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Functional and Radiological Outcomes in Ipsilateral Femur and Tibiafractures (Floating Knee)

Vanamali Seetharam[1], Somashekar Doddabhadre Gowda[2], Sunil Basavarajanna[3], Shreekantha KS[4]

[1]Department of Orthopaedics, Bangalore Medical College and Research Institute, Bengaluru, Karnataka, India
Email id: *vanamaliseetharam[at]gmail.com*

[2]Department of Orthopaedics, Bangalore Medical College and Research Institute, Bengaluru, Karnataka, India
Email id: *somu201990[at]gmail.com*

[3]Department of Orthopaedics, Bangalore Medical College and Research Institute, Bengaluru, Karnataka, India
Email id: *sunil_bee[at]yahoo.co.in*

[4]Department of Orthopaedics, Bangalore Medical College and Research Institute, Bengaluru, Karnataka, India
Email id: *dr.shreekantha.ks[at]gmail.com*

Abstract: ***Fractures of the ipsilateral femur and tibia has variable results depending on modes of treatment. The aim of our study is to evaluate clinical, functional and radiological outcomes of these injuries, managed surgically. Patients presenting with floating knee injuries from the year 2011 to 2014 were included in the study. After detailed clinical and radiological assessment of injured limb, definitive fixation of the floating knee was done according to classification type and fracture morphology. Assessment of the end result was done based on the Karlstrom criteria after bony union. Fifty-two patients were treated,out of which18 patients had open fractures and 34 were closed. Mean duration of follow up was 2.3 yearswith mean duration of radiological union for tibia was 17.8 weeks and for femur was 21.8 weeks. Non-union of femur was seen in 2 patients, with tibial non-union in 4 patients. Best outcomes are obtained with intramedullary nailing of both the fractures.The higher incidence of ligament injuries in type 2 floating knees requires routine MRI evaluation and poor results were obtained in type 2 floating knees even after appropriate treatment. We have obtained excellent results by fixing the tibia first.***

Keywords: Floating knee, Fraser classification, Blake & McBryde classification, Functional outcome, Karlstorm criteria

1. Introduction

Ipsilateral fractures of the femur and tibia are called 'floating knee' injuries and may include a combination of diaphyseal, metaphyseal, and intra-articular fractures [1]. These fractures range from simple diaphyseal to complex articular types [2]. Numerous associated injuries occur in conjunction with floating knee and are more commonly observed in young patients after high-energy traumatic injuries. They are mostly caused by motor vehicle accidents, and local trauma to soft tissue is extensive, with multiple injuries in same extremity [3]. The mortality with these injuries is observed in 5 to 15 percent, reflecting the seriousness of the associated injuries [3].When these injuries occur simultaneously in the same limb, complications are high and end results are poor if not managed appropriately [4]. They are associated with potentially life-threatening injuries of the head, chest and abdomen. Complications attributable to floating knee injuries include excessive blood loss, fat embolism, neurovascular damage, infection, malunion, delayed or non-union, knee stiffness, prolonged hospitalization, amputation, and ankylosis [5]. Articular, meniscal, ligament injuries and instability of the knee are common [6]. Better results and fewer complications are observed when both fractures are diaphyseal than when either or both are intra-articular [1].

Although the precise incidence of a floating knee is not known, it is a relatively uncommon injury. The largest series reported in the literature was of 222 patients over an 11-year period [7] [8]. Surgical stabilization of both fractures and early mobilization of the extremity and the patient produces the best clinical outcomes [7]. Several studies (Karlström and Olerud 1977, Fraser et al. 1978, Bansal et al. 1984, Veith et al. 1984, Letts et al. 1986, Behr et al. 1987, Bohn and Durbin 1991, Anastopoulos et al. 1992) have been published emphasizing the outcome of these injuries after non-operative or combination of operative and non-operative or only operative treatments. Higher grades of injury, operative treatment complications such as infection, stiffness, nonunion, malunion, result in poor outcomes. But there are areas of disagreement and dispute in treatment of floating knee injuries such as advantages of fixing tibia or femur first, incidence of fat embolism in simultaneous nailing of femur and tibia, assessment and management of ligamentous injuries of knee, comparison of outcomes in type II subgroups, which need further evaluation.Purpose of our study is to evaluate clinical, functional and radiological outcomes in floating knee injuries while examining above mentioned areas of management.

