

# Treatment of open supracondylar-intercondylar fractures of the femur by ilizarov external fixator

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## Abstract

### Introduction

Open supracondylar-intercondylar fractures of the femur constitute one of the challenges in orthopaedic practice. The problem is exaggerated by the associated contamination, soft tissue damage, comminution, and articular damage. The aim of this study was to evaluate the outcomes of using Ilizarov external fixator to treat open intraarticular distal femur fractures.

### Patients and Methods

This prospective study included 19 patients with 13 males and 6 females. The mean age was 37.26 (Range 21-51) years. Most cases (16 fractures) were due to road traffic accidents, while three were secondary to gun-shot trauma. The average duration from trauma to surgery was (Range 1-10) days. All fractures were AO-OTA type 33C. Fifteen cases were open grade III-A, 3 cases were grade III-B, and one case was grade III-C. Seven patients (36.8%) had associated injuries. Patients were treated by Ilizarov external fixator with cannulated lag screw fixation of the condylar fragments. Additional proximal tibial fixation was needed in 9 cases. Bone grafting was required in 5 cases. The frame was removed after an average of 6.31 months.

### Results

The follow-up duration averaged 31.32 months. At the last follow-up, union was achieved in all cases. ROM averaged 94.47° (Range 50°-125°). Mild valgus angulation (5-7°) occurred in four cases. Three cases had shortening of about 1.5 cm. Pin track infection occurred in 14 cases. Two cases suffered deep infection. According to ASAMI criteria, 10 patients had excellent bone results, 7 cases had good results, and the remaining two had fair results. Functional results were excellent in 8 patients, good in 6 cases, and fair in 5 cases.

### Conclusions

Ilizarov fixator provided a viable treatment alternative for open supracondylar-intercondylar femur fractures allowing early ambulation. Despite having reduced knee ROM in several patients, adequate limb alignment was obtained, and the patients were pain free with stable knee allowing for daily activities.

### Key words

open fracture; distal femur fracture; supracondylar intercondylar fracture; Ilizarov; external fixator.

## Introduction

Distal femoral fractures are relatively common injuries with a bimodal distribution of the mechanism of injury. In elderly, they are commonly caused by a low-energy trauma. In younger patients, supracondylar fractures frequently occur following high-energy trauma by motorcycle or motor vehicle accidents with considerable fracture displacement, comminution, open wounds, and soft tissue injuries. About 5-10% of these fractures are open injuries [1]. Open supracondylar-intercondylar fractures of the femur constitute one of the challenges in orthopaedic practice. The

problem is exaggerated by the associated contamination, soft tissue injuries and periosteal stripping, extensor mechanism affections, comminuted bone fragments, and articular damage. They are frequently complicated by infection, nonunion, and reduced knee motion [2,3].

Distal femoral fractures can be treated by different methods of stabilization including variable plate and screw designs through traditional ORIF or less invasive approach (e.g. 95-degree blade plate [4], DCS [5], modern fixed angle locking plate [6], and variable angle locking plate [7], Double-plating [8]), intrame-

dullary nailing (IMN) [9], and external fixation [10]. External fixator is the workhorse for fixation of open fractures providing a swift versatile method of stability without periosteal stripping or additional exposure even in demanding situations. Ring fixators as Ilizarov fixator are used in juxta-articular fractures with soft tissue injury [11]. Reported studies on using external fixation for definitive management of distal femur fractures are few, mostly after high-energy open fractures [1].

The purpose of the current study was to evaluate the outcomes of using Ilizarov external fixator to treat open intraarticular distal femur fractures.

## Patients and Methods

The inclusion criteria of this prospective study included Gustilo and Anderson [12] grade III open supracondylar-intercondylar fractures of the distal femur in skeletally mature patients treated by Ilizarov fixator. Exclusion criteria were pathological fractures or patients lost during follow-up. After initial trauma resuscitation, patients were thoroughly assessed clinically and radiographically for the open fractures and associated injuries. Standard orthogonal radiographs and CT scans were done for assessment of the fracture and preoperative planning. Angiography was needed for vascular assessment in two patients.

