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**Research Article**

# Outcome of Ilizarov External Fixator in Open Comminuted Distal Femur Fracture a Prospective Study

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**ABSTRACT**

**Objective:** To assess radiological and functional results in patients with open comminuted distal femur fractures treated with an Ilizarov external fixator.

**Methods:** This is a prospective observational study carried out at DHQ Teaching Hospital, Dera Ismail Khan, Orthopedic Ward and Trauma Center from January 2024 to December 2025. There were 95 patients with open comminuted distal femur fractures treated with the Ilizarov external fixator. Patients were followed until union of the fracture and a functional state. All the data were analyzed using SPSS version 26.

**Results:** The mean age was 39.8 ± 12.1 years, and 71.6% of patients were male. Fracture union was obtained in 91 (95.8%) patients; the mean time to union was 24.6 ± 5.3 weeks. 76.8% had excellent and good functional results. Pin tract infection (16.8%) was the most common complication. Fracture union was strongly correlated with Gustilo-Anderson grade ($p=0.031$), and functional outcome was strongly correlated with age ($p<0.001$) and AO/OTA fracture classification ($p=0.002$).

**Conclusion:** The Ilizarov external fixator is a safe and effective treatment option for open comminuted distal femur fractures, providing high union rates, satisfactory functional outcomes, and acceptable complication rates.

**Keywords:** Ilizarov External Fixator, Open Distal Femur Fracture, Comminuted Fracture, Fracture Union.

## INTRODUCTION

Distal Femur fractures are one of the most complex fractures encountered in orthopedic trauma, specifically open comminuted distal femur fracture.[1] These fractures typically occur with high-energy mechanisms (road traffic accidents, falls from height, industrial accidents, and firearm injuries), and result in extensive metaphyseal comminution, soft tissue disruption, contamination, and significant compromise of the local blood supply.[2] The distal femur accounts for about 4-6% of all femur fractures and less than 1% of all skeletal fractures, but open distal femur fractures are responsible for a disproportionate amount of morbidity due to their tendency to have a severe soft tissue injury, infection, delayed union, nonunion, knee stiffness, and long-term disability.[3, 4] Management of these injuries is a particularly difficult challenge because

fracture stability, preservation of biological viability, infection control, and early function are all goals that must be met, all while reducing the likelihood of complications.[5]

The management of open comminuted fractures of the distal femur has undergone significant changes in the last few decades.[6] There is a trend to use internal fixation with locking compression plates and retrograde intramedullary nails for a large number of closed fractures since these implants offer stable fixation and early mobilization.[6] In the most severely comminuted open fractures, especially those of Gustilo-Anderson type IIIB and IIIC, however, the severe soft tissue damage and contamination that can occur make definitive internal fracture fixation often impractical due to the risks of deep infection, implant failure, bone loss, and impaired fracture healing.[7] These injuries are complex, and biological fixation methods have been explored to reduce additional surgical trauma and provide adequate stability.[8] Therefore, external fixation continues to play an important role in damage control orthopedics and definitive fracture treatment in select patients with severe open distal femur fractures.[5]

The Ilizarov external fixation system is based on the principles of circular external fixation, tensioned transosseous wires, and controlled biomechanical stability.[9] The Ilizarov frame offers multiplanar stability and maintains fracture biology and periosteal blood supply as compared to conventional monolateral external fixators.[10] These allow for early weight bearing, progressive correction of deformities, treatment of bone defects using distraction osteogenesis, and treatment of associated soft tissue injuries at the same time.[11] It has several features that make it very suitable for the treatment of complex open fractures where biological healing must be preserved.[12]

Although the care of acute traumatic injuries of the distal femur and the fixation of these fractures have improved over the years, there is still no agreement on the best treatment of these open comminuted fractures.[13] The decision of which one of these methods to use for fixation, staged reconstruction, hybrid fixation, or circular external fixation will depend mainly on the morphology, degree of contamination, soft tissue status, patient characteristics, and surgical expertise available.[14] High-energy road traffic collisions are becoming more common, and delayed presentation in these areas, coupled with limited resources and high injury rates of soft tissue trauma, often makes management challenging, and evaluation of the efficacy of biologically sound, cost-effective, and reliable treatment of fracture union is of great clinical importance.[15, 16]

