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ORIGINAL PAPER

Refracture after Ilizarov fixation of infected ununited tibial fractures—an analysis of eight hundred and twelve cases

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Abstract

Introduction Refracture of the tibia after union is a challenging problem for the patients and the surgeons. The purpose of the current study is to present our experience in conservative management of such patients with refracture of infected ununited tibia after successful treatment by Ilizarov external fixator and bone transport.

Material and methods We reviewed the files of 812 patients with infected ununited tibia who were treated by debridement, corticotomy, and bone transport using Ilizarov methods in our institute between 1997 and 2017. Inclusion criteria were patients with refracture after union and removal of the Ilizarov apparatus. Twenty-two patients with 23 refracture tibia were included in the study. All the 23 tibias were treated conservatively by above knee cast that was converted to Sarmiento below knee cast after early callus formation, except in the case of upper tibial fracture that continued in above knee cast till union. Afterwards, a protective splint was used for additional two months.

Results There were 19 males (86.4%) and three females (13.6%), the mean age of the patients was 38.39 years, the mean time of Ilizarov external fixator application was 10.86 months (range, 6–17), and the mean time of refracture after fixator removal was 2.33 months. Union was achieved in 19 tibias (82.6%), with a mean time of 7.2 months (range, 4–12). Complications included five cases of skin irritation that was treated by large windows in the cast and changing the casts more frequently, three cases developed DVT (deep venous thrombosis), and axial deviation occured in four tibias (17.3%).

Conclusion Conservative treatment of refractured tibia after removal of Ilizarov external fixator following treatment of infected non-union tibia by above knee cast is effective in achieving union. However, complications as skin irritation, DVT (deep venous thrombosis), and axial deviation can be anticipated.

Keywords Infected non-union · Refracture · Tibia · Ilizarov · Cast

Introduction

Achievement of bony union after infection is difficult; many surgeries are required; long periods of immobilization and rehabilitation are expected, with subsequent financial and psychological burden on the patients [1, 2]. Although the union rate of infected non-union of the tibia improved significantly after the use of Ilizarov techniques, many complications still encountered as joint stiffness, recurrence of infection, and refracture [3, 4]. Refracture of the tibia after union is a challenging problem for the patients and the surgeons; patient became bored and hopeless; surgeons became less interested in treating such patient because of long follow-up period and limited option of treatment, as well as limited financial support because most of these patient are of low economic class and not covered by insurance [2].

Level of evidence: IV cases series, a retrospective study

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The reported refracture incidence in literature is about 4% [4]; however, management of such complicated cases are not well described, with most of them were treated by re-application of the fixator. In our institute, we used to schedule these patients for frame re-application. Surgery was delayed in some patients who were kept in above knee cast. We noticed callus formation with complete union in most of these cases. So, we hypothesized that the area of refracture is biologically active and may be considered as a closed fracture and could be managed conservatively as acute fracture by cast immobilization followed by bracing.

The purpose of the current study is to present our experience in conservative management of patients with refracture of infected united tibia who had complete union after treatment by Ilizarov methods.

Patients and methods

The current study is a retrospective study, approved by institutional board review of the University. Files of 944 patients were reviewed and 132 were excluded due to incomplete data. So, this series is based on 812 patients with infected ununited tibia who were treated by debridement and bone transport using Ilizarov method in our institute between 1997 and 2017. Inclusion criteria were patients with refracture after union and removal of the Ilizarov apparatus. Patients files were reviewed, and the fracture site, mechanism of injury, time since removal of the fixator, and clinical assessment of the limb especially neurovascular status and skin condition were recorded.

Twenty-three tibias of 22 patients with refracture tibia after Ilizarov fixator removal were included in the current study. There were 19 males (86.4%) and three females (13.6%); the mean age of the patients was 38.39 years (range, 18–73). Right side was affected in 13 patients (56.5%) and left side in ten patients (43.5%). Seven cases (31.8%) had rotational flap during the index procedure. Thirteen patients were smokers, three had controlled diabetes mellitus, and one case had hepatitis c with compensated liver. The oldest patient (73 years) had received a drug for management of severe osteoporosis (teriparatide) for six months. Table 1 summarizes demographics of the refracture cases.

The patient's radiographs were assessed which included X-rays both antero-posterior and lateral views after removal of the fixator and after the refracture, and CT scan to confirm the refracture. Post-reduction radiographs and follow-up radiographs were also reviewed till last follow-up.

