



# Ilizarov Fixator in Femoral Supracondylar Fractures: A Case Series with 1 - 6 - Year Follow-up

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## Abstract

**Background:** The current study aimed at determining the clinical effectiveness and safety of Ilizarov external fixation on the treatment of femoral supracondylar fracture.

**Methods:** The current retrospective case series study was conducted on patients with femoral supracondylar fracture. The patients were treated by Ilizarov technique and followed up for 1 - 6 years. The complication rate was determined by knee society score (KSS) and functional knee score (FKS).

**Results:** Most of the 47 assessed patients were in the age range of 31 - 40 years (38.3%) and 83% of them were male. Average fixation time was  $4.82 \pm 0.96$  months (range three to seven months); 40 cases (84.5%) until five months and all patients until seven months post-operation achieved complete union without major complications. The mean range of extension lack and flexion of the knee at the final follow-up were  $1.91 \pm 3.54$  and  $121.17 \pm 14.45$  degrees, respectively. The means of KSS and FKS at final follow-up were  $90.8 \pm 7.2$  and  $90.57 \pm 8.16$ , respectively. Although superficial pin-tract infection was observed in 28 pin sites (59.6%), no patient developed deep infection or osteomyelitis.

**Conclusions:** The Ilizarov fixative technique can be used as an effective and available method with low complications to treat severe femoral supracondylar fractures.

**Keywords:** Ilizarov, External Fixation, Distal Femoral Fracture

## 1. Background

Femoral supracondylar fracture comprises 4% - 7% of all femoral fractures (1). These fractures usually occur in females over 50 years old due to injury in a fall when walking or osteopenia, and in younger patients (males 15 - 50 years) due to road accidents and sports injuries (1-3). Supracondylar femoral fracture occurs in the distal (9 cm) of the femur between the diaphyseal - metaphyseal junction and the femoral condyle (2). The fracture is often hard to treat, and needs careful management such as initial skeletal traction, followed by cast immobilization, dynamic condylar screw, interlocking nails, the use of an intramedullary fixation device, or external fixation. Nevertheless, there is no agreement on the treatment of choice among orthopedic surgeons (3, 4).

Ilizarov is an external fixation device applied in the orthopedic surgeries to treat and also correct bone fractures and deformities and limb-length differences. Also, it aids to create the repair of angulation, multiplanar stability, and rotation at the nonunion site (1, 5). The current study

reported the experience at a teaching hospital to manage femoral supracondylar fractures fixed using the Ilizarov technique.

## 2. Methods

### 2.1. Patient and Setting

The current retrospective case series study was approved by our Institutional Review Board of Research. In the first step, the recorded data of all supracondylar femoral fractures due to high velocity trauma fixed by Ilizarov technique from 2010 to 2015 were reviewed. Then, via phone calls, subjects that completed the follow-up course (two weeks following the surgery and then every month until achieving complete union and extracting Ilizarov device) were invited to the under study hospital orthopedic clinic to assess the final surgery results. The mean follow-up course was 3.5 years (range, one to six) and

patients were in the age range of 20 to 75 years. Eventually 47 patients were included in the current study (20% dropouts).

The main variables analyzed in the current study included demographic characteristics such as age, gender, and type of supracondylar fracture based on A/O classification (6), and other characteristics including open or closed fracture, mean time of Ilizarov fixator, union, chronic osteomyelitis, pin insertion site infection, range of motion, limb shortening, knee society score (KSS), and functional knee score (FKS). In order to better interpret the study results while achieving more precise calculations, KSS and FKS scores of 85 - 100 were considered excellent, 70 - 84 good, 60 - 69 fair, and < 60 poor.

## 2.2. Surgical Procedures

First, the patient was placed in supine position and underwent general anesthesia. Articular surfaces were set by the help of fluoroscopy as close or mini-open incision, and fixed using some 6.5 partially threaded cancellous screws. One or two rings and three pins (having olive if possible) per each ring were used at the femoral condylar area distal to fracture site. Also, 1/2 or 3/4 rings with two or three Schanz of 5 mm for each ring were applied at the proximal area of fracture site. Corticocancellous autogenous bone graft harvested from iliac crest of similar site was used to fill the defect if bone defect more than 1/3 of bone diameter existed in the fracture site. After fixation, complete manipulation of knee from full extension to full flexion was done and finally stability of fracture site was checked.