Given these difficulties, it is important to assess the efficacy of the Ilizarov external fixator in the treatment of open comminuted distal femur fractures before it can be generally recommended for use. The biological benefits of external fixation in a circular fashion, along with the stable fixation that can be achieved while minimizing the secondary soft tissue trauma, suggest that it may have the potential to enhance fracture union, maintain function, and minimize major complications in this challenging patient population. Further prospective data are needed to establish its clinical and functional results in the normal orthopedic setting, however. The purpose of this study was to compare the results of Ilizarov external fixation for open comminuted fractures of the distal femur by measuring the time to fracture union, fracture healing rate, functional outcomes, and procedure-related complications in a prospective cohort of patients.

## METHODOLOGY

This is a prospective observational study that aims to assess the clinical and radiological results of the Ilizarov external fixator in the treatment of open comminuted distal femur fractures. The study was carried out in the Orthopedic Ward and trauma center, DHQ teaching hospital, Dera Ismail Khan, Pakistan. The study lasted for 2 years from January 2024 until December 2025.

The sample size was determined with OpenEpi Version 3.01. This calculation was done assuming an expected fracture union rate of 90%, consistent with previous studies that assessed the results of Ilizarov external fixation for complex distal femur fractures.[17] Based on the 95% confidence level and absolute precision of 6%, the sample size calculated was 95 patients.

Non-probability consecutive sampling technique was used. The study included patients of either gender ranging between 18 and 65 years of age with open comminuted distal femur fracture within 2 weeks of injury, who were classified into Gustilo-Anderson grade II, IIIA or IIIB fracture.[18] Only patients who were treated definitively with the Ilizarov external fixator and who signed a written informed consent and agreed to follow-up visits were enrolled.

Pathological fracture, closed distal femur fracture, 'Gustilo-Anderson grade IIIC' fracture with primary vascular reconstruction, previous surgery on the affected distal femur fragment, polytrauma patients who died before definitive fixation, patients who refused consent, and patients who were lost to follow-up were excluded from the study.

On approval from the Institutional Ethical Review Committee, patients presenting to the ED and trauma center with suspected open distal femur fracture were evaluated for Advanced Trauma Life Support (ATLS).[19] A detailed history and thorough clinical examination were carried out after initial resuscitation. Standard anteroposterior and lateral radiographs of the affected femur with the knee joint were taken to confirm the diagnosis and to classify the fracture in accordance with the AO/OTA classification, and soft tissue injury was graded in accordance with the Gustilo-Anderson classification.[20, 21]

Routine preoperative investigations of patients that met inclusion criteria comprised complete blood count, renal function tests, serum electrolytes, coagulation profile, blood grouping, and viral screen. Immediate intravenous broad-spectrum antibiotic therapy and tetanus prophylaxis were given per the institutional protocol on admission. Immediate debridement of the wound under sterile conditions was performed for all patients, and definitive stabilization with an Ilizarov circular external fixator was done by skilled orthopedic surgeons. If necessary, other soft tissue surgeries such as delayed closure or skin grafting were conducted.

Patients were treated with the same regimen of antibiotics, pain management, and thromboprophylaxis postoperatively as indicated. The physiotherapy started on the first postoperative day and focused on strengthening the quadriceps, range-of-motion exercises, and progressive weight bearing as tolerated. Patients were followed up at regular intervals at 2 weeks, 6 weeks, 3 months, 6 months, and subsequently as often as needed until radiological union was achieved. Clinical examination and X-ray evaluation were conducted at every follow-up appointment to assess the healing of the fracture, alignment, the condition of the pins, and range of knee movement, function, and complications from the surgery. The final follow-up was conducted using the Karlström-Olerud functional scoring system.[22] Primary outcome measure included fracture union; secondary outcome measures included time to union, knee range of motion, functional outcome, pin tract infection, delayed union, nonunion, malunion, limb shortening, and the need for a second surgical procedure. A predesigned structured proforma was used to document all findings.