Nineteen fractures in 19 patients were treated by the Ilizarov external fixator between December 2014 and February 2017 including 13 males (68.4%) and six females (31.6%). The age of patients averaged 37.26 (Range 21-51; SD 8.69) years. Eight patients (42.1%) had right fractures and the left side was fractured in 11 patients (57.9%). Most cases (16 fractures; 84.2%) were due to road traffic accidents, while the remaining 3 fractures (15.8%) were secondary to gun-shot trauma. The mean duration preceding surgery was 4.26 (Range 1-10; SD 2.54) days. According to the AO/OTA classification [15], all fractures were AO-OTA type 33C. Fifteen cases (78.9%) were open grade III-A, 3 cases (15.8%) were grade III-B, and one case (5.3%) was grade III-C who had popliteal artery injury and was treated initially with spanning unilateral external fixator and vascular repair. Seven patients (36.8%) had associated injuries including popliteal artery injury (one case), ipsilateral tibial plateau, patellar, and ankle fractures (one case), patellar fracture (four cases), and rib fracture (one case).

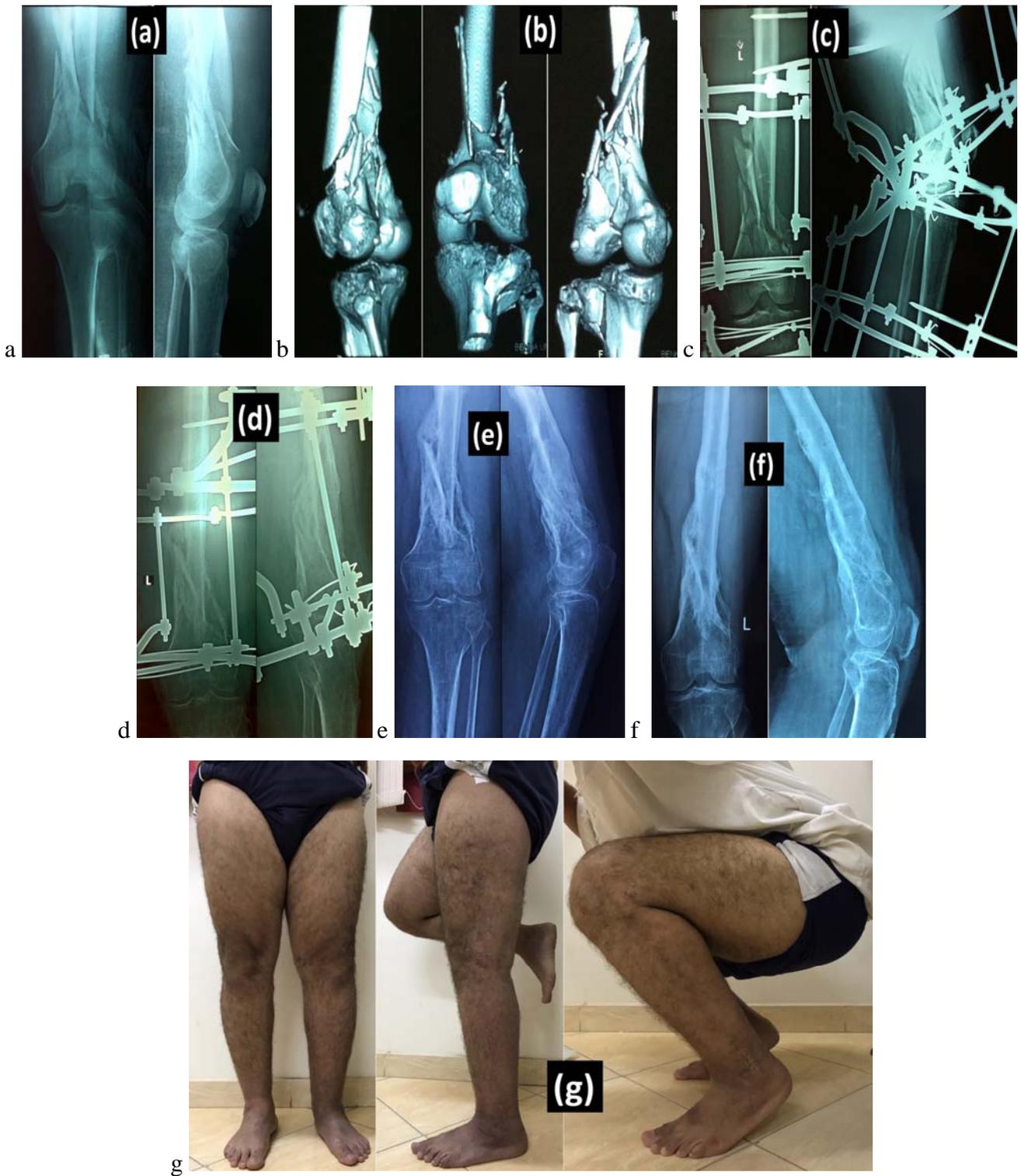
Standard care of open fractures was done including irrigation, debridement of necrotic and contaminated