## 2.3. Post-Operative Advice

Necessary trainings were presented to all patients about care of the wires and Ilizarov rings and disinfection of pin area (at least twice a day) by disinfectant solutions such as betadine and alcohol; standing with support and knee mobilization along with physiotherapy were applied to all patients under exact supervision and if patient had no pain at 48 hours and two weeks after operation, respectively. Partial weight bearing was allowed for all patients immediately after operation, but full weight bearing was allowed just based on improvement progress of clinical and radiological outcomes.

## 2.4. Statistical Analysis

All results were analyzed with SPSS version 21 using general linear model (GLM), repeated-measures ANOVA, and chi-square. Chi-square test was used to compare qualitative variables (open or closed wound and infection in the pin area) based on age categories. Repeated-measures ANOVA was used to compare KSS, FKS, knee flexion, and lack of knee extension during the measurement period

and also trend of change based on age categories. Quantitative variables had normal distribution based on Chi-square test. Finally, the Friedman test was used to compare knee function status during the evaluation period as a rated variable.  $P < 0.05$  was considered as significant in all statistical analysis.

## 3. Results

Among 61 patients treated with Ilizarov method, 47 cases were enrolled in the current study including 39 males and eight females (mean age of  $35.57 \pm 10.77$  years). Table 1 shows the demographic characteristics. There were 16 patients (34%) aged 20 - 30 years, 18 patients (38.3%) 31 - 40, nine patients (19.1%) 41 - 50, and four patients (8.5%) above 50. Most of the patients (61.7%) had open fracture. Based on the A/O classification, the most frequent type of fracture was 33-C3, observed in 19 of the 47 cases (40.4%). Fractures of 33-A2, 33-B1, and 33-B3 types did not exist. The mean time of using Ilizarov fixator was  $4.82 \pm 0.96$  months (range three to seven months). Superficial pin-tract infections occurred at 28 pin sites (59.6%) in the first two months and were treated with antibiotics and care of the pin sites.

The mean of maximum time of infection in the patients was  $2.28 \pm 1.18$  months and none of them had deep infection or report of osteomyelitis. Moreover, all pin site infections were treated at the end of six months.

Until five months post-operation, 40 cases (84.5%) and until seven months post-operation all patients achieved complete union. The mean duration of union time was  $4.68 \pm 0.93$  months after surgery (Table 1 and Figures 1 - 3).

The mean range of knee extension lack was  $5.91^\circ \pm 6.04$  and  $2.34^\circ \pm 3.88$  and  $1.91^\circ \pm 3.54$ , after six months, one year, and in the last visit, respectively. Also, the mean range of knee flexion was  $108.62^\circ \pm 17.37$  at six months;  $118.72^\circ \pm 16.33$  after one year, and  $121.17^\circ \pm 14.45$  in the final visit. Limb length discrepancy lower than 10 mm was ignored in the current study and there were just three patients (6.4%) with limb length discrepancy all of which had fracture type C and primary bone graft. The discrepancy in two patients was 1.5 and 2 cm in the last visit.

Figure 4 shows that, as time passed, the mean KSS and FKS scores rose among the study cases. The mean KSS scores were  $84.12 \pm 9.69$ ,  $89.8 \pm 6.8$ , and  $90.8 \pm 7.2$  at six months, one year, and the final follow-up, respectively ( $P < 0.0001$ ;  $F = 63.74$ ). Also, the mean FKS scores were  $84.76 \pm 9.96$ ,  $89.97 \pm 7.81$ , and  $90.57 \pm 8.16$ , in six months, one year, and at the last follow-up visit, respectively ( $P < 0.0001$ ;  $F = 40.67$ ) (Figure 4).