All the data collected were entered and analyzed through the software program called Statistical Package for Social Sciences (SPSS) version 26.0. The quantitative variables such as age, time to fracture union, hospital stay, follow-up time, and knee ROM were represented as mean ± SD or median and interquartile range as appropriate. Qualitative variables were described in terms of frequency and percentage. The Chi-square test and Fisher's exact test were used to evaluate the association between categorical variables. A p-value of less than 0.05 was considered statistically significant with a 95% confidence interval throughout the analysis.

## RESULTS

The study was performed on 95 patients who underwent treatment for open comminuted distal femur fractures with the Ilizarov external fixator. The mean age of participants was 39.8 ± 12.1 years, while the age group of 31-45 years accounted for a majority of the participants (38.9%). The study population was dominated by males (71.6%), and road traffic accidents (66.3%) were the most common mechanism of injury, followed by falls from height (21.1%). The right lower limb was more commonly affected than the left (55.8% vs 44.2%). (Table 1)

The majority of fractures were graded as Gustilo-Anderson IIIA (48.4%), IIIB (26.3%) and II (25.3%). The most common fracture type was 33-C2 (40.0%), followed by 33-A3 (31.6%) and 33-C3 (28.4%) fractures. Approximately half of the patients (51.6%) did not require additional soft tissue procedures, whereas delayed primary closure and split-thickness skin grafting were performed in 29.5% and 18.9% of patients, respectively. (Table 2)

The overall rate of fracture union was 95.8%, and nonunion occurred in 4.2% of cases. The mean radiological union time was 24.6 ± 5.3 weeks, and early weight bearing within 8 weeks was started in 61.1% of patients. The mean length of hospital stay was 8.7 ± 2.6 days, which showed a good postoperative outcome after Ilizarov fixation. (Table 3)

Functional assessment based on the Karlström–Olerud scoring system revealed good results:

40.0% excelled, and 36.8% had a good result. In 15.8% of patients, fair and poor functional outcomes were noted, respectively, showing that most of the patients had a satisfactory functional recovery. (Table 4)

The most frequent complication was pin tract infection (16.8%), with knee stiffness (12.6%) and delayed union (9.5%) coming next. The incidence of nonunion (4.2%), wire loosening (4.2%), malunion (3.2%), and limb shortening (3.2%) was lower, while the incidence of deep infection (2.1%) during the follow-up period. (Table 5)

There was a significant association between fracture union and the severity of open injury. Fracture union was seen in all patients with Gustilo-Anderson grade II fractures, while the rate of healing progressively decreased with grade IIIA and IIIB fractures. There was a statistically significant difference in union rate based on Gustilo-Anderson classification ($p = 0.031$). (Table 6)

A significant relationship was found between functional outcome and age of the patient. Functional recovery was superior in younger patients, with over 90% of those between 18-30 years having excellent/good functional outcome, and poor functional outcome being most common in those over 60 years. This relationship was very statistically significant ($p<0.001$). (Table 7)

The best and the worst functional outcomes were obtained in patients with AO/OTA type 33-A3 and type 33-C3 fractures, respectively. This was a significant ($p = 0.002$) association between fracture classification and functional outcome. (Table 8)

Table 1. Baseline demographic and clinical characteristics of the study participants (n = 95)

| Variable | Category | n (%) |
|---|---|---|
| **Age (years)** | 18–30 | 28 (29.5) |
| | 31–45 | 37 (38.9) |
| | 46–60 | 22 (23.2) |
| | >60 | 8 (8.4) |
| **Mean age (years)** | | 39.8 ± 12.1 |
| **Gender** | Male | 68 (71.6) |
| | Female | 27 (28.4) |
| **Mechanism of injury** | Road traffic accident | 63 (66.3) |
| | Fall from height | 20 (21.1) |
| | Crush injury | 8 (8.4) |
| | Others | 4 (4.2) |
| **Side involved** | Right | 53 (55.8) |
| | Left | 42 (44.2) |

Table 2. Fracture characteristics (n = 95)

| Variable | Category | n (%) |
|---|---|---|
| **Gustilo-Anderson classification** | Grade II | 24 (25.3) |
| | Grade IIIA | 46 (48.4) |
| | Grade IIIB | 25 (26.3) |
| **AO/OTA classification** | 33-A3 | 30 (31.6) |
| | 33-C2 | 38 (40.0) |
| | 33-C3 | 27 (28.4) |
| **Associated soft tissue procedure** | None | 49 (51.6) |
| | Delayed primary closure | 28 (29.5) |
| | Split-thickness skin graft | 18 (18.9) |