All the 23 tibias were treated conservatively (Figs. 1, 2, 3, and 4) by above the knee cast that was converted to Sarmiento below the knee cast after early callus, except in case of upper tibial fracture that continued in above the knee cast till union. After union, a protective splint was used for an additional two months.

Table 1 Demographic data of the refracture cases

Number of refractures	23 out of 812 cases
Site of refracture	16 distal tibia 6 mid shaft tibia 1 upper tibia
Mean age	33.4 years
Side	13 right tibias 10 left tibias
Gender	19 male 3 females
Comorbidities	3 diabetes mellitus 1 hepatitis c

Regular radiological follow-up was done weekly in the first month, and then every 2 weeks till adequate callus formation and then monthly till union was achieved. The cast was changed in four patients in the first month due to unaccepted angulation and accepted position could be achieved. At final follow-up, patients were evaluated by ASAMI functional score. Radiological assessment of union was evaluated according to Whalen et al. radiographic union score for tibial fractures (RUST) [5].

Statistical analysis was done using SPSS version 12.0 (SPSS Inc., Chicago, IL) and a p value < 0.05 was considered statistically significant.

Results

The mean time for Ilizarov external fixator application was 10.86 months (range, 6–17), and the mean time of refracture after fixator removal was 2.33 months (range, 0.25–6). The mechanism of injury was low energy trauma in all cases, 17 patients (77.3%) had fell during walking, and 5 patients (22.7%) had a direct trauma. The site of refracture was at the docking site in all cases. Refracture was in distal tibia in 16 tibias (69.6%), mid diaphysis in 6 tibias (26.2%), and at upper tibia in one case (4.3%). Distraction of about 1 cm was evident in three cases (Fig. 3).

Union was achieved in 19 tibias (82.6%), with a mean time of 7.2 months (range, 4–12). One case developed tibiofibular synostosis (Fig. 2), one case treated by re-application of Ilizarov fixator and united after eight months, and two patients refuse further surgery and used braces for walking. There was no correlation between time to union and patient's age, length of bone transport, or duration in fixator. (P value 0.6, 0.09, and 0.5 respectively).

The cast was changed in four patients in the first month due to unaccepted angulation and accepted position could be achieved. Wedging the cast to correct the alignment was

Fig. 1 **A** X-ray of a 45-year-old male, with infected non-union fracture RT. Tibia, treated by bone transport by Ilizarov external fixator. **B** X-ray showing refracture occurred 3 months after fixator removal. **C** Wedging the cast was performed to correct the malalignment and cortical window to watch the skin. **D** Plain X-rays antero-posterior and lateral, 1 year after cast removal. **E** Plane X-ray antero-posterior and lateral after 7 years follow-up

done in six cases. The mean time of follow-up after cast removal was 20.3 months (range, 12–36).

At final follow-up, ASAMI score bone results of the patients were 12 excellent (52.2%), six good (26.1%), three fair (12.9%), and two poor (8.6%). The functional results were excellent in three patients (12.9%), good in 13 (56.5%), fair in five (21.7%), and poor in two (8.6%).

Complications included five cases (21, 7%) developed skin irritation that was treated by large windows in the cast and frequently changing the casts. Three cases (13%) developed DVT and treated by anticoagulants with no further consequence. Comparison of the axial deviation before the refracture and at last follow-up revealed more than 10° axial deviation in 4 tibias (17.3%) with an average of 11.6° (range, 10–14) (Fig. 3). Post-cast lower limb oedema was reported in 14 cases which were treated by elastic stocking for 6 months after cast removal with complete resolution.