In the final visit, knee function status was excellent in 31 patients (66%) and no patient showed poor results (Table 2). There were no significant associations between the demographic features, and KSS and FKS scores. But in open

Table 1. Demographic Features of the Patients

Number (N = 47)	Baseline Parameter					Preoperative Results					
	Age (year)	Gender	Fracture Type (A/O) (Classification)	Wound Type	Fixator Duration (mn)	Pin Site Infection (mn)			Union (mn)		
						< 2	2 - 6	> 6	< 2	2 - 6	> 6
1	24	F	33 C <sub>2</sub>	Open	4	No	No	No		Yes	
2	30	M	33 C <sub>3</sub>	Open	6	Yes	No	No		Yes	
3	26	M	33 C <sub>1</sub>	Close	5	Yes	No	No		Yes	
4	21	F	33 C <sub>3</sub>	Close	4	No	No	No		Yes	
5	30	M	33 C <sub>2</sub>	Close	4	No	No	No		Yes	
6	27	M	33 C <sub>3</sub>	Close	7	Yes	No	No		Yes	
7	24	M	33 C <sub>1</sub>	Open	5	No	No	No		Yes	
8	22	F	33 C <sub>2</sub>	Open	6	No	No	No	Yes		
9	27	M	33 C <sub>3</sub>	Open	4	Yes	Yes	No			Yes
10	22	M	33 A <sub>1</sub>	Open	5	No	No	No		Yes	
11	26	M	33 C <sub>3</sub>	Open	4	Yes	No	No		Yes	
12	23	M	33 C <sub>1</sub>	Open	4	No	No	No	Yes		
13	29	F	33 C <sub>3</sub>	Close	3	Yes	No	No		Yes	
14	28	M	33 A <sub>3</sub>	Close	4	No	No	No		Yes	
15	22	M	33 A <sub>3</sub>	Open	5	Yes	Yes	No	Yes		
16	25	M	33 C <sub>3</sub>	Open	4	No	No	No		Yes	
17	40	M	33 C <sub>3</sub>	Close	3	No	No	No		Yes	
18	38	M	33 C <sub>1</sub>	Open	5	Yes	Yes	No		Yes	
19	31	M	33 C <sub>3</sub>	Close	4	No	No	No		Yes	
20	36	F	33 C <sub>3</sub>	Open	5	Yes	No	No		Yes	
21	37	M	33 C <sub>3</sub>	Open	6	Yes	No	No	Yes		
22	39	M	33 C <sub>1</sub>	Open	6	Yes	Yes	No		Yes	
23	35	M	33 C <sub>2</sub>	Close	4	No	No	No		Yes	
24	34	F	33 C <sub>3</sub>	Open	5	Yes	Yes	No		Yes	
25	33	M	33 C <sub>1</sub>	Open	4	Yes	No	No			Yes
26	36	M	33 C <sub>1</sub>	Close	4	No	No	No		Yes	
27	31	M	33 A <sub>3</sub>	Open	6	Yes	No	No		Yes	
28	37	M	33 C <sub>2</sub>	Open	5	Yes	Yes	No		Yes	
29	39	M	33 A <sub>3</sub>	Close	4	Yes	Yes	No			Yes
30	40	F	33 C <sub>3</sub>	Open	6	Yes	No	No		Yes	
31	32	M	33 C <sub>2</sub>	Open	5	Yes	No	No		Yes	
32	34	M	33 C <sub>3</sub>	Open	7	Yes	No	No			Yes
33	37	M	33 B <sub>2</sub>	Close	4	No	No	No		Yes	
34	38	F	33 C <sub>1</sub>	Close	4	No	No	No		Yes	
35	42	M	33 A <sub>3</sub>	Open	5	Yes	No	No		Yes	
36	50	M	33 C <sub>2</sub>	Open	5	Yes	Yes	No		Yes	
37	44	M	33 C <sub>1</sub>	Open	5	Yes	Yes	No		Yes	
38	42	M	33 C <sub>3</sub>	Open	6	Yes	No	No			Yes
39	42	M	33 C <sub>3</sub>	Close	3	No	No	No		Yes	
40	41	M	33 C <sub>2</sub>	Close	5	No	No	No		Yes	
41	45	M	33 A <sub>3</sub>	Open	6	Yes	Yes	No		Yes	
42	44	M	33 C <sub>3</sub>	Open	5	Yes	No	No		Yes	
43	45	M	33 C <sub>1</sub>	Close	5	No	No	No		Yes	
44	61	M	33 C <sub>2</sub>	Open	6	Yes	Yes	No			Yes
45	53	M	33 C <sub>3</sub>	Close	5	No	No	No		Yes	
46	54	M	33 C <sub>3</sub>	Close	5	Yes	No	No		Yes	
47	56	M	33 A <sub>3</sub>	Open	5	Yes	Yes	No			Yes



**Figure 1.** A 25 - year - old male with an open comminuted fracture of the distal femur (type C3) due to motor car accident. A: Follow-up radiographs 5 months; B: 10 Months, and C: 18 Months post-surgery; D and E: Flexion and extension of knee joint.

wounds and older patients, the rate of infection was significantly higher ( $P < 0.001$  and  $P < 0.0001$ , respectively).

