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Evaluation of Radiological and Functional Outcomes of Closed Complex Mid-shaft Tibia Fractures Treated with Primary Definitive All Wire Ilizarov Ring Fixator: A Prospective Study at Tertiary Care Centre of Nepal.

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ABSTRACT

Introduction: Closed complex tibial shaft fractures are frequently encountered fractures in lower limb injuries. Various surgical methods for these fractures include primary or delayed fixation with intramedullary nails, minimal invasive plates, and primary definitive external stabilization using ring fixators. We conducted this study to evaluate the radiological and functional outcomes of primary definitive fixation of these fractures using an all-wire Ilizarov circular fixator.

Objectives: The objectives of this study were to evaluate the radiological and functional outcomes of primary definitive fixation of closed complex tibial mid-shaft fractures in patients with compromised soft tissue status.

Methodology: We defined Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopedic Trauma Association (AO/OTA) 42-B1 to AO/OTA 43-C3 fractures as complex tibial shaft fractures for this prospective observational study, and evaluated all 26 patients for the functional and radiographical progression according to ASAMI classification.

Results: Twenty-six patients were stabilized with an all-wire circular ring fixator. The union time on average was 27.61 weeks. Among all patients, 7 (37.5%) cases had minor pin tract infections, and one (2.7%) patient landed a non-union, which required bone graft.

Conclusion: With the use of an all-wire Ilizarov circular frame, there is a good mean time to union, fewer chances of re-operations, and good functional outcomes without any major complications.

INTRODUCTION

The closed-complex mid-shaft tibial fracture is frequently encountered long bone fracture with an incidence greater than 75,000 per year in developed countries.[1] This type of complex fracture usually is a result of high-velocity trauma.[2] These closed complex mid-shaft tibial fractures are often accompanied by significant soft tissue injury which frequently ends with complications such as nonunion, delayed union, malunion, and chronic infections.[3] The results of conservative management with the cast are limited because of inadequate stability and frequent serious complications.[4] Because the tibia is a subcutaneous bone with poor soft tissue coverage and limited blood supply, which is further severely compromised in these fractures, primary definitive fixation is not preferred and the commonly practiced management for these fractures is delayed nailing after soft tissue healing or secondary intramedullary nailing, following primary tubular external fixation.[5-6] Very few orthopedic surgeons prefer to proceed with primary definitive management with an Ilizarov circular frame. The

Ilizarov frame is a construct that permits early functional vertical loading to the injured tibia, increases vascularity of injured bone thus promoting early fracture healing. In the same frame it also provides options for the management of complications like residual deformity correction, or dealing with non-union by coticotomy and histogenesis. The Ilizarov frame also provides stabilization in multiple planes and at different segment of tibia that allows early weight-bearing and adjacent joints mobilization.[7] In developing countries like Nepal, where patient's presentation is delayed and early management is not always possible, complex mid shaft tibial fractures are usually treated with uniplanar tubular external fixator followed by interlocking nailing as secondary delayed surgery.[8] This made us propose the Ilizarov circular frame as a primary definitive fixation apparatus for the treatment of these complex mid-shaft tibial fractures. The aim of this study is to evaluate the radiological and functional outcomes of primary definitive fixation of complex tibial shaft fractures in patients with a compromised soft tissue condition using an all-wire Ilizarov circular fixator.

METHODOLOGY

This prospective study was conducted at a tertiary-level center from May 2022 to November 2023. In this study, we included 26 patients with complex midshaft tibial fractures with jeopardized overlying soft tissue conditions. For this study, we obtained approval (IRC-PA-288/78) from our Institutional Ethical Committee and patients were enrolled after obtaining an informed consent. We excluded the patients with a pathological fracture or having any contraindication to surgery and with associated injury or neurovascular injury to the affected limb.