tissues, and tetanus prophylaxis. An antibiotic combination of aminoglycoside and cephalosporin was given for three days followed by cephalosporin alone. Metronidazole was added with suspected anaerobic contamination. The definitive procedure was done once the general condition of the patient was stable with control of any associated morbidities. The procedure was explained to the patients and an informed consent was obtained.

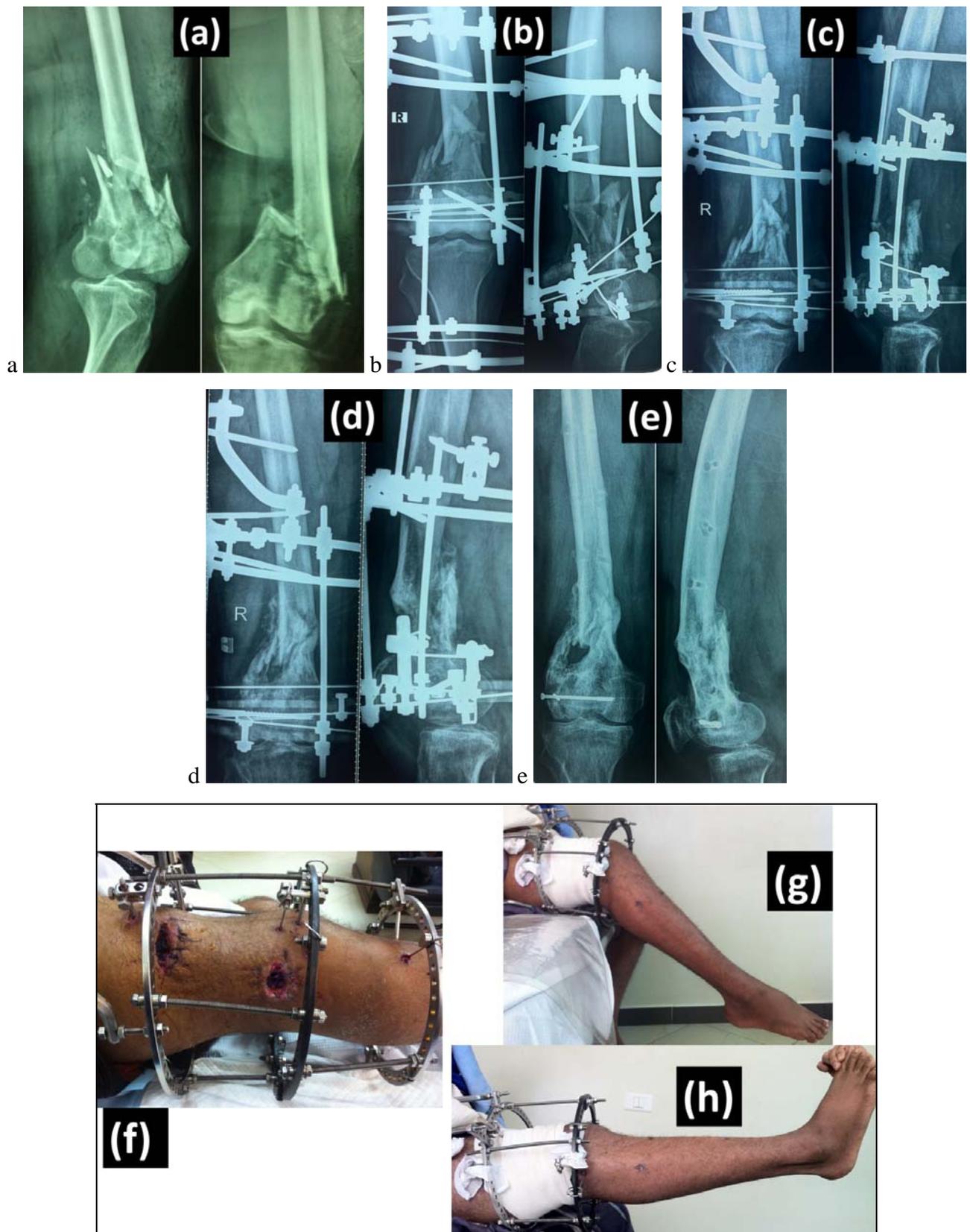
## Surgical technique

Following epidural anaesthesia, the patient was positioned supine on traction table to achieve alignment, aid ligamentotaxis reduction, and permit easy access to the whole circumference of the thigh for easy frame application. The procedure started by adequate debridement of any nonviable tissues while keeping the soft tissue attachments to the bony fragments. The next step was reduction of the intercondylar element of the fracture under image intensifier helped by traction and reduction clamp. This could be assisted by gentle manipulation through the open wound or through limited medial parapatellar incision if needed. A Schanz pin was sometimes used as a joy-stick to reduce fragments. The reduced condylar fragments were fixed by one or two cannulated lag screws. Then, one ring was applied to the femoral condyles and fixed by three or four wires. The proximal shaft was attached to another ring with an arch using 5 or 6 mm Schanz pins. The wires and Schanz pins used for fixation were inserted according to the safe corridor guided by the goniometric atlas of the Association for the Study and Application of the Method of Ilizarov (ASAMI) [13]. The knee was flexed when the wires pass through the quadriceps.

Thereafter, the condylar ring was connected to the proximal construct by rods while reducing the recurvatum deformity and restoring alignment under image intensifier. In case of severe comminution, one ring was fixed to the proximal tibia to add more stability. The open wound was repaired over drain. Any skin tenting on wires was released. Lastly, Crepe bandage was applied over dressings. An associated ipsilateral tibial plateau and patellar fractures was addressed in the stage by extending Ilizarov fixator across the knee (Fig. 1). Four cases had associated patellar fractures including; three displaced fractures treated by ORIF before Ilizarov fixator application, and a non-displaced one treated by extending the circular fixator spanning the knee to the upper tibia (Fig. 2).



**Fig. 1:** A case of left comminuted supracondylar-intercondylar femur fracture associated with fractures of the ipsilateral tibial plateau and patella. (a) Preoperative radiographs. (b) Preoperative CT scans. (c) Postoperative radiographs showing fixation of the distal femur and tibial plateau fractures by the Ilizarov fixator. (d) Radiographs after removal of the tibial frame and progression of healing distal femur fracture. (e) Radiographs after Ilizarov fixator removal. (f) Follow-up radiographs after 2 years. (g) Clinical photos showing alignment, full weight bearing, full knee extension, and knee flexion of about 125 degrees.