**Table 2.** Knee Society Score and Functional Knee Score Qualified Results

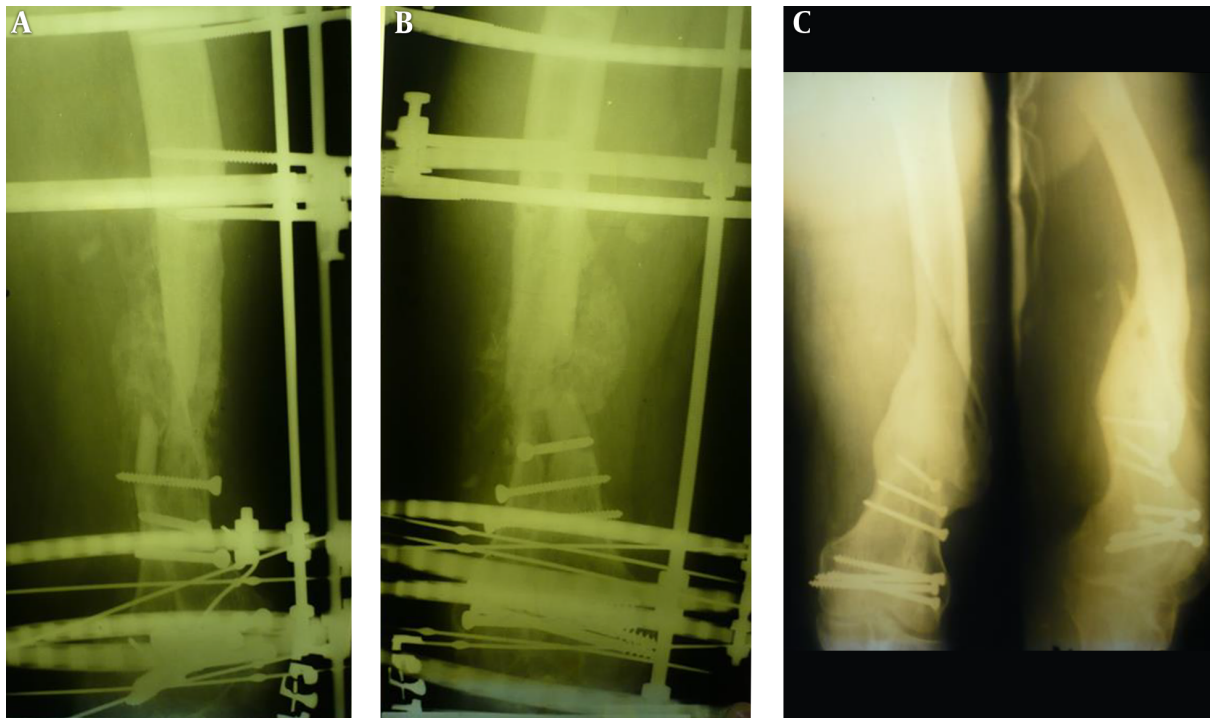
Category	6 Months Post-surgery	1 Year Post-surgery	Final Follow-up Visit
Excellent	15 (31.9%)	29 (61.7%)	31 (66%)
Good	24 (51.1%)	15 (21.9%)	14 (29.8%)
Fair	6 (12.8%)	3 (6.4%)	2 (4.3%)
Poor	2 (4.3%)	0	0

#### 4. Discussion

The current study evaluated 47 patients with femoral supracondylar fractures treated with Ilizarov. The main variables in the current study were union, infection, range of motion, knee function status, and limb length discrepancy.