Discussion

Ilizarov method has gained popularity in treatment of infected ununited tibia due to the high success rate [1, 6–11]. However, it is a long and complicated procedure which can extend for many months to gain the planned bone length, correct mal-alignment, and achieve solid union. Refracture after fixator removal is a real challenge to the patient and the treating surgeon as there are limited treatment options

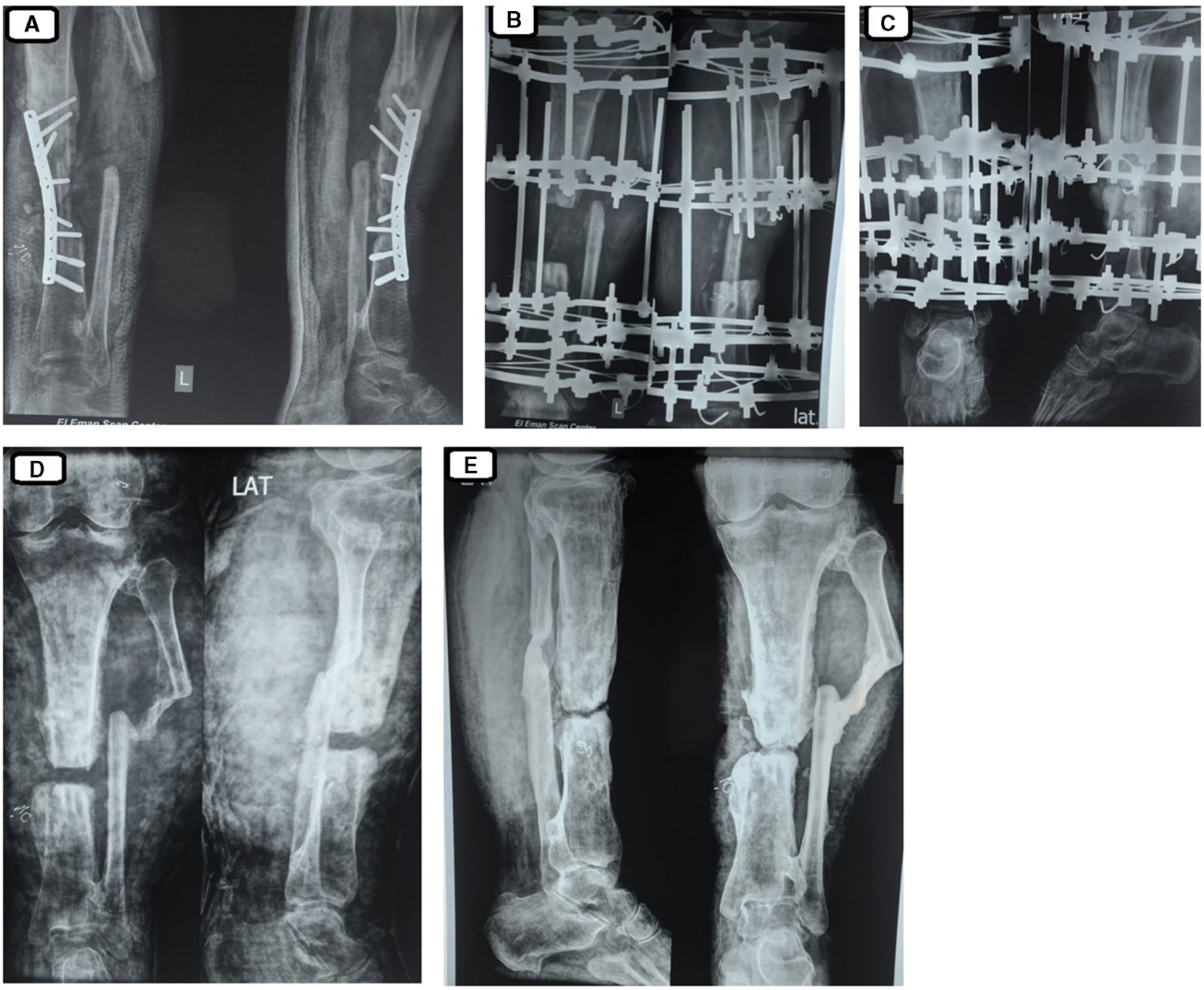

Fig. 2 **A** xray of 36 Y Old male, with Infected nonunion of the left tibia after plate fixation and below knee Amputation on the right side. **DB** x-ray after removal of the hardware, debridement and bone transport by Iilizarov circular fixator, **C** X-ray showing union after gradual compression to close the bone defect. **D** xray showing refracture one week after fxator removal and distraction **E** X-ray showing upper and lower tibiofibular synostosis

available including the following: re-application of the fixator [6, 8, 10–13], internal fixation [14], and finally amputation [9].