Table 3. Radiological and clinical outcomes following Ilizarov fixation (n = 95)

| Outcome | Category | n (%) |
|---|---|---|
| **Fracture union** | Yes | 91 (95.8) |
| | No (nonunion) | 4 (4.2) |
| **Mean time to union (weeks)** | | 24.6 ± 5.3 |
| **Weight bearing initiated** | ≤8 weeks | 58 (61.1) |
| | >8 weeks | 37 (38.9) |
| **Mean hospital stay (days)** | | 8.7 ± 2.6 |

Table 4. Functional outcome according to Karlström–Olerud score (n = 95)

| Functional outcome | n (%) |
|---|---|
| Excellent | 38 (40.0) |
| Good | 35 (36.8) |
| Fair | 15 (15.8) |
| Poor | 7 (7.4) |

Table 5. Postoperative complications (n = 95)

| Complication | n (%) |
|---|---|
| Pin tract infection | 16 (16.8) |
| Knee stiffness | 12 (12.6) |
| Delayed union | 9 (9.5) |
| Nonunion | 4 (4.2) |
| Malunion | 3 (3.2) |
| Limb shortening (>2 cm) | 3 (3.2) |
| Deep infection | 2 (2.1) |
| Wire loosening/breakage | 4 (4.2) |

Table 6. Association of Gustilo-Anderson grade with fracture union (n = 95)

| Gustilo grade | Union n (%) | Nonunion n (%) | p-value |
|---|---|---|---|
| Grade II (n=24) | 24 (100.0) | 0 (0.0) | |
| Grade IIIA (n=46) | 45 (97.8) | 1 (2.2) | |
| Grade IIIB (n=25) | 22 (88.0) | 3 (12.0) | 0.031 |

Table 7. Association of functional outcome with age group (n = 95)

| Age group (years) | Excellent/Good n (%) | Fair/Poor n (%) | p-value |
|---|---|---|---|
| 18–30 (n=28) | 26 (92.9) | 2 (7.1) | <0.001 |
| 31–45 (n=37) | 31 (83.8) | 6 (16.2) | |
| 46–60 (n=22) | 15 (68.2) | 7 (31.8) | |
| >60 (n=8) | 1 (12.5) | 7 (87.5) | |

Table 8. Association of AO/OTA fracture type with functional outcome (n = 95)

| AO/OTA type | Excellent/Good n (%) | Fair/Poor n (%) | p-value |
|---|---|---|---|
| 33-A3 (n=30) | 28 (93.3) | 2 (6.7) | 0.002 |
| 33-C2 (n=38) | 31 (81.6) | 7 (18.4) | |
| 33-C3 (n=27) | 14 (51.9) | 13 (48.1) | |

## DISCUSSION

Distal femur fractures are commonly open fractures with large soft tissue defects, contamination, comminution, and are an orthopedic trauma challenge in itself due to a high risk of infection and nonunion. The most important goal of treatment is to maintain stable fixation and maintain the biological environment that allows the fracture to heal. The external fixator is accepted as a biological fixation method, which offers stable multiplanar fixation, early weight bearing, reduced secondary soft tissue trauma, and promotes fracture healing. The present study showed that the Ilizarov technique achieved favorable radiological and functional results, with a fracture union rate of 95.8%, mean time to fracture union of 24.6 ± 5.3 weeks, and excellent or good functional results in 76.8% of patients.

Patients' mean age was 39.8 ± 12.1 years, with 71.6% of the wounds being suffered by males and 66.3% from road traffic accidents. These findings are in keeping with recent epidemiology studies which indicate that distal femur fractures in younger adults tend to be due to high-energy trauma. In 2024, Singh et al. showed that the majority of patients with open distal femur fracture were young males involved in road traffic accidents, highlighting the high-energy trauma burden in developing countries.[23]

In the present study, the rate of fracture healing was 95.8% with the Ilizarov external fixator, which proves its usefulness in the treatment of complex open distal femur

fractures. The results are similar to those found by Zoghli et al., who reported that 100% of patients with open intra-articular distal femur fracture had been treated with Ilizarov fixation and had excellent alignment and satisfactory functional recovery.[24] Similarly, Kumar et al. showed good union in 92% of their grade III open distal femur fractures treated with primary Ilizarov fixation, concluding that circular fixation is sufficient to provide stability without compromising fracture biology.[25]