Although in the current study most of the patients had type C fracture and open wound, complete union was achieved in all patients. Nonunion is a serious complication especially in open and comminuted fractures. In the previous studies it was reported that nonunion generally occurred in 4% of fractures of distal of femur (7). In dif-





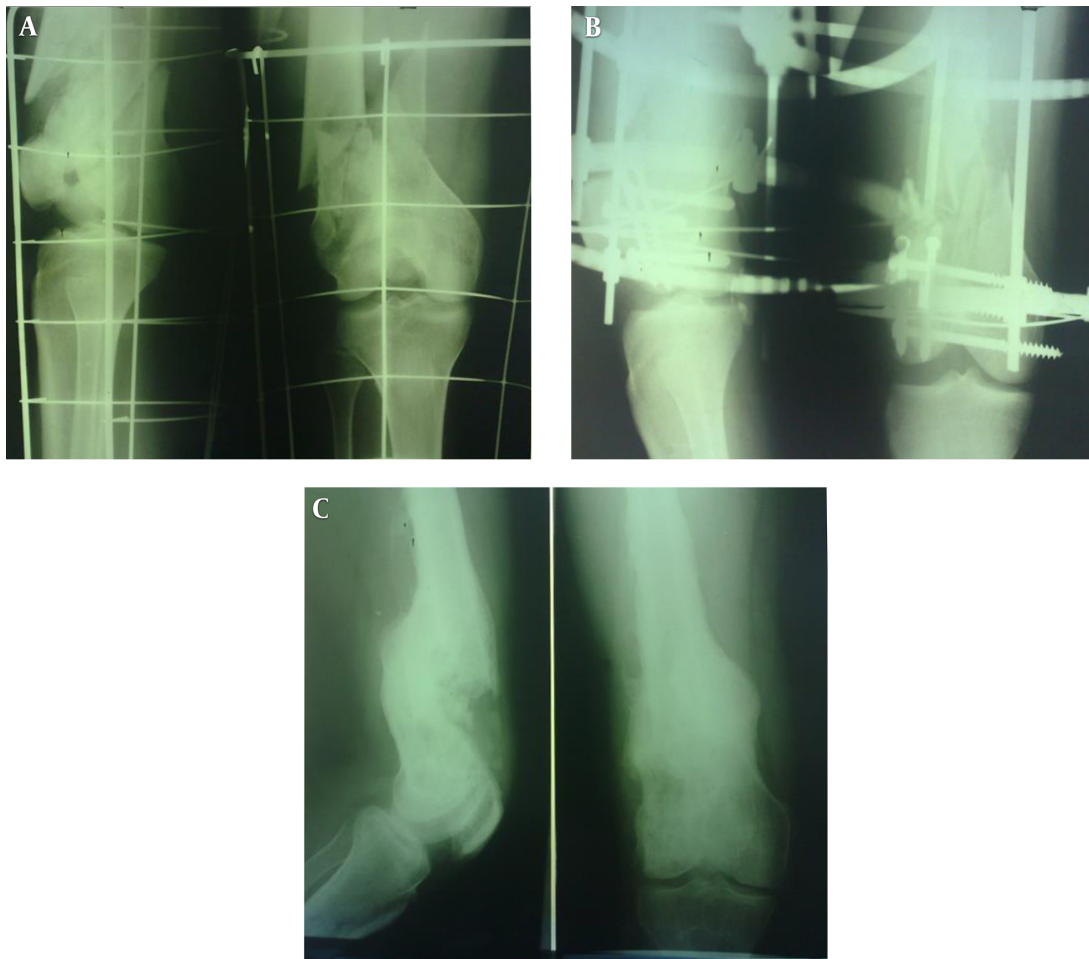
**Figure 2.** A 37-year-old male with an open comminuted fracture of the distal femur (type C3). A and B: Follow-up radiographs 6 months; C: 18 Months post-surgery.

ferent studies on femoral supracondylar fractures using Ilizarov and other therapeutic methods, obtaining complete union is evaluated. In the study by Cavusoglu et al., (7) complete union was gained in all fractures of patients with femoral supracondylar fracture treated with Ilizarov. In another study on the patients with femoral supracondylar and infracondylar fractures treated with Ilizarov, just 7.5% of patients had nonunion (8). Also, in the study by Ali and Saleh (9), only 7.6% of patients with distal fracture of femur that were fixed by Ilizarov had nonunion. While in the study by Ricci et al., conducted on the patients with distal fracture of femur and treated with locked plate fixation, 17% and 7.5% of patients showed nonunion and implant failure, respectively (10). In the current study, the maximum time to obtain complete union was seven months, which was lower than that of some studies (11), but higher than those of some other studies (7-9, 12) that evaluated the Ilizarov technique.