2. Materials and Methods

This Retrospective study included 52 patients aged between 18 and 65 years (TABLE 1), who presented to our tertiary care trauma center over a period between 2011 and 2014. Children below 18 years, pathological fractures, floating knee which are managed conservatively were excluded from the study.Details on the demography, mode and mechanism of injury were collected. Initial management involved

resuscitation and hemodynamic stabilization of the patient. Thorough primary and secondary surveys were done to identify other injuries. Pain was managed with suitable analgesia. Open fractures were classified according to Gustilo & Anderson classification [9]. Initial wound irrigation, tetanus immunization and antibiotic therapy were initiated for open fractures. The affected limb was splinted in a Thomas splint. Radiographs of the chest, pelvis, spine and affected extremities were done. The floating knee injury was classified according to Fraser classification and Blake & McBryde's Classification after radiography [8] [11]. Patients with associated head, chest or abdominal injuries were managed appropriately prior to surgical stabilization of the fractures, which was delayed till these injuries were dealt with. Detection of head injuries was assessed by Computerized tomography scan (CT scan) in suspected cases. Detection of chest injuries was assessed by radiograph and CT scan if required. Detection of abdominal injuries was assessed by clinical assessment and ultrasonography. In any suspicion of intra-abdominal injury by clinical assessment and ultrasonography, an urgent CT scan was indicated. Suspected cases of fat embolism patients were managed in surgical intensive care unit till the patient was stabilized.

Surgical management of both the fractures were done once patients were hemodynamically stable and fit for surgery. The tibial fracture was fixed prior to the femur fracture in cases where both femoral and tibial fractures were treated with intramedullary nailing. Femoral fractures were stabilized with distal femoral skeletal traction while fixing tibia first to prevent excessive movement at femoral fracture during tibial nailing.Both the femoral and tibial nails were inserted antegrade. External fixation was used in most of the open tibia fractures, and this was the definitive management in many of the cases. Ligamentous injuries of knee were diagnosed by clinical assessment and Magnetic resonance imaging (MRI). Lachman's test and posterior drawer's test were used clinically to assess the anterior and posterior cruciate ligaments respectively. If a knee ligament injury is confirmed and if patient complaints were suggestive of knee instability, ligament reconstruction was done at a later date.

Postoperative thromboprophylaxis was administered to all patients. Rehabilitation was initiated 48 hours after surgery. Patients were kept on non-weight bearing ambulation for 6 to 8 weeks, followed by partial weight bearing. Full weight bearing was allowed only after clinical and radiological union had been confirmed. Weight bearing was delayed in patients treated with plate and screws or external fixators.The patients were followed-up every two weeks for first 6 weeks, followed by monthly review for six months, and every three months thereafter. Clinical, functional and radiological assessment of the limb was done in each follow up. Functional assessment and final outcome were measured using the Karlstrom criteria, modified Harris hip score & Modified Hospital for Special Surgery Score at the final follow-up. Range of motion of hip and knee were also assessed during follow up.

3. Results

The mean age of the study group was 39 years (± years). Mean duration of follow up was 2.3 years (1.2 to 4.1 years). Forty-four patients were male and eight patients were female. Right side was involved in 34 patients and left side in 18. Road traffic accident was the most common mode of injury (38 patients) and 14 patients sustained fall from height. Associated injuries are elaborated in Table 5. There were 34 closed fractures and 18 open fractures (isolated compound tibia in 9 patients, isolated compound femur in one patient and both tibia & femur open fracture in 8 patients) (TABLE 1). According to Fraser classification, 41 patients were type 1, 4 were type 2A, 5 were type 2B, and 2 were type 2C. According to Blake & McBrydeclassification, 40 patients were type 1, 11 patients were type 2A, 1 patient were type 2B (Table 2).

Intramedullary nailing of both the fractures was the commonest method i.e., 23 patients (FIG 1). External fixator to both the fractures was performed in 6 patients (FIG 2).

Remaining patients underwent combination of external fixator, CC Screws, plate and screws, ILN, long PFN(TABLE 3&4) (FIG 3). Mean duration to radiological union for tibia was 17.8 weeks and for femur was 21.8 weeks. Complications include non-union of femur in 2 cases, tibial nonunion in 4 patients (FIG 2), superficial wound infection in 7 patients and deep infection in 2 patients, knee stiffness was seen in 5 cases, 2 underwent amputation, 5 patients developed fat embolism, as diagnosed by Gurd's criteria (Table 5). According to Karlstrom criteria, 27 had excellent results, 14 had good functional outcome, 6 had fair and 5 had poor outcome (Table 5). According to modified Harris Hip Score 28 had excellent results, 13 had good, 7 had fair and 4 had poor results. According to Modified Hospital for Special Surgery Knee Score, 29 had excellent results, 14 had good results, 5 had fair results, 4 had poor results.