**Fig. 2:** A case of right comminuted distal femur fracture with longitudinal patellar fracture caused by a gunshot injury. (a) Preoperative radiographs. (b) Postoperative radiographs with the Ilizarov frame crossing the knee to the proximal tibia to support the patellar fracture. (c) Radiographs after proximal tibial fixation removal. (d) Radiographs showing the progression of union. (e) Radiographs after removal of the Ilizarov fixator showing sound union. (f) Clinical photos showing the postoperative fixation with knee spanning and the wounds of the gunshot. (g) Range of knee flexion after tibial frame removal. (h) Full extension.

## Postoperative Care

Patients were discharged after an average of 5 days (Range 3-8 days). Pin site care was instructed to the patients as well as the gradual range of motion (ROM) exercises for the ankle and for the knee in cases without knee spanning frame. Early foot-touch weight-bearing was allowed as tolerated, and was gradually increased with progression of fracture healing. The follow-up visits were scheduled on weekly basis till sound healing of the wound. Radiographic follow-up was done biweekly for 2 months, then every month until removal of the fixator. Clinical follow-up included the assessment of the wound healing and its complications, pin sites, ROM of the joints, progression of weight-bearing, fracture reduction, bone alignment, and the progress of union. Removal of the Ilizarov ring from the proximal tibia in cases of knee spanning frames was done after 4 weeks in highly comminuted fractures and after 8 weeks in the case with associated tibial plateau fracture. Removal of the main frame was done after adequate union seen in radiographs with bridging callus. Clinical union was identified by painless full weight-bearing. The fixator removal was done under general anaesthesia to allow for some manipulation of the knee to facilitate postoperative rehabilitation. Following fixator removal, the patient was seen every 3 months for one year and yearly thereafter. ASAMI (Association for the Study and Application of the Method of Ilizarov) bone and functional results criteria [14] were used for evaluation.

## Statistical Analysis

The software program of IBM SPSS Statistics for Windows (Version 22.0, IBM Corp., Armonk, NY, USA) was used for descriptive and statistical analysis with setting of  $p < 0.05$  as the level of significance. Comparative analysis was performed using the Paired-Samples Student's t-test.

## Results

Table 1 demonstrates the summary of the demographics and the results of the patients. Crossing the knee with additional proximal tibial ring was needed for severe comminution 6 cases (31.6%) and associated ipsilateral tibial plateau (one case; 5.3%) and patellar fractures (2 cases; 10.5%). Bone graft was needed in 5 cases (26.3%). The upper tibial ring was removed after about 4-8 weeks. The circular fixator was removed following an average external fixation period (EFP) of 6.31 (Range 5-7.5; SD .69) months. Union was achieved in all cases. The patients were followed-

up for an average of 31.32 (Range 18-43; SD 7.296) months. Knee ROM ranged from 45° to 70° (Mean 59.47; SD 8.48) just after fixator removal. ROM improved with postoperative physiotherapy. At the last follow-up visit ROM averaged 94.47° (Range 50-125; SD 22.66) with significant improvement from the earlier values ( $p = .000$ ). Four cases were not compliant with physiotherapy and had ROM of 50° to 65°. All patients were capable of full extension. Five patients had mild exertional knee pain.

Mild valgus angulation (5-7°) occurred in four cases. Three cases had leg-length discrepancy (LLD) of about 1.5 cm. Refracture did not occur in any patient. Pin track infection was the most observed complication and occurred in 14 cases (73.7%). However, this was superficial and treated by oral antibiotics and pin site dressing. Two cases (10.5%) suffered deep infection that was treated by drainage and debridement. None had iatrogenic neurovascular injury, DVT, or complications related to the bone graft donor site

According to ASAMI criteria, 10 patients (52.6%) had excellent bone results, 7 (36.8%) cases had good results, and the remaining two (10.5%) had fair results. Functional results were excellent in 8 patients (42.1%), good in 6 cases (31.6%), and fair in 5 cases (26.3%).

## Discussion

Open distal femur fractures are very challenging. Having few muscular attachments, the distal femur is more liable for expulsion of the fragments resulting in bone loss. Additionally, there is frequent articular extension with crushing of the articular cartilage. Occasionally, the wound is small but large fragment could be ejected and the wound shrinks owing to the elasticity of tissues. Their relative rarity and the considerably different configurations make it hard to establish a standard treatment protocol [16]. The type of definitive fixation for open supracondylar-intercondylar fractures remains a controversial issue [17].