Since in the current study, patient's knee was set in full flexion and extension after the fixation of fracture and no types of motion were observed in the fracture site, rigid fixation may be one of the reasons that complete union was obtained in the current study patients. On the other hand, despite the rigid fixation, early full weight bearing (FWB) was allowed for all patients. The application of FWB immediately after external fixation is associated with lack of

nonunion and infection. Also, it is possible that FWB is one of the causes of complete union in the current study patients. Different studies showed that several factors were effective in union of bone fracture, among which high velocity trauma, open or closed wound, and injury area can be mentioned. In the current study, despite the high velocity trauma in all patients and open fracture in 69.7% of them, appropriate outcomes about complete union were achieved.

Another reason for the complete union in the current study was lack of deep infection in the enrolled patients. Although superficial pin-tract infections were observed in more than half of the patients, no cases with deep infection were reported. Also, in the study by Cavusoglu et al. (7), contrary to the existence of superficial pin-tract infection in all cases, no cases with deep infection were observed. Furthermore, no cases of deep infection were observed in the study by Ali and Saleh (9). However, 7.15% of patients in the study by Arazi et al., had deep infection (8). Different degrees of infection were also reported in other therapeutic methods of femoral supracondylar fractures. For instance, in the study by Hutson et al., performed as prospective on the patients with type C, open fracture of distal of femur treated with limited internal and external tensioned wire fixation, one case of pin-tract infection, one case of septic arthritis, and one case of osteomyelitis were reported (13).



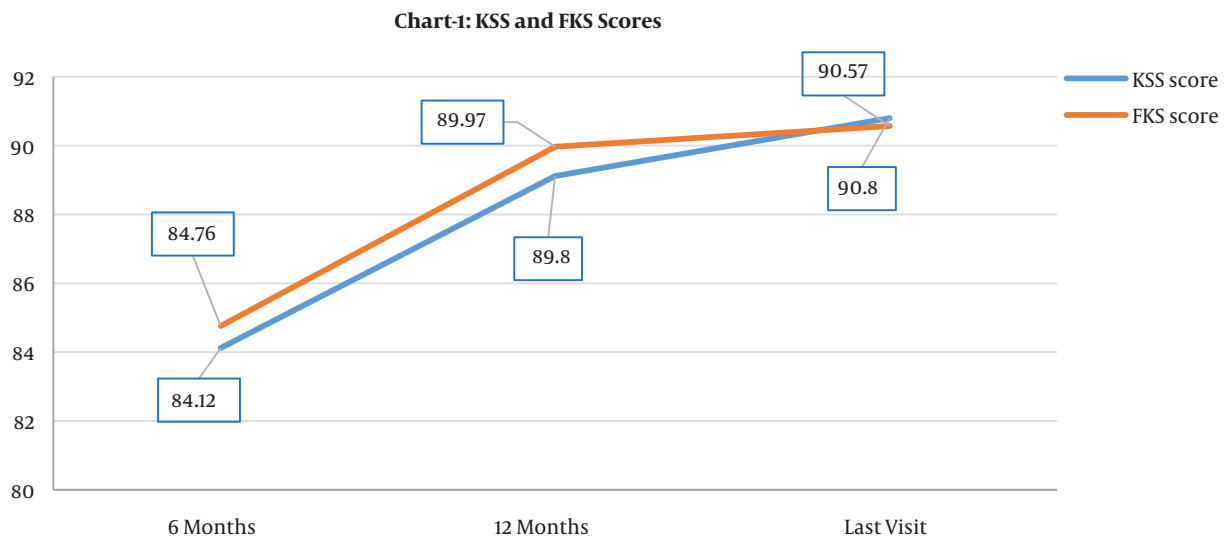
**Figure 3.** A 34 - year - old male with an open comminuted fracture of the distal femur (type C3). A: The preoperative radiographs of the patient; B: Follow-up radiographs 6 months and C: 20 Months post-surgery.

Notwithstanding the acceptable complete union by Ilizarov, decrease in range of motion, especially in flexion position, is one of the most significant complications of this method. However, the current study findings about flexion and extension deficit were better and more acceptable than those of other similar studies (8, 9, 11). Moreover, the possibility to pass pins from the quadriceps muscle is one of the most important limitative causes of knee motion, especially in the flexion status after external fixation. On the other hand, despite the decrease in the range of motion, KSS and FKS in final visit were acceptable, which indicates the patients' satisfaction.