Refracture is a complicated problem which is underestimated in the English literature due to small number reported cases (Table 2), and short follow-up. Hosny et al. reported refracture in two paediatric cases out of 36 (5.5%) infected tibial non-union managed by Ilizarov with the mean age of the patients 11.4 years. Both cases united after management in cast with no further details about time to union [15]. Yin et al. reported two patients of refracture tibia out of 72 patients at the docking site after removal of the Ilizarov external fixator. Both cases were treated by re-application of Ilizarov external fixator [6]. Surendher et al. reported two refracture tibia out of 21 patients after fixator removal and they had been also treated by re-application of Ilizarov external fixator [8]. Madhusudhan et al. had reported one case of refracture of the united tibia and the patient refused re-application of the fixator with no further information [9]. Bakhsh et al. and Khan et al. reported one and two cases with refracture tibia respectively at the docking site, with no details of treatment [10, 11].

In the current series, based on 812 patients with infected ununited tibia who were treated by debridement and bone transport using Ilizarov, 23 cases of refracture were reported. Internal fixation was not an option because of the high rate of pin track infection in our patients and the long time in the fixator which may increase the possibility of disastrous deep infection following internal fixation. All our patients were treated conservatively using above

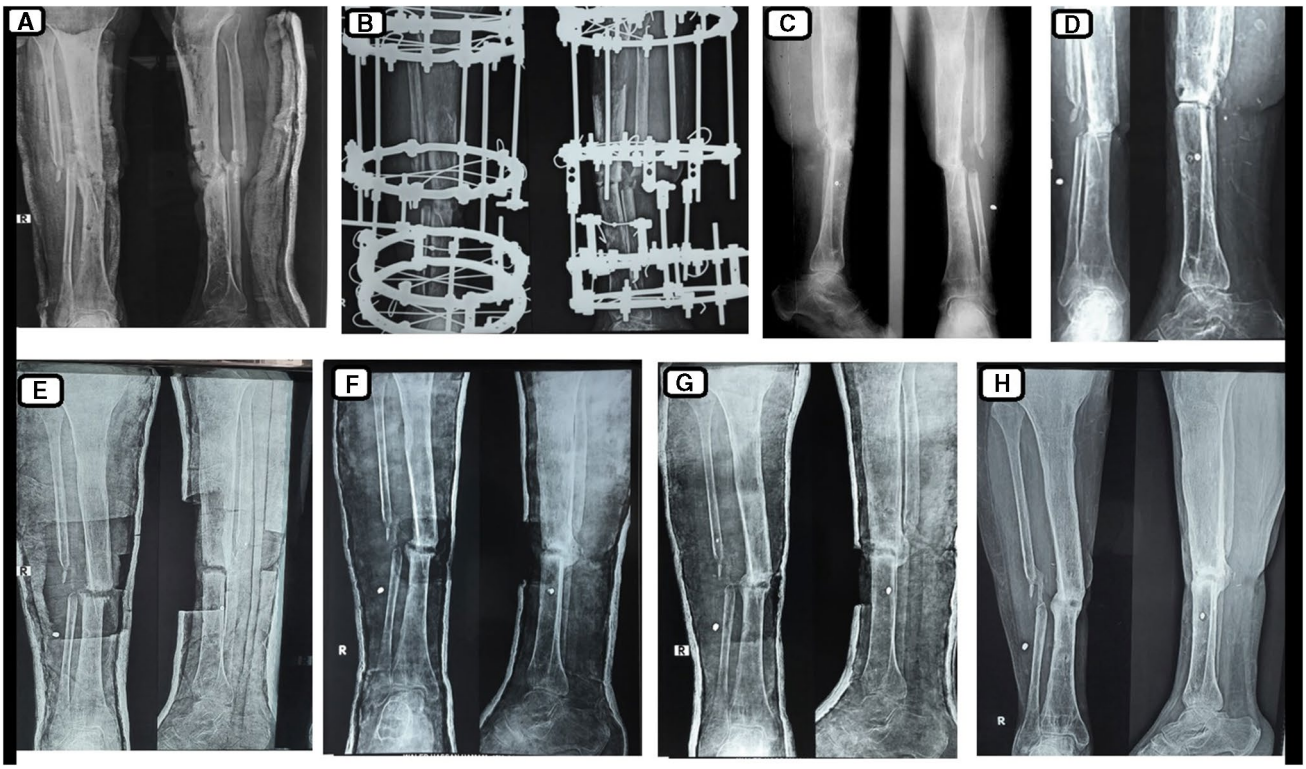

Fig. 3 **A** X-rays of a 42-year-old male with infected non-union fracture tibia. **B** X-ray antero-posterior and lateral views showing bone transport by Ilizarov external fixator. **D** X-rays after fixator removal showing union at fracture site. **E** X-rays showing refracture of the united tibia 1 month after fixator removal. **F** X-rays with above knee cast with fracture gap about 1 to 2 cm. **G** X-rays show external callus formation and gap disappearance 3 months in above knee cast. **H** X-rays after 5 months show union of the tibia in above knee cast. **I** X-ray antero-posterior and lateral views show solid union 6 months after cast removal