For this study, we defined the complex midshaft tibia fracture as AO/OTA 42-B1 to AO/OTA 43-C3 tibial fractures according to Orthopedic Trauma Association (OTA) classification.[9]

We applied an all-wire Ilizarov frame, using 1.8 mm olive wires or 1.8 mm Ilizarove drop wires without adding half pins, for prevention of ring translation. The Ilizarove frame was designed with four rings and two working blocks (proximal and distal) as shown in Figure 1 . This design maintains distraction between proximal-most (R1) and distal-most (R4) rings and, at the same time achieves compression between rings (R2 and R3) adjacent to the fracture site. The proximal first ring (R1) was fixed with 1.8 mm olive wires at the level of the head of the fibula and the distal ring (R4) ring was fixed parallel and two cm proximal to the ankle joint. The mediolateral shift of the proximal and distal fragments was then aligned with the help of the addition and tensioning of olive wire either in R2 or R3.

Fig 1: Ilizarov frame design

Once the sagittal shift aligned, the proximal and distal fragments were aligned for coronal translation. Post-operative care was taken with pin-track dressings with betadine gauze. In all patients active knee and ankle movements were started by the second postoperative day and were educated for partial to full-weight bear walking with the help of axillary crutches (Figure 4). Final results were done according to the Association for the Study and Application of the Methods of Ilizarov (ASAMI) method.[10] The union status, deformity, infection, and limb length discrepancy were studied. Paley's criteria were taken for assessment of pin tract infection .[11] All the data were collected and statistical analysis was done using SPSS software (version 22).

RESULTS

This prospective study included 26 patients with complex midshaft tibial fractures who were surgically treated with an all-wire Ilizarov circular frame. The study population had a mean age of 37.2 years. Among 26 patients, 23 (88.46%) patients were men, and 3 (11.54%) patients were women, which shows male predominance. The fracture pattern was classified based on the AO/OTA classification and the status of surrounding soft tissue was classified according to Oestern and Tscherne grade of soft tissue injury.[12] The pre-operative description of patients and fractures is shown in Table 1.

Table 1: Patient details and pre-operative fracture descriptions

Mode of Trauma	Oestern and Tscherne grade of soft tissue injury	AO/OTA classification
RTA – 80.76%	II- 23.07%	42-B1-11.53%
Fall Injury- 3.84%	III- 57.69%	42-B2- 3.84%
Farm Injury- 7.69%	IV- 15.38%	42-B3- 34.61%
Sports Injury- 7.69%		42-C1- 23.07%
		42-C2- 3.84%
		42-C3- 19.23%

All patients were asked to follow up at the end of the second week, sixth week, three months, six months, and 12 months. At all follow-up, patients were evaluated for radiological parameters (alignment and new bone formation), Figure 2,3,4 & 5. Fracture union time was recorded as the time to attain full radiological (judged by the appearance of bridging callus in three out of four cortices) and clinical union (judged by clinical testing of painless walk i.e. dis-assembling the connection between proximal and distal block and allowing patient full weight bear walk). In this study average union time was 27.61 weeks.

