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Primary ilizarov external fixation in open grade III type C distal femur fractures: Our experience

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ABSTRACT

Introduction: Open comminuted distal femur fractures are notorious for septic or aseptic non-union. The recommended fixed angle distal femur locking plate in such situations can lead to a septic non-union due to its extensive approach and further periosteal stripping. Supracondylar nails, though have a minimally invasive approach, are not suitable for type C2 and C3 (AO/ASIF) fractures. A monolateral fixator as damage control followed by plating may be recommended. But if wound healing is delayed it results in difficult articular reduction, poor alignment and a stiff knee. We therefore used ilizarov circular external fixators (ICEF) for such open fractures (type C1, C2 and C3) and analysed its radiological and functional outcomes.

Materials and methods: 25 male patients, with a mean age of 31.04 ± 6.62 years (range, 22–44 years), with open grade III type C distal femoral fractures were treated with ICEF. There were 7 fractures of type C1and C3 each, 11 were of type C2. Articular reduction and compression was achieved with inter-fragmentary screws through minimal open technique by extending the open wound and then stabilising the fracture with ICEF. The main outcomes evaluated were union, range of motion, final shortening, Knee Society scoring and ASAMI scoring system for radiological and functional outcomes.

Results: The mean follow-up period was 19.12 ± 1.14 months. All fractures except two united at a mean period of 30 ± 3.02 weeks, without the need of bone grafts. The bony assessment (according to ASAMI score) was excellent in 8 cases (33.33%), good in 9 cases (37.5%) and fair in 5 cases (20.83%), while there were 2 poor clinical end results. The functional results were excellent in 6 cases (25%), good in 9 cases (37.5%) fair in 6 cases (25%) poor in 3 cases (12.5%). The complications included shortening, extension lag and pin tract infections.

Conclusion: With the encouraging results, the use of ICEF with minimal internal fixation in grade III open comminuted distal femur fractures as a primary definitive treatment is a valuable alternative.

1. Introduction

The treatment of comminuted distal femur fracture is always challenging to orthopaedic surgeons. Assembling the condylar fragments to reconstruct the articular surface and attaining alignment of the limb is the primary aim in its surgery. Open reduction and internal fixation is the recommended treatment. Distal femoral locking compression plate is the most preferred implant in such scenarios with its reported good outcome.[1] Retrograde supracondylar nails which have advantages, such as limited exposure and minimal blood loss are good options.[2,3] However these nails are not suitable for comminuted fractures of type C2 and C3 (AO/ASIF classification).[4,5] Both the above implants can be used in closed fractures, open grade I and II type (Gustilo-Anderson)[6] fractures. However, with grossly contaminated open fractures of type III, internal fixation with plate or nail bears the risk of infection.[7]

The preferred treatment in such open comminuted intra-articular type of injuries is a temporary knee spanning monolateral external fixation till the wound heals, followed by a second stage plating.[8] However if the wound healing is delayed, it

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delays the definitive procedure leading to unreduced articular fragments, a displaced metaphyseal distal femur fragment, poor alignment as well as knee stiffness. For the reduction of the condylar fragments we use multiple Kwires before applying the plate. Ilizarov tensioned wires over a ring are an extension of these K wires, holding the reduction. The Ilizarov external ring fixator has a greater mechanical stability than with a monolateral external fixator. Besides low blood loss, minimal surgical exposure, no additional periosteal stripping the fixator can be used as a definitive procedure for open distal femur fractures.[9,10]

However there are very few literature describing the use of ilizarov external fixator in open comminuted distal femur fractures.[11,12] We hypothesised that since ilizarov circular fixator is so versatile and stable, its use in a open comminuted distal femur fracture would not only yield good union results, early stabilisation and weight bearing but also would help in managing complications such as shortening and deformity. We analysed the radiological and functional outcome of primary ilizarov external fixator in the treatment of grade III open type C distal femur fractures with minimal internal fixation.

2. Materials and methods

This was a prospective study done between 2013 and 2017 at a tertiary centre. 25 male patients with open distal femoral fractures who underwent ilizarov external fixation with minimal internal fixation were included following an informed consent. Inclusion criteria comprised of age group 20–60 years, open fractures of Gustillo and Anderson[6] grade IIIa and IIIb and fracture severity C1-C3 (AO/ASIF classification)[5] and minimum of 12 months of follow up. Patients with a floating knee, vascular compromise, pathological fractures, pre-existing joint disease, severe systemic illness and head injury that would interfere with rehabilitation were excluded from the study. A careful physical examination of the patient with the distal femoral fracture was done to assess for peripheral circulation of the limb, associated fractures. Radiological evaluation comprised of antero-posterior and lateral view radiographs of the knee with thigh and a computed tomography of the knee was done to note the number of fragments, precise location of the fragments.