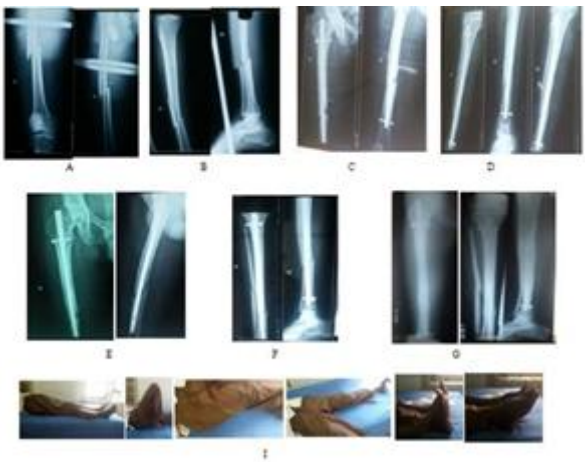

Figure 1

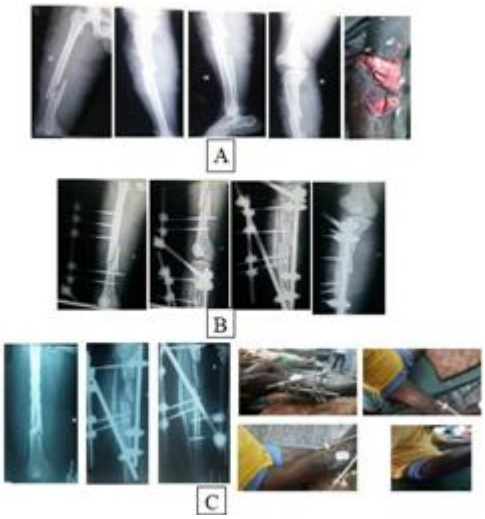

Figure 2

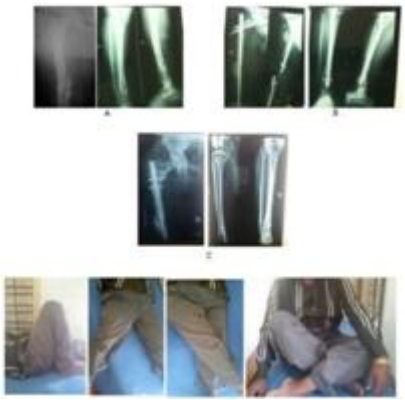

Figure 3

4. Discussion

When Fractures of the femur and tibia occurs on the same limb, they are called 'floating knee' injuries [1]. Frequently they are associated with life threatening injuries. Adamson et al in their study had 71% major associated injuries with 21% vascular injuries [12]. In our study associated injuries has affected the initial management but not significantly affected results of final follow up.Various authors have reported results of various modalities including conservative, operative and combinations of both. Hojer et al, Karlström and Olerud, Veith et al., have reported excellent results following internal fixation of both fractures [3] [4] [11]. Hayes JT opined that in a patient with multiple fractures in the same extremity, operative fixation of one or more of fractures is valuable in the management of the entire limb [13]. Ratcliff AH proposed that internal fixation of both the fractures should be done wherever possible as these patients were less likely to develop knee stiffness or shortening and patients were in hospital and off work for less time than those treated conservatively[14]. Omer GE treated the floating Knee by both conservative and operative fixation, found that when internal fixation was done for both femoral and tibial fractures, the healing time was about 8 weeks earlier than the group managed conservatively. Behr JT treated patients with the Floating knee by closed intramedullary nailing with Ender nails and achieved femoral union at an average of 10.3 weeks and tibial union at 18 weeks[16]. Dwyer applied combined modalities of treatment with one fracture managed conservatively and the other surgically. They concluded that the treatment method for the tibia did not interfere with joint mobilization [18]. Ostrum et al, Rios J, Oh CW et al have recommended single incision technique for nailing of both fractures [17] [20] [21]. We have treated all the patients surgically which is recommended in the present practice. Theodoratus et al recommended intramedullary nailing as the best choice of treatment except for grade 3B & C open fractures [19]. Intramedullary nailing of both fractures gives the best results according to Ostrum and Gregory et al [17] [22]. Similarly, in our study, the best results were seen when both fractures were fixed with intramedullary nailing.