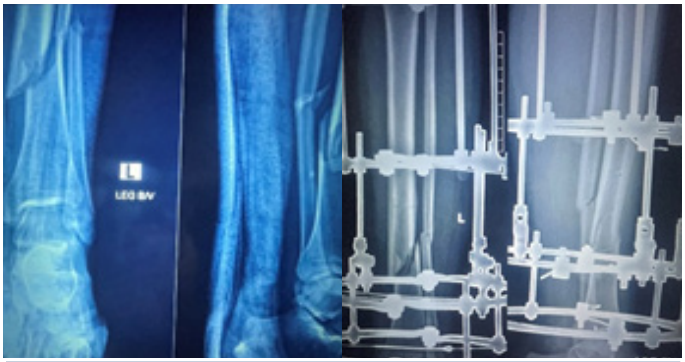

Fig 2: Pre-op Xray

Fig 3: Pre-op Xray

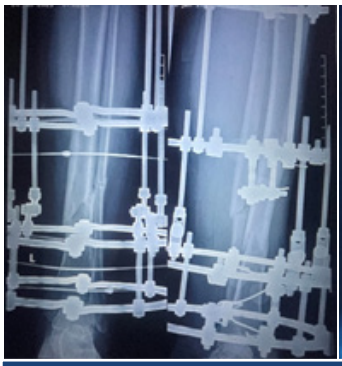

Fig 4: Immediate post-op

Fig 5: Sixteen week follow-up

One patient with AO/OTA 42-C3 fracture pattern, and Tscherne grade III soft tissue injury had non-union with no bridging callus by six months of follow-up and underwent additional surgery with cortico-cancellous bone graft from the iliac crest. This patient however had good union without any further complication. We recorded, Paley's grade I pin tract infections in Seven (26.92%) and managed with oral antibiotics. One patient (3.85%) had 5 degrees of varus deformity, and none had shortening. By the final follow-up of patients, ASAMI bone and functional results were recorded and are shown in Table 2. ASAMI bone results were excellent in 76.92%, good in 11.53%, and fair in 11.53% of cases. Similarly, ASAMI functional result was excellent in 84.6%, good in 7.69%, and fair in 7.69% of cases.

Table 2: Asami bone and functional results

BONE SCORE	FUNCTIONAL SCORE
Excellent- 76.92%	Excellent-84.6%
Good- 11.53%	Good-7.69%
Fair- 11.53%	Fair-7.69%

DISCUSSION

Complex midshaft tibial fractures are a serious type of injury because of their association with a high complication rate.[13] As severely comminuted in nature, these fractures are inherently unstable. Conservative treatment for these high-energy fractures is not recommended as the reported results are not acceptable. Also, opting for an optimal surgical method of stabilization of these fractures is a challenge. The major reason for this dilemma is because of the higher grade of injury to the surrounding soft tissues, further compromising the vascularity of bone. Thus, they require optimal biomechanical fixation without the additional devascularisation that may occur with internal fixation methods like plates and intramedullary nails.[14,15]

The Ilizarov technique for the management of different types of tibial fractures has been well-documented in the literature for over two decades.[16] The smooth-wire circular frame helps in indirect reduction by distraction between proximal-most and distal-most rings. This surgery does not require larger incisions and only minimal stab skin incisions of a few millimeters are required when olive wires are needed. The other advantage of the Ilizarove frame is that it provides a multiplaner and multilevel stability, which allows immediate full weight-bearing and adjacent joint mobilization.

The current study aimed to evaluate the efficacy of an all-wire circular Ilizarov fixator in the treatment of complex closed midshaft tibia fractures accompanied by the compromised overlying soft tissue condition of the bone.

The average age of the study population in this study with such injuries is 37.2 years (range 27-58 years) which is comparable to the study reported by Abdelsatar et al. evaluating 30 cases with an age range of 13-69 years and an average age of 33.47 years.[17]

In our study average time of union as recorded was 27.61 weeks which is comparable with other studies. In a study by Foster et al., a total of 21 patients with complex mid-shaft tibia fractures were treated and the total time to healing was a median of 166 days (87 to 370).[18]

In the present study, 7 cases (26%) had Paley's grade I-II pin tract infections at multiple levels on multiple occasions, which were well healed with simple dressing and oral antibiotics. This has no difference with a similar study by Rayal et al, where 40 patients with complex tibia fractures were managed with an Ilizarove frame and among them, 15 patients (37.5%) had pin tract infections.[19]

We observed malalignment in one patient measuring 5° varus and 5° procurvatum, without any shortening. However, this radiological malalignment was not evident as clinical deformity and the patient did not have any complaints regarding gait disturbance. Our observation regarding malalignment is quite similar to results published by Abdelsatar et al., in their series of 40 cases, one patient had shortness of the limb with associated valgus deformity of more than 7°.[17]