2.1. Operative procedure

All patients were operated in supine position under spinal anesthesia. No traction table was used. After thorough debridement of the wound, exposure of the articular surface of the femur was done by an extension of the preoperative wounds simulating a Swashbuckler approach or a lateral approach to distal femur according to the open wound present. Articular reconstruction was achieved initially by minimal exposure and indirect reduction with pointed reduction clamps and K-wires. The major condyle blocks were compressed with 7 mm cannulated cancellous screws. Quadriceps tear if any were repaired and partial closure of the skin was done. 1.8 mm olive wires were passed through the distal fragment and attached to a full ring. One of the wires (reference wire) was parallel to the knee joint which was a guide for positioning of the frame. The frame was then built up in a progressive way proximally. The final frame consisted of 3 rings (R1, R2, R3 from distally upwards) and an Italian arch with 2–3 schanz pins in each segment and wires only in the distal fragment. R3 was a step ring or a full ring according to the length of the thigh. Care was taken not to impinge the quadriceps. Acute docking up to 4 cm was done at the fracture site if needed, but keeping an eye on the distal pulse of the limb. Final reduction was checked in an image intensifier. Patella fractures were fixed with tension band wiring if fragments were large or an encirclage wire if comminuted. Ilizarov frame was extended to leg in cases associated with patella fractures or quadriceps tear. Primary closure of the wound was achieved in 16 cases and 8 cases had defects which healed by regular dressings.

2.2. Postoperative care

Mobilisation of the knee and partial weight bearing with the help of a walker was started as pain permitted. The patients were followed up every week till 6 weeks, then every month for the next 5 months, and then every 2 months till 12 months. Patient and their relatives were taught to do pin tract dressings before discharge. We ensured that all patients reported once to outpatients for pin dressings in 7–10 days for the first 3 weeks, which helped keep the pins healthy and also allow supervision of the exercise programs. The pin–skin junction is cleaned with gauze soaked in saline to remove the debris and redressed with a small amount of betadine ointment. If needed the fracture site was compressed further during follow up. If shortening of more than 2 cm was noted than a lengthening corticotomy was done with witnessing of early callus at fracture site.

In patients with a tibial frame, the frame was removed at 6 weeks and knee mobilisation was started. The femur frame was removed on confirmation of radiological union of at least 3 cortices and a knee brace was given with intermittent knee mobilisation for the next 6 weeks.

Radiological results were evaluated according to Association for the Study and Application of the Method of Ilizarov (ASAMI) classification[13] and functional evaluation was done by both Knee Society Score (KSS)[14] and ASAMI classification after union was achieved. Knee Society Score between 80 and 100 was regarded as excellent, between 70 and 79 was regarded as good, between 60 and 69 was regarded as fair, and <60 was regarded as poor.[15]

2.3. Statistical analysis

Statistical analysis was done using the SPSS 19.0 statistical software (IBM SPSS, New York, USA). Kruskal-Wallis test was used to compare the time to union, range of movements, and final shortening, KSS score between the C1, C2 and C3 fracture types.

3. Results

The mean age of the study group was 31.04 ± 6.62 years. According to the OTA classification, 7 fractures were type C1, 11 were of type C2 and 7 were of C3 type. There were 17 type IIIa open fractures and 8 type IIIb fractures. 14 patients had an isolated fracture and 11 patients had an associated quadriceps tear or patella fracture. One patient who had C2 type of fracture was lost to follow up. The mean follow up period was 19.12 ± 1.14 months.

All the fractures except two united at mean time period of 30 ± 3.02 weeks. There was no difference in time to union with respect to fracture severity. The total range of motion in C1 type of fractures was $106.43 \pm 14.06^{\circ}$, for C2 was $104.90 \pm 10.28^{\circ}$, and for type C3 group was $97.14 \pm 8.09^{\circ}$. The limitation of knee range of motion was greatest in patients with a type C3 fracture. The mean extension lag was $8.25 \pm 4.90^{\circ}$. However the extension lag was significantly higher in patients with associated patella fractures and quadriceps tear ($p = 0.0002$) (Fig. 1).