ORIF may be precluded as a safe way of treatment because of higher infection risk due to augmented risk of wound contamination of open fractures, additional soft tissue surgical trauma, the presence of contused soft tissue coverage of the implants, and long surgical time [18]. Acceptable outcomes are reported with minimally invasive plating of those fractures; however deep infection is still a problem [19,20]. HENDERSON et al. [6] reviewed 10 studies treating distal femur fractures with locked plates and reported a nonunion rate of 0-17% and plate failure of 0 to 20%. Open distal femur fractures treated with internal fixation re-

ported variable results. Ricci et al. [21] reported a series of 335 distal femur fractures including 110 open fractures treated by internal fixation. They reported a nonunion rate of 10% with closed fractures and 37% with open fractures. Implant failure was 12% for open fractures compared with 5% with closed fractures. Deep infection occurred in 7% of open fractures and 4% of closed fractures. They concluded that open fractures, diabetes, smoking, increased body mass

index, and short plate length were evident risk factors for nonunion and implant failure. Dugan et al. [22] treated 15 open distal femur fractures by a staged protocol of locked-plating internal fixation and antibiotic beads, and subsequent bone grafting with medial plating. Healing obtained in all cases without infection or malalignment. However, knee stiffness occurred in several cases and the mean knee motion arc was 2°-88°.

**Table 1:** Characteristics and results of the patients

Pt No	Age	Sex	Duration from trauma (days)	Grade of open fracture	Bone grafting	EFP (m)	F-U (m)	First knee flexion (degrees)	Last knee flexion (degrees)	ASAMI outcome	
										Bone	Function
1	28	Male	10	III-A	No	6.5	38	45	65	Good	Fair
2	50	Male	3	III-A	No	5.0	18	60	95	Good	Good
3	41	Male	7	III-A	No	6.0	34	50	80	Good	Fair
4	36	Fem.	3	III-A	No	5.0	43	70	110	Excellent	Excellent
5	32	Male	1	III-A	No	7.0	32	60	100	Excellent	Good
6	40	Fem.	5	III-A	Done	6.5	40	65	95	Good	Good
7	26	Male	2	III-A	No	7.0	35	50	105	Excellent	Excellent
8	36	Fem.	9	III-B	No	7.0	28	65	110	Excellent	Excellent
9	21	Male	7	III-A	Done	7.5	24	70	125	Excellent	Excellent
10	47	Fem.	5	III-B	No	6.0	40	70	115	Excellent	Excellent
11	39	Male	3	III-A	No	7.0	37	60	100	Excellent	Good
12	51	Fem.	4	III-A	Done	6.5	24	55	60	Fair	Fair
13	25	Male	3	III-A	No	6.0	29	65	100	Excellent	Good
14	39	Male	6	III-C	Done	6.5	32	70	120	Excellent	Excellent
15	33	Male	3	III-A	No	6.0	37	45	55	Fair	Fair
16	39	Male	2	III-A	No	7.0	24	60	115	Good	Excellent
17	48	Male	4	III-B	No	5.5	18	50	50	Good	Fair
18	32	Fem.	3	III-A	No	6.0	33	65	110	Excellent	Excellent
19	45	Male	1	III-A	Done	6.0	29	55	85	Good	Good

\* Pt No (Patient Number), Fem. (Female), EFP (External Fixation Period), m (months)

Ilizarov external fixator has several advantages including percutaneous application avoiding stripping of soft tissues, versatility allowing reduction and deformity correction, and high stability permitting early ambulation and weight-bearing. On the other hand, its application is complex with a cumbersome frame requiring patient care and cooperation. Moreover, it has known complications such as danger of neurovascular injuries, pin track infections, and joint stiffness [23].