the knee cast and union was achieved in 19 out of the 23 tibias. Re-application of fixator was necessary only in one patient. We fond cast application was better accepted than re-application of fixator by the patients. Re-application of fixators carries more financial and psychological burden.

The aetiology of refracture after fixator removal was not reported clearly in the literature. New trauma after removal of the fixator was reported as a cause in some cases. Early removal of the fixator is accused in some patients, but most cases were idiopathic [6, 11–15]. Kessler et al. had advocated that the main aetiology of refractures after initial union is bone necrosis due to avascularity which caused either by trauma or the surgical intervention [16]. In the current study, 17 patients sustained indirect trauma during walking which was not clearly described by the patient while five patients reported direct trauma. Early removal of the fixator was suspected to be a factor in refracture in five patients only.

Axial deviation has been reported during treatment of the infected non-united tibia by Ilizarov bone transport. Yin et al. [6] reported 32 patients with axial deviation, 20 tibias, and 12 femora, while Bakhsh et al. [10] had reported six patients with axial tibial deviation. In the current study, axial deviation was found in four tibias. All of them were satisfied with no impairment in walking.

Complications associated with cast application such as dermatitis, pressure sores, joint stiffness, compartmental syndrome, osteopenia, and DVT are reported in literature [17]. The higher rate of such complications in the current study may be explained by the poor initial skin condition as a consequence of rotational flap or dehiscence and skin scares from previous operations necessating extra care and frequent change of cast if any skin complication is suspected.

Teriparatide, a biologically active parathyroid hormone that have been successfully used in limited studies to improve bone healing especially in osteoporotic patients [18]. The drug was used primarily to treat male osteoporosis in the oldest patient in the current study (Fig. 4).

To the author's knowledge, the current study is the first standalone detailed report about refracture of the united tibia after treatment of infected non-union by Ilizarov external fixator. In the current study, we presented outcome of conservative treatment of 23 refracture tibias after removal of the Ilizarov fixator in 22 patients. Assuming that the refracture site is biologically active like acute fractures [19, 20], patients were treated conservatively where new fracture