Good and excellent FKS in the current study in comparison with those of the study by Ali and Saleh (9) can be due to obtaining complete union in the appropriate time, lack of deep infection, and achieving acceptable range of motion in all patients.

Also, limb shortening was observed in 6.25% of patients with C3, open, and seriously crushed. Different shortening rates were reported after using Ilizarov external fixator as 15.38% (9), 35% (8), and 80% (11); despite the fact that limb shortening was also reported by other methods (14). It seems that limb shortening is more related to the type and severity of fracture rather than therapeutic method and is mostly observed in cases with C type and seriously crushed fractures in different studies. Table 3 shows the comparison of the current study distal femoral fracture results with those of other studies.

The current study results showed that Ilizarov external fixator was very successful to treat femoral supracondylar fractures and the main causes of this success were rigid fixation and early full weight bearing. Despite the acceptable outcomes, one of the biggest problems in the use of external fixator is the long time it takes for care attending and



**Figure 4.** Knee Society Score and Functional Knee Score

some limitations are induced in the patient's movements including daily activities such as sitting, standing, and sleeping. Indeed, it can be said that existence of this fixator due to large size and lack of flexibility causes stress for patients. Since no tests were used in the current study to evaluate the psychological conditions of the patients, the exact psychological effects of treatment of femoral supracondylar fractures by Ilizarov cannot be expressed. Lack of any psychological evaluations of the current study patients due to the retrospective nature of the study was one of the limitations. Another limitation was case - series nature of the study. It is possible to obtain better and more acceptable outcomes using prospective studies along with control groups, other therapeutic methods, larger sample sizes, longer follow-up period, and evaluation of psychological conditions of patients.

#### 4.1. Conclusion

The Ilizarov fixative technique can be used as an effective and available method with low complications to treat severe femoral supracondylar fractures.

#### Footnote

**Conflict of Interests:** The authors declared no conflict of interest.

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**Table 3.** Comparison of the Results of Distal Femoral Fractures with Those of Other Studies

Author	Type of Fixator	No.	Open (%)	Fracture type (%) (AO Classification)			Range of Motion	Nonunion	Time to Union (wk)	Knee Flexion (in C2 fractures) 73 (in C3 fractures)	Follow-up (mm)	Fixator Duration (mm)	Excellent and Good Result	Complications (%)	
				A	B	C								Deep Infection	Muscle Shortening
M. Arazl 2001 (8)	Ilizarov	14	-	3	-	11	-	1	16	105(35-130)	14	5	64%	1	0.5-2.5 cm (in 4 patients)
Pankaj Kumar 2006 (11)	Ilizarov External Fixation	20	-	-	-	20	-	-	39	110 (in C2 fractures) 73 (in C3 fractures)	12-52	-	-	-	4 cm (in 8 patients) 1.5 cm (in 8 patients)
Hutson, James J Jr 2006 (13)	Limited Internal and External Tensioned Wire Fixation	16	75%	-	-	16	0-92	-	-	Less than 90 (5 patients)	35	6	-	Osteomyelitis (1 patient) septic arthritis (1 patient)	-
Ali F. Saleh M 2000 (9)	External Fixation	13	53.8%	4	-	9	0-100	1	24	-	30	-	69.2	-	-
William M. Ricci 2014 (10)	Locked Plate Fixation	335	32.8 3%	131	-	204	-	271	-	-	-	-	-	13	-
Ali Turgay Cavusoglu 2009 (7)	low-profile Ilizarov external Fixator	10	40%	7	-	3	8-100	-	-	-	74	22	60%	-	1-3 cm (in 4 patients)
Fazal Ali, Michael Saleh 2002 (15)	External Fixation	15	60%	-	-	-	0-80	1	41	-	55	-	-	-	-
A. Sardis, 2005 (6)	Ilizarov	13	-	-	10	3	-	-	-	-	42.4 (After removal of the frame)	10	12	-	-
Agus H 2002 (14)	Indirect Plate Osteosynthesi	6	50%	-	-	6	-	-	15	-	25	-	2	-	1-2.5 cm (in 3 patients)
Current study	Ilizarov	47	61.7%	8	1	39	-	-	19	121/7	12-72	4.82	95.8%	-	15-2 cm (in 3 patients)