The mean time until fracture union in the current study was 24.6 weeks and is comparable with previously published studies. The mean union time after staged management of open distal femur fractures was reported as 22.6 weeks by Singh et al., and 30 weeks by Kumar et al. after primary Ilizarov fixation.[1, 26] Abdel et al. also reported good healing with an average external fixation time of about seven months.[9] The relatively short period of healing in our study may be explained by the precision of debridement, the stable fixation, the standardized rehabilitation, and careful follow-up of the patient.

The results of functional recovery after Ilizarov fixation in our series were encouraging: 76.8% (100/130) of patients had excellent or good functional recovery. The results are similar to those of Kumar et al., who reported excellent or good ASAMI functional scores in about two-thirds of patients with grade III distal femur fractures (Open).[26] In the same way, Abdel et al. showed good to excellent functional results and satisfactory knee function in all patients at mid-term follow-up.[9] A comparison of Ilizarov fixation versus double plating also revealed that overall functional results were similar, but Ilizarov fixation allowed for earlier weight bearing and reduced blood loss.

In our study, pin tract infection was the most common complication with 16.8% of patients, followed by knee stiffness (12.6%) and delayed union (9.5%). The results are in accordance with previous reports regarding superficial pin tract infection being the most prevalent complication of circular external fixators.[27] Limited access to medical services also led to pin tract infection, extension lag, and limb shortening as main complications, reported by Shrimal et al., whereas Abdel et al. reported only two cases of deep infection despite the severity of injuries.[9, 28] Pin tract infections are superficial and usually appear when an infected pin remains in place with no disruption of fracture healing and can be treated with pin care and oral antibiotics, and may not require pin removal.

An important finding of the present study was the significant association between the severity of soft tissue injury and fracture union. The union rate was 100% for 'Gustilo-Anderson grade II' injuries, but gradually dropped as the grade increased to grade III. These findings have been echoed in more recent trauma literature, which has shown that greater soft tissue damage has a negative impact on fracture healing and contributes to the incidence of infection, delayed healing and additional procedures.[29] Open fractures of the distal femur have consistently been studied, and it has been recognized that a successful outcome is highly dependent on the preservation of the bone and careful attention to the soft tissue.[30]

In conclusion, findings from the present study are consistent with the existing literature and suggest the Ilizarov external fixator is a reliable method for healing open comminuted distal femur fractures. The technique is fracture-stable and maintains soft tissue biology, yielding high union rates, acceptable complication rates, and satisfactory function. While careful surgery, careful pin care, and careful rehabilitation are still critical factors to achieving the best outcome, the Ilizarov method is still a great option for achieving limb salvage, especially when there is a high risk for infection and soft tissue damage with traditional internal fixation in high-energy open fractures.

**Limitations**

There were several limitations in this study. The study was performed in a single tertiary care center, which might restrict the external validity of the results. Second, no comparison group used an alternative method of fixation (e.g., locking compression plates or retrograde intramedullary nails), which makes it difficult to compare the outcomes of treatment. Thirdly, due to the limited sample size, there may have been limited statistical power for subgroup analyses. Furthermore, only fracture healing and early function were evaluated during the follow-up period, so long-term outcomes including post-traumatic osteoarthritis, implant-related complications, and quality of life were not determinable. Finally, the differential severity of fractures, soft tissue trauma, and patient compliance with treatment may have contributed to the results reported.

## CONCLUSION

The use of the Ilizarov external fixator was an effective and reliable treatment for open comminuted distal femur fractures; fracture union rates were high with good functional outcomes and a relatively low complication rate. This technique allowed early mobilization and achieved biological fixation without soft tissue damage in most patients, with successful limb salvage. The patients with less severe soft tissue lesions and simpler fracture patterns had better functional outcomes, emphasizing the need for early intervention and careful execution of the surgery. The Ilizarov technique is still an important option for treating complex open distal femur fractures, especially in resource-limited environments where maintenance of fracture biology and infection control are very critical.

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