Robertson et al. managed 14 patients with similar fractures using the primary undreamed tibial nailing method and had a deep infection in 3 of these 14 patients. Also, seven out of these 14 patients required a second operation. Though they used different primary fixation methods and the Ilizarov fixator was not the first choice, comparable to them, in our series of patients none of them had deeper soft tissue infection, but one patient required second surgery at 6 months of follow-up with

an autologous cortico-cancellous bone graft from ipsilateral iliac crest as the patient had signs of delayed union.[20]

In our study ASAMI bone results were excellent in 76.92%, good in 11.53%, and fair in 11.53% of cases. This is comparable to a study by C P Pal et al. where they treated 16 patients of compound tibial diaphyseal fracture with Ilizarove frame, and achieved excellent results in 56.25%, good results in 18.75%, fair results in 12.50% poor in 12.50% of patients. We also achieved ASAMI functional results as excellent in 84.6%, good in 7.69%, and fair in 7.69% of cases. The functional ASAMI results achieved in our study are again comparable to results shown by C P Pal et al. where they had 68.75%, good in 18.75%, and fair in 12.50% of cases.[21]

Several studies have well documented the fact that with the Ilizarov technique, tethering of muscles and tendons cannot be avoided, resulting in different amounts of muscle contracture along with joint stiffness, if the apparatus is in-situ for longer periods .[22]

In our study, we evidenced restricted ankle movement in three cases, however this was re-established by continuous ankle stretching exercises, without hampering the final outcome. This makes us believe that the initial ankle stiffness associated with the Ilizarov frame mostly recovers with timely done physiotherapy, thus patient education and early range of motion activities are a must to avoid problems of stiffness. We do not have any such restricted movement at the knee in any of our patients. This is probably because, the Ilizarove frame, surgical instruments, and the surgical method do not violate the knee joint as with an intramedullary tibia nail thus permitting an early range of movement at the knee.

We allowed all our patients immediate full-weight bear walk including climbing stairs from the second post-operative day and was continued through the entire follow-up, with the Ilizarov circular apparatus in the leg. Few patients were able to perform their occupation during follow-up such as teaching and office work. However, all our patients experienced some amount of physical inconvenience like difficulty with clothing (thus causing social problems while working in the office,) and sleeping(which was well compensated by putting a pillow in between legs during sleep).[23]

All other surgical methods available to treat complex tibial mid-shaft fractures (intramedullary nails or plates), always require another major surgical intervention for implant removal. In our study, in all patients, Ilizarove rings and wires were removed without sedation and anesthesia (few patients required 2% xylocaine local anesthesia for the removal of olive wires). Thus a primary definitive fixation with an all-wire Ilizarove circular Frame also avoids the second major surgical intervention for implant removal.

CONCLUSION

The treatment of closed complex midshaft tibial fractures is associated with higher chances of complication due to severe damage to surrounding soft tissues. An all-wire Ilizarov apparatus involves minimal-invasive operation, provides multiple-level stability, and preserves the vascularity of fracture fragments. It also permits early weight bear walk and allows adjacent joint movement. It also greatly reduces the possibility of deeper infection associated with other forms of surgery (plates and nails). The complications (pint tract infection, frame discomfort, muscle tethering, and joint stiffness) with the Ilizarov frame are less serious. We conclude that an all-wire Ilizarov frame is a safe and effective method for the primary definitive fixation of closed complex mid-shaft tibia fractures and to escape the second major surgery for implant removal.

RECOMMENDATIONS We recommend a comparative study of all wire Ilizarove circular frame with other frequently done surgeries like primary definitive nailing for the closed-complex midshaft tibia fracture.

LIMITATIONS OF THE STUDY Our study does have several limitations. Few of them include small sample sizes and a lack of comparisons with other well-established surgical methods such as intramedullary locking nails.

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CONFLICT OF INTEREST We declare no conflict of interest with our study.

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