The mean shortening of the study group was 1.42 ± 0.78 cm postoperatively. 2 patients with type C3 fracture had a shortening of 3.5 cm and 3.2 cm respectively and they were treated with lengthening over the same frame. They needed a corticotomy between rings R2 and R3. None of the patient had more than 10° of mal-union. The mean time to removal of femoral frame was 31.88 ± 2.17 weeks (Table 1).

Fig. 1. A case illustration of C1 type of fracture.

Table 1
Clinical outcomes of the patients.

	C1 (n = 7)	C2 (n = 10)	C3 (n = 7)	Test statistics	P value
Time to union* (weeks)	28 ± 1.52	30.8 ± 2.62	30.43 ± 4.03	3.715	0.156
Range of motion (degrees)	106.43 ± 14.058	104.9 ± 10.28	97.14 ± 8.09	2.705	0.259
Shortening (cm)	1.14 ± 0.24	1.5 ± 0.97	1.57 ± 0.89	1.628	0.443

*Excluding the two patients who had premature frame removal.

The bony assessment (according to ASAMI score) was excellent in 8 cases (33.33%), good in 9 cases (37.5%) and fair in 5 cases (20.83%), while there were 2 poor clinical end results. The functional results were excellent in 6 cases (25%), good in 9 cases (37.5%) fair in 6 cases (25%) poor in 3 cases (12.5%). The KSS at the end of first year of follow up was 81.86 ± 4.77 for C1 group, 70.7 ± 3.43 for C2 group and 65.29 ± 8.26 for C3 group. There was a statistical significant difference (p = 0.001) between the fractures types in terms of Knee society score. The bony and functional results according to ASAMI protocol and the knee society scoring evaluation is illustrated in (Table 2)

Superficial pin-tract infections occurred in 5 (20.83%) patients and resolved after oral antibiotics and care of the pin sites. No one required wire or pin removal that could have compromised the stability of the frame. Of the two non-unions one belonged to type C2, the other to type C3. Both had grade IIIb open fracture. Though both could have been managed on the same ilizarov frame, however due to lack of compliance, the frame had to be removed at 4 months and 6 months respectively. We waited for three weeks thereafter for the pin tracts to heal before both underwent open reduction and plating with iliac crest bone grafting later and achieved union; however both had poor knee function.

4. Discussion

Distal femur fractures with intra-articular extension and metaphyseal comminution is challenging in its management. Open fractures with gross contamination and additional insult by devitalisation of metaphyseal fragments during plating may lead to septic or aseptic non-union.[16,17] Recent studies have shown that minimally invasive plating (LISS) in those fractures can result in acceptable outcomes; however the need to make permanent femoral shortening to get good surface contact, bone grafting and deep infection is still a problem.[18,19] Failures of LISS has been attributed to technical errors in application of plate and early weight bearing in the presence of a delayed union of the fracture.[20]

The Ilizarov external fixation has been recently used in the treatment for many complex distal femur fractures, including open and comminuted fractures as a primary definitive fixation.[21,22] Arazi et al.[21] in his study used closed methods and ligamentotaxis for the articular surface reduction without any internal fixation. However, they obtained only fair and poor results in C2 and C3 type fractures since they could not obtain anatomical reduction by ligamentotaxis. We have used limited open reduction and minimal internal fixation for reconstructing the articular surface for all the patients. The use of lag screws has been described in literature for tibial plateau fractures along with tensioned olive wire and has proven advantage over only olive wires.[23] Various surgeons have used a traction table for such procedures.[21,24] However, we did not use a traction table since we needed to flex the knee to expose and directly reduce the articular surface. Traction was given manually by an assistant surgeon during metaphyseal reduction.