The present study reports treatment of 19 open supracondylar-intercondylar fractures treated by Ilizarov circular fixator with successful healing in all cases

after a mean EFP of 6.31 months. This was comparable to reports of Ali and Saleh (6.8 months with open fractures group, and 5.2 months for closed fractures) [24], and Hassankhani et al. (30 weeks) [25]. Sala et al. [17] reported longer period of 45 weeks and this was attributed to the presence of cases with large bone defects treated by bone transport. Other studies reported shorter EFP of 25 weeks [10], and 19 weeks [26].

Two cases of the present study suffered deep infection. None had nonunion. Mild valgus (5-7°) was evident in four cases, and three had LLD of 1.5 cm.

These complications varied among different studies. Iyengar et al. [16] reported one deep infection, 100% union rate, 14 cases of angulation, and 11 cases of LLD (2-7 cm) in their series of 18 fractures. The study of Hassankhani et al. [25], with 34 fractures, had 7 deep infections, 2 nonunions, 5 angulations, and 2 LLDs. Whereas Sala et al. [17] treated 20 fractures with three nonunions, but without deep infection or LLD more than 2.5cm.

Reduction of the knee ROM was evident in the current study with an average range of knee flexion of 94.47°. This is a common complication after distal femoral fractures. Several factors may contribute to this complication including the severity of the articular damage, extent of the associated periarticular soft tissue damage, and lack or reluctance of early and persisting ROM exercises. Moreover with fixation of these fractures by circular fixators, the juxta-articular soft-tissue tether by the transfixing wires and pins may cause further limitation of knee motion. The wires and pins passing through the quadriceps muscle act as a checkrein to knee flexion [27]. For this, in the present study, the knee was flexed while passing the wires in the quadriceps to stretch the knee extensor mechanism. The mean flexion ROM varied among different studies (49° [16], 77° [26], 95° [17], 88° [22], 87.5° [25], 110° [27], and 118° [18]).

Iyengar et al. [16] treated 18 open intraarticular distal femur fractures by free fibular strut graft and cortico-cancellous grafting with different fixation methods (13 cases with lateral condylar buttress plate, 2 cases by dynamic condylar screw, and 5 cases with Ilizarov fixator). Union achieved in all cases with an average flexion knee ROM of 49°, and 14 malalignments.

Arazi et al. [28] treated 14 distal femur fractures (including 4 open) by Ilizarov fixator, and reported one nonunion, one deep infection, and a mean flexion ROM of 105°. The Neer score was excellent in 2, good in 7, fair in 3, and poor in 2 cases. Kumar et al. [27] presented a series of 20 open distal femur fractures treated by Ilizarov fixator and union was obtained in all cases. Mean knee flexion was 110° with type C2 and 73° with C3 fractures. However, all cases an extension deficit of 5°-10°, and 40% of cases had 4cm shortening. Sala et al. [17] used Taylor Spatial Frame to treat 20 open fractures. Union was obtained in 17 cases. Four patients had abnormal mechanical axis deviation. ASAMI bone criteria were 37% excellent, and 63% good and the functional outcomes were 5% excellent, 58% good, and 37% fair. Hassankhani et al. [25] treated 34 open fractures using hybrid fixator. Their ASAMI bony results were excellent in 70.5%, good in 17.7%, fair in 5.9%, and poor in 5.9%, and functional results were excellent in 29.4% cases, good in 41.2%, fair in 17.6%, and poor in 11.8%.

The present study has several limitations including the retrospective methodology, the small number of cases, lack of control group, and the lack of long term assessment. The small number of the study could be explained by the limiting inclusion criteria to get a homogenous group of fractures. Future large randomized controlled multi-center study with long term follow-up would provide better evaluations of these challenging fractures.

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## Conclusions

Ilizarov fixator provided a viable treatment option for open supracondylar-intercondylar femur fractures. The fixator stability allowed for early ambulation and functional limb use. Despite having reduced knee ROM in several patients, adequate limb alignment was obtained, and the patients were pain free with stable knee allowing for daily activities.

**Conflicts of Interest:** The authors declare that they do not have any conflict of interest.

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