Most of the authors recommend antegrade nailing [11] [4] [3]. But some of the authors like Ostrum et al, Rios J, Oh CW et al recommend single incision technique for nailing of both the fractures which reduces operative time and intra operative blood loss [17] [20] [21]. We used antegrade nailing for both tibia and femur fractures. Problem with retrograde nailing is interference with ligament reconstruction after retrograde nailing and increase chances of intraarticular infection and post-operative knee pain and stiffness.According to Fraserand Bansal, the functional outcome was poor in the presence of articular fractures [8] [23]. Similarly, in our study, type 2 floating knees produced fair or poor results. We also compared results between different subtypes of type 2 floating kneesand found the worst results from Fraser type 2C. Between type 2A and 2B Fraser classification, type 2A had the worse results.Almost all of the authors fixed femur first followed by tibia. But we have fixed tibia first followed by femur, which is contrary to the prevailing school of thought. Femoral fracture did not interfere with flexing the knee during tibial fixation. Fixing tibia fractures initially permits application of traction using the boot of the traction device and manipulation under image intensifier for subsequent femoral fracture fixation. Excellent results were obtained with fixing the tibia first followed by femur.

Sheidt et al reported a 12 percent incidence of fat embolism intra-operatively when both fractures were reamed at same setting [24]. In our study, 5 out of 23 patients who underwent intramedullary nailing and reaming in same setting developed fat embolism, an incidence of 21%, which was diagnosed based on Gurd criteria. Because of this high incidence of fat embolism following reaming in our study, we conclude that continuous monitoring for symptoms and signs of fat embolism is paramount when both fractures are reamed. Szalay et al demonstrated knee ligament laxity in 53% of patients, while 18% complained of instability [25]. Most of the patients with instability had a rupture of the anterior cruciate ligament with or without damage to other ligaments. They concluded that knee ligament injury was more common with floating knee injuries than with isolated femoral fractures and advocated careful assessment of the knee in all cases of fractures of the femur and floating knee injuries. Paul et alreported that the incidence of knee ligament injuries in the floating knee was up to 50%, most of which were missed in the initial assessment [26]. Fraser reports that only 8% of the patients were discharged from hospital with a diagnosis of instability, but when reassessed,

this number was as high as 39% [8]. Twenty percent of patients in our study were found to have knee instability. We performed routine MRI evaluation for all cases prior to skeletal fixation, and found 8 out of 10 patients with knee instability to be of type 2 floating knee. Hence, we recommend routine MRI should be done in patients with floating knee, more importantly to the patients with type 2 floating knee.

5. Conclusion

Fractures of the ipsilateral femur and tibia fractures have precariously high complication rates. Timely and appropriate management protocol with good postoperative rehabilitation by an experienced treating team is essential for good clinical and functional outcome. The best outcome has been obtained with intramedullary nailing of both the fractures. The notably greater incidence of ligamentous injuries in type 2 floating knees necessitates routine MRI evaluation. Incidence of fat embolism has been the greatest when both fractures are reamed in the same sitting. Despite appropriate management, type 2 floating knees produced poor clinical and functional outcomes. Contrary to guidelines by prevailing literature, fixing tibia first followed by femur has produced excellent results, with no difference in functional outcomes compared to study groups in which femur was fixed first.

Conflicts of Interests: None

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and soft tissue injury. *J Orthop Trauma* 1990;4(3):309-14.

Figure Captions:

Figure 1 (CASE 1): A&B – Preoperative X-rays, **C&D** – Post-operative X-rays, **E&F** – Radiographs 6 weeks post-surgery, **G** – X-rays taken at 6 months follow up (united femur and tibia fracture), **I** – clinical photos after 6 months.

Figure 2 (CASE 7): A- Preoperative radiographs of femur (Type 2 open fracture), tibia (Type 3b open fracture) and clinical wound photograph; **B –** Immediate post-operative radiographs of femur and tibia stabilized with external fixator; **C –** X-rays taken 6 months later showing femur fracture union in progress with gap non-union of tibia and clinical photos at 6 months.