There have been different frame structures used by various authors.[21,22,24,25] We used one ring distal and two rings proximal to the fracture site and an arch at the proximal most. Arazi et al.[21] used one distal ring and two proximal arches. None of the patients in their study had more than 2.5 cm of shortening. Pankaj Kumar et al.[24] used a half and a full ring distally, a half ring and arch proximally. However there were 40% patients who had more than 4 cm shortening. Cavusoglu et al.[25] used two half rings proximally and two rings distally. They however did not report any shortening in the 3 open type C2 fractures in their study. In our study we had a mean shortening of 1.42 ± 0.78 cm. However there was no statistically significant difference in terms of shortening among the fracture types. We were able to lengthen the femur. Our frame constructs were ideal for lengthening that was needed in two patients as lengthening could be done over 4 rods. To increase the patient compliance we avoided a knee spanning fixator in isolated distal femur fractures.[26,27]

In this study all patients except two united at a mean period of 30 ± 3.02 weeks without any bone grafting. It was 39 ± 9 weeks in the study by Pankaj et al.[24] They had done secondary bone grafting in all the cases. Arazi et al. achieved union at a mean period of 16 weeks. However only 28.57% of the patients in their study had open fractures. In our study premature frame removal was done for 2 patients due to failure to comply with the external frame. However both of them had pin site infections. They were later taken up for plating and bone grafting. Yildiz C et al. [27]has reported that use of Ilizarov circular fixator can be psychologically stressful, create sleeping problems because of its long duration and many

Table 2
Bony and Functional outcomes (ASAMI score) and KSS scores of the study.

	C1 (n = 7) No of patients (%)	C2 (n = 10) No of patients (%)	C3 (n = 7) No of patients (%)
Bony results			
Excellent	5 (71.42)	2 (20)	1 (14.28)
Good	2 (28.58)	4 (40)	3 (42.86)
Fair	0	3 (30)	2 (28.57)
Poor	0	1 (10)	1 (14.28)
Functional results			
Excellent	3 (42.85)	2 (20)	1 (14.28)
Good	4 (57.14)	3 (30)	2 (28.57)
Fair	0	4 (40)	2 (28.57)
Poor	0	1 (10)	2 (28.57)
Knee society score (Mean ± SD)	81.86 ± 4.77	70.7 ± 3.43	65.29 ± 8.26

complications. In his study there was at least one psychiatric symptom in 52.5% of the subjects treated with a circular external fixator.

The mean knee range of motion in our study was 103.1 ± 11.21°. Patients with type C3 fractures reported a lower range of motion. We achieved excellent bony results in one third of our patients and good results in 37.5% patients. Similarly ASAMI scoring of functional outcome yielded excellent and good results in 10 (41.67%) and 7 cases (29.16%) respectively. We consider the result comparable with other studies.[21,22,24,28,29] Patients also reported with a mean extension lag of 8.25 ± 4.90°. However the lower range of function can be attributed to the associated injury to the quadriceps and comminuted patella fracture, due to which early range of motion exercises could not be started. Further, use of external fixator in the form of wires and schanz pins in the femur invariably transfix quadriceps and act as checkerin even though we had passed all the wires and the pins in some degrees of knee flexion. The healing of the wounds that could not be closed primarily further added to the insult as it lead to secondary healing with scarring decreasing the range of motion further. However, we consider that even a primary skin graft would have still given the same result,[24,29] as that would need extension of frame across the knee and on healing it would also lead to tethering. Pin tracts infection occur more in femur than in tibia due to bulkier muscle covering the femur.

This fixator is safe and versatile and is effective in providing stability and allowing early rehabilitation. Dugan et al.[30] have reported 100% union rate, and good functional outcome using early fixed angle distal femur bridge plating, and antibiotic beads usage followed by delayed autogenous bone grafting. In his study he has done medial plating along with bone grafting in a delayed sitting. However, more the surgical insult over the thigh more is the scarring and limitation of range of motion.

On the basis of our study, we suggest adopting ilizarov method for functional limb salvage after compound high-energy distal femoral injuries. Ilizarov ring fixator application for such fractures has certain advantages like a minimally invasive technique, versatile frame assembly correction of malalignment and lengthening during the entire process of fracture healing. It provides better mechanical stability by three dimensional construct.

5. Conclusion

Based on the encouraging results of the study, in the setting of open fractures of grade III distal femoral fractures primary ilizarov external fixation may be considered as definitive treatment modality.

Conflicts of interest

There are no conflicts of interest.

Contribution of authors

Dr Rakesh Kumar (RK), Dr Soumya Shrikanta Mohapatra (SSM), Dr Kamlesh Kumar (KK), Dr Rajendra Gora (RG) were the operating surgeons in the whole series. Dr SSM and Dr RK reviewed the literature and wrote the paper. Dr Narendra Joshi, Dr S.K. Goyal critically reviewed the paper. Dr SSM, Dr KK and Dr RG maintained all the records of the patients and followed them.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2019.01.026.

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