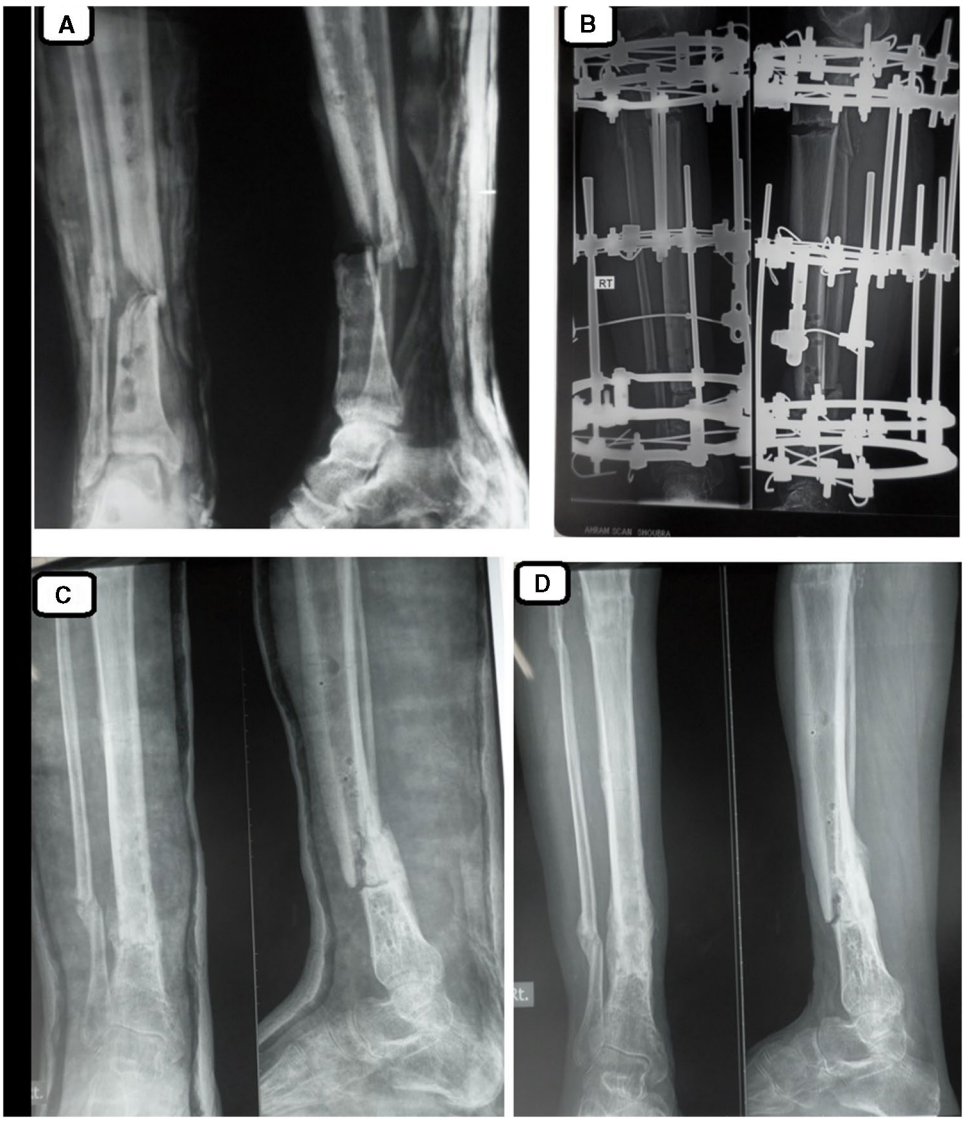

Fig. 4 **A** 73-year-old male, diabetic osteoporotic, and hepatitis C. Positive with infected ununited tibia. **B** X-rays show treatment of infected tibial non-union by debridement and bone transport by Ilizarov external fixator. **C** X-rays showing treatment of the patient by above knee cast after refracture of the tibia. **D** X-ray antero-posterior and lateral views showing solid union of the tibia after treatment of the patient by above knee cast for 5 months with administration of teriparatide

haematoma is formed, stem cell differentiated into fibrous, cartilaginous, and osteoid cells. Union was achieved in 19 cases in an average period of about 7.2 months (range, 4–12). Union was achieved with distraction at the refracture site in three patients supporting our hypothesis that refracture site is biologically active. The absence of correlation

Table 2 Demonstrates different studies of tibial refracture after management of tibial non-union using Ilizarov methods and their management

Name of study	NO. of patients	Mean follow-up in months	No. of refractures	Time of refracture	Method of treatment
Dujardyn and Lammens (2007) [12]	28	-	3	-	-
Madhusudhan et al. (2008) [9]	22		1	-	Refuse treatment
Surendher et al. (2014) [8]	21	45 (30–70)	2	2 months after frame removal	Re-application of Ilizarov
Yin P. et al. (2015) [6]	72	23.12 (14–46)	2	-	Re-application of Ilizarov
Khan et al. (2015) [11]	24	11 (8–46)	2	-	Re-application of Ilizarov
Kayode et al. (2017) [13]	30	24	1	Several months after beginning of weight bearing	Re-application of Ilizarov
Bakhsh et al. (2019) [10]	56	20 (7–36)	1	-	Re-application of Ilizarov
Hosny et al. (2019) [15]	36	24	2	-	Above knee cast

between time to union and duration in fixator and length of bone transport further support our hypothesis.

The current study has some limitations including the retrospective nature and the limited number of patients. Future controlled prospective multicentre studies are recommended.

Conclusion

Conservative treatment of refractured tibia after removal of Ilizarov external fixator following treatment of infected non-union tibia using casting followed by bracing is a simple, low cost, and effective treatment option with high union rate. However, complications as skin irritation, DVT, and axial deviation have to be expected.