Figure 3 (CASE 52): A – Preoperative X-rays showing fracture shaft of femur with ipsilateral femoral neck fracture and fracture of both bones leg on same side. **B –** Radiographs taken 6 months after surgery show nonunion of shaft femur and united fracture (varus union) neck of femur and united both bones leg. **C –** X-rays taken after 24 months showing united fracture shaft femur after exchange nailing and tibial nail was removed after fracture union of both bones leg. **D** Clinical photos at 2 year follow up.

Table 1: Baseline Characteristics, Fracture Type, Type of Floating Knee and Type of Treatment.

Case	*Age (Yrs)*	*Sex*	*Side*	*Closed or open*	*Type (Fraser)*	*Type (Blake and McBryde)*	*Method of treatment*	
							Tibia	Femur
1.	30	M	R	Closed	1	1	ILN	ILN
2.	35	M	R	Open(tibia & femur)	1	1	Ex-fix	Ex-fix
3.	50	M	R	Open(tibia & femur)	2b	2a	Ex-fix(later plating)	Ex-fix(later plating)
4.	60	F	L	Closed	1	1	ILN	ILN
5.	35	M	R	Closed femur and open tibia	1	1	Ex-fix	ILN
6.	55	M	L	Closed	1	1	ILN	ILN
7.	25	M	R	Open (femur & tibia)	1	1	Ex-fix	Ex-fix
8.	27	M	R	Open(femur & tibia)	1	1	Ex-fix	ILN
9.	27	M	R	Closed	2c	2a	CC screw	CC screw
10.	45	M	R	Open tibia and closed femur	1	1	Ex-fix later ILN	ILN
11.	30	M	R	Closed femur & tibia	1	1	ILN	ILN
12.	65	F	L	Closed	1	1	ILN	ILN
13.	34	M	R	Closed	2a	2a	Plate and screws	ILN
14.	46	M	L	Closed	1	1	ILN	ILN
15.	19	M	R	Closed	1	1	ILN	ILN
16.	44	M	L	Closed	2b	2a	ILN	Plate and screws
17.	38	F	L	Open tibia and closed femur	1	1	Plate and screws	ILN
18.	34	M	R	Closed	1	1	ILN	ILN
19.	48	M	L	Open tibia & closed femur	1	1	Ex-fix	ILN
20.	32	F	R	Closed	2a	2a	Plate and screws	ILN
21.	31	M	R	Closed	1	1	ILN	ILN
22.	41	M	L	Closed	1	1	ILN	ILN
23.	38	M	R	Open tibia and closed femur	1	1	Ex-fix	ILN
24.	46	M	R	Closed	2b	2a	ILN	Plate and screws
25.	28	M	L	Closed	1	1	ILN	ILN
26.	55	M	R	Closed	1	1	ILN	ILN
27.	34	F	R	Closed femur and open tibia	1	1	Ex-fix	ILN
28.	24	M	L	Open(femur & tibia)	1	1	ILN	Ex-fix
29.	45	M	R	Closed	2b	2a	ILN	Plate and screws
30.	36	M	R	Open tibia &closed femur	1	1	Ex-fix	ILN
31.	61	M	L	Closed	1	1	ILN	ILN
32.	26	M	R	Closed	1	1	ILN	ILN
33.	18	M	R	Closed	1	1	ILN	ILN
34.	35	M	L	Open tibia and closed femur	1	1	Ex-fix (later ILN)	ILN
35.	42	M	R	Closed	1	1	ILN	ILN
36.	48	M	L	Closed	2b	2a	ILN	Plate screws
37.	33	M	R	Closed	1	1	ILN	ILN
38.	23	M	R	Open(tibia & femur)	1	1	Ex-fix	Ex-fix
39.	38	M	R	Closed	2a	2a	Plate and screws	ILN
40.	34	M	R	Closed	1	1	ILN	ILN
41.	39	M	R	Closed	1	1	ILN	ILN
42.	47	M	L	Open(tibia & femur)	1	1	Ex-fix (later plating)	Ex-fix (later nailing)
43.	57	M	R	Closed	1	1	ILN	ILN
44.	45	M	L	Closed	1	1	ILN	ILN
45.	28	M	R	Open (femur & tibia)	1	1	Ex fix	Exfix (later plating)
46.	42	F	L	Closed femur & tibia	1	1	ILN	ILN
47.	37	M	R	Closed	2c	2a	CC screw	Plate screw
48.	39	F	L	closed tibia and open femur	1	1	ILN	Ex-fix
49.	35	M	R	Closed	2a	2a	Plate screws	ILN
50.	33	M	R	Closed	1	1	ILN	ILN

51.	63	F	L	Open tibia & closed femur	1	1	Ex-fix	ILN
52.	56	M	R	Closed	1	2b	ILN	Long PFN

M – Male, F – Female, R - Right, L – Left, Ex Fix – External fixator, ILN – Interlocking nail, PFN – Proximal femoral nail, CC Screws – Cannulated cancellous screws.

