunion which is significant as $p=0.002$ and of the 9 tibial fractures which had original deformity 7 healed in malunion which is significant as $p=0.018$.

Discussion

Floating knee injuries occur usually due to high velocity trauma. There is an increase in the occurrence of floating knee injuries due to the increase in number of road traffic accidents. These are always associated with high morbidity. Most of these injuries results in some permanent disability. In our study the all injuries were due to road traffic accidents. Out of thirty patients 28 were involved in vehicle collisions. This is due to the fact that more and more number of motor vehicles is plying on the road and high velocity accidents are becoming much common. The more number of road traffic accident cases were due to the fact that our hospital is in the heart of city with heavy traffic and that our hospital is a tertiary referral centre.

The age distribution was from 18 years to 75 years. A cluster of patients was seen in mid-twenties to mid-thirties i.e. 22 patients (73.3%) which is comparable to other studies.

Malunion is an important complication in floating knee injuries. Most of the studies say about the complications in these injuries and very few studies were done to predict this complication in floating knee injuries (those which study about the prognostic factors). AAOS identifies two studies in this regard, (Orthopaedic trauma directions 2006), by Hee H, Wong H^[3], Low Y, *et al*^[2] and Yokoyama K^[5], Tsukamoto T, Aoki S, *et al*^[5]. Hee *et al* stated that The presence of 2 or more communitated bones increased risk of malunion dramatically, RR_{adj} = 61.0; 95% CI (2.6–1000), but the wide confidence interval indicates that the estimate is based on small numbers of patients.

In our series 12 patients had malunion which was a significant number. The functional outcome was significantly affected by the occurrence of malunion. The factors which seemed to be important in deciding the occurrence of malunion were

- Velocity of injury-the higher the velocity of injury greater will be the complexity of injury and more chance will be for malunion
- Pattern of fracture – communitated and segmental fracture will go for malunion
- Level of fracture- intraarticular and metaphyseal fracture will go for malunion. In these patients reconstruction of articular surface and metaphyseal region was important which depends more than often of the early fixation.
- Presence of deformity at the fracture site has a greater influence
- When the fracture is open especially Type IIIB open fractures develop malunion.
- Type of fixation -when both fractures are fixed with intramedullary nail the chance of malunion is less. But nothing much could be drawn from this as most of times it is pattern and level of fracture that determines type of fixation.

Conclusion

These results show that high velocity injuries with articular and juxta articular fractures, fractures which are communitated and are open are more likely to go for malunion. Early surgery with exact articular reconstruction would have had some difference. Hence functional outcome in this group of patients will be acceptable to poor and one cannot expect more than acceptable outcome in these patients. Hence it is prudent to inform this prior to the concerned patient and if possible surgeon must attempt to correct the deformity at the fracture site as much as possible. More studies are needed in this direction.

No external/internal grants received for this study

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