Author contribution 1st author: surgical performance, data collection.
2nd author: surgical assistant, data collection.
3rd author: shared in data collection and manuscript revision.
4th author: surgical assistant, data collection, manuscript editing, and corresponding author.

Data availability Available.

Declarations

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Bioethics Committee of the Medical our University.

Consent to participate All patients signed an informed consent after clear explanation of the surgical procedure or other completing procedures.

Consent for publication Patients signed informed consent regarding publishing their data and photographs if needed.

Conflict of interest The authors declare no competing interests.

References

1. Meselhy M, Singer M, Halawa A, Hosny G, Adawy A, Essawy O (2018) Gradual fibular transfer by Ilizarov external fixator in post-traumatic and post-infection large tibial bone defect. Archive Orthop Trauma Surg 138:653–660
2. Abulaiti A, Yilihamu Y, Yasheng T, Alike Y, Yusufu A (2017) The psychological impact of external fixation using the Ilizarov or Orthofix LRS method to treat tibial osteomyelitis with a bone defect. Injury 48:2842–2846
3. Foda A (2015) Treatment of post traumatic femoral bone loss using Ilizarov external fixator; technical difficulties and complications analysing approach. Internat J Orthop 2(6):26–28
4. Aktuglu K, Erol K, Vahabi A (2019) Ilizarov bone transport and treatment of critical-sized tibial bone defects: a narrative review. J Orthop Traumatol 20:22
5. Whelan DB, Bhandari M, Stephen D et al (2010) Development of the radiographic union score for tibial fractures for the assessment of tibial fracture healing after intramedullary fixation. J Trauma 68:629–632
6. Yin P, Zhang L, Li T, Zhang L, Wang G, Li J (2015) Infected nonunion of tibia and femur treated by bone transport. J Orthop Surg Res 10:49
7. Sakale H, Aick C, Kar B (2018) Management of infected non-union of tibia by Ilizarov technique. J Orthop Traumat Rehab 10(1):1–6
8. Surendher R, Ravichandran S, Ashish K, Krishnagopal R (2014) Management of complex non-union of shaft of tibia using Ilizarov technique and its functional outcome Int Surg J 1(2):84–87
9. Madhusudhan T, Ramesh B, Manjunath K, Shah H, Sundaresh D, Krishnappa N (2008) Outcomes of Ilizarov ring fixation in recalcitrant infected tibial non-unions - a prospective study. J Trauma Manag Outcomes 2(1):6–12
10. Bakhsh K, Atiq-Ur-Rehman ZF, Mohammad E, Ahmed W, Saaiq M (2019) Presentation and management outcome of tibial infected non-union with Ilizarov technique. Pak J Med Sci 35(1):136–140
11. Khan M, Umer H, Qadir I, Hafeez K, Iqbal A (2015) Salvage of infected non-union of the tibia with an Ilizarov ring fixator. J Orthop Surg (Hong Kong) 23(1):52–55
12. Dujardyn J, Lammens J (2007) Treatment of delayed union or non-union of the tibial shaft with partial fibulectomy and an Ilizarov frame. Acta Orthop Belg 73(5):630–634
13. Kayode M, Adewole O, Shoga M, Giwa S (2017) Experience with managing complicated fractures using Ilizarov principals in Lagos. Nigeria J West Afr Coll Surg 7(3):24–43
14. Emara K, Allam M (2008) Ilizarov external fixation and then nailing in management of infected nonunions of the tibial shaft. J Trauma 65(3):685–691
15. Hosny G, Ahmed A (2019) Infected tibial nonunion in children. Is radical debridement mandatory? Injury 50:590–597
16. Kessler S, Deiler S, Schiffl-Deiler M (1992) Refractures: a consequence of impaired local bone viability. Arch Orthop Trauma Surg 111:96–101
17. Halanski M, Noonan K (2008) Cast and splint immobilization: complications. J Am Acad Orthop Surg 16:30–40
18. Babu S, Sandiford N, Vrahas M (2015) Use of Teriparatide to improve fracture healing: what is the evidence? World J Orthop 6(6):457–461
19. Mc Kibbin B.(1978) The biology of the fracture healing in long bones. J Bone Joint Surg [Br] 60(2):150–162
20. John Dabis, Oliver Templeton-Ward, Alice E Lacey, et al (2017) The history, evolution and basic science of osteotomy techniques Strategies Trauma Limb Reconstr 12(3):169–180