Table 2: Number of Patients according to Classification Offloating Knee

Classification	*Fraser*	*Blake And Mcbryde*
TYPE 1	41	40
TYPE 2A	4	11
TYPE 2B	5	1
TYPE 2C	2	NIL

Table 3: Type of implants used in femur and tibia fractures

IMPLANT	*FEMUR*	*TIBIA*
ILN	30	37
EXFIX	15	8
PLATE	5	5
CC SCREWS	2	1
LONG PFN	1	--------

Table 4: Methods of Fixation used in both femur and tibia fractures.

Method Of Fixation	*Both Iln*	*Only Femur Iln*	*Only Tibia Iln*	*Both External Fixator*	*Only Femur External Fixator*	*Only Tibia External Fixator*
Number Of Patients	23	14	7	6	2	9

Table 5: Time for union, associated injuries, functional outcome and complications of all cases

Case	*Time for radiological union (in weeks)*		*Associated injuries*	*Outcome (Karlstrom criteria)*	*Complications*
	TIBIA	*FEMUR*			
1.	16	20		Excellent	
2.	19	24		Good	Superficial infection.
3.	36	42		Poor	Nonunion of tibia,deep infection,knee stiffness.
4.	12	14		Excellent	Fat embolism
5.	22	17		Good	
6.	14	18	Ipsilateral humerus fracture, intracranial bleed.	Excellent	
7.	24	28	Knee instability	Fair	Superficial infection, Non union of tibia
8.	**P**	18		Poor	Nonunion of tibia
9.	22	21	Knee instability	Fair	Knee stiffness
10.	18	16	Fat embolism, acetabular fracture	Excellent	
11.	14	18		Excellent	Fat embolism
12.	12	20		Excellent	
13.	18	16	Patella fracture ipsilateral, Knee instability	Good	
14.	16	22		Excellent	Fat embolism
15.	14	17		Excellent	
16.	18	24	Knee instability	Good	Knee stiffness
17.	24	18	Contralateral clavicle fracture	Good	
18.	13	23		Excellent	
19.	26	16		Excellent	Superficial infection
20.	18	17	Knee instability	Good	
21.	18	24		Excellent	Fat embolism
22.	14	18		Excellent	
23.	28	18	Contralateral tibia	Good	Superficial infection
24.	18	16	Patella fracture ipsilateral,Knee instability	Fair	Knee stiffness
25.	14	18		Excellent	
26.	16	17		Excellent	
27.	**A**	18	Pneumothorax, Fat embolism	Poor	Below knee amputation, non- union of femur
28.	18	28		Good	Superficial infection
29.	18	22		Good	
30.	23	19	Thrombosis of anterior tibial artery	Fair	Mid tarsal amputation
31.	16	14		Excellent	
32.	16	22	Fat embolism	Good	Fat embolism
33.	18	21		Excellent	
34.	26	18		Excellent	

35.	18	19		Excellent	Fat embolism
36.	16	26	Ipsilateral metacarpal fracture	Good	
37.	12	14		Excellent	
38.	32	**P**	Haemothorax	Poor	Nonunion, deep infection.
39.	24	20	Knee instability	Fair	
40.	16	20		Excellent	
41.	14	18	Contralateral femur	Excellent	
42.	36	42		Good	Superficial infection
43.	18	16		Excellent	Fat embolism
44.	14	22		Excellent	
45.	**P**	32		Poor	Nonunion of tibia, Superficial infection
46.	17	21		Excellent	Fat embolism
47.	22	28	Knee instability	Fair	Knee stiffness
48.	18	26		Excellent	
49.	19	20	Kneeinstability, pubic rami fracture	Good	
50.	18	17	Ipsilateralmetatarsal fracture	Excellent	Fat embolism
51.	24	18	Knee instability	Good	
52.	18	72	Ipsilateral neck of femur fracture	Excellent	

A- Amputation, P- Pseudoarthrosis