To Evaluate the Outcome of Ilizarov Ring Fixator Using Hybrid Technique in Tibial Trauma

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Abstract
Introduction: The management of infected nonunion of the tibia is challenging, particularly with segmental bone loss, multiple draining sinuses, poor soft tissue cover, osteopenia, adjacent joint stiffness, limb deformity, or multidrug-resistant polymicrobial infection. The Ilizarov method permits early rehabilitation and addresses all the problems such as non-union, infection, shortening, soft tissue loss and deformity simultaneously at single stage. The conventional all wire Ilizarov frame has certain disadvantages when done in diaphysis such as muscle and tendon transfixation which leads to pain and contracture of adjacent joints, neurovascular injury and patient discomfort.

Half pins used in hybrid Ilizarov causes minimal transfixation of the surrounding soft tissues and neurovascular injury thus causing less morbidity and increased range of motion.

Methods: The present study was a prospective randomized open study in which aim was to evaluate outcome of Ilizarov ring fixator using Hybrid technique in tibial trauma. The study was conducted in 30 skeletally mature patients in Department of Orthopaedics, SGRD University of health sciences, Amritsar from July 2017 to May 2019. The patients were assessed clinically based on history and physical examination. Radiological evaluation using plain antero-posterior and true lateral radiographs of the involved leg was done and evaluated by ASAMI score and complications.

Results: Mean age was 37.7 years. Out of 30 cases 24(80%) were male and 6(20%) were female. Right tibia was involved in 24 cases out of 30 cases. 29 cases had history of road side accident and 1 had history of fall from height. The bone results were excellent in 21 cases (70%), good in 6 cases (20%), fair in 2 cases (6.67%) and poor in 1 case (3.33%). Functional results were excellent in 17 cases (56.67%), good in 9 cases (30%) and fair in 4 cases (13.33%). No poor functional result was noted. In present study following complications were noted, limp in 12 cases (40%), ankle stiffness in 7 cases (23.33%), pin site infection in 9 cases (30%), limb oedema in 7 cases (23.33%), knee stiffness in 3 cases (10%), loosening of pins in 2 cases (6.67%), deformity in 2 cases (6.67%) and refracture in 1 case (3.33%). There was no complication of neurovascular injury, malunion, breakage of wires, axial deviation or limb length discrepancy.

Conclusion: It is thus concluded in present study that with the use of hybrid Ilizarov fixator, bone results are same, functional results are better, post-operative pain is less, less neurovascular injury, decreased joint stiffness, increased range of movements as compared to conventional all wire Ilizarov fixator. Although studies state that pins increase the stiffness of the frame thus decreasing union rate, we found that union rate in hybrid Ilizarov fixator was same as compared to conventional all wire Ilizarov fixator. Thus we conclude that hybrid Ilizarov fixator is better than conventional Ilizarov fixator in all aspects.

Keywords: hybrid Ilizarov, half pins, ASAMI Score.
Introduction

In the past, patients with open infected and non-union fractures had little treatment available to them and ultimately landed up in amputation. The treatment of such conditions was revolutionised by Dr. Gavril Ilizarov. The Ilizarov frame takes its name from Dr. Gavril Abramovich Ilizarov.\(^1\)

Ilizarov has been found to show encouraging results in infected nonunion of tibia as it can not only offer a one-stage solution to infection, shortening and deformity,\(^2\) but also produces regenerate without bone graft.\(^3\)

Conventional ilizarov is all wire fixator. They are stable and elastic type of external fixator and allow axial micromotion allowing “trampoline effect” which are conductive to healing of fractures and regeneration. Conventional Ilizarov fixator with all wires possesses high axial stiffness.\(^4\) The main disadvantage of fine-wires in diaphysis is the relatively narrow anatomic corridors in which they can be placed to minimize the risk of neurovascular damage. These wires often transfix muscle and irritate tendons, leading to pain, loss of mobility, and potentially increasing the risk of pin site infection and contracture of adjacent joints. Wires are more painful and their removal is difficult. Another disadvantage is increased frame complexity and construction. Reducing the number of wires decreases these problems, reduction in fixation time and lower risk of complications.\(^5\)

Hybrid assembly is an advancement of the original Ilizarov apparatus introduced by the Lecco group in Italy in 1986, where half pins were used in diaphysis in place of wires.\(^6\) Addition of half pins in diaphysis causes minimal transfixation of the surrounding soft tissues and due to its insertion in anatomically safe areas cause less morbidity, increased mobility and improved patient comfort and decreased postoperative pain.\(^7\) Addition of half pins in metaphysis increases the stability of the construct thereby reduces the incidence of pin site infection, loosening, allows early mobilisation. The Hybrid frame is easy to apply, versatile, and less expensive than other commercially available adaptors and frames.\(^8,9\)

Methods

The present study was a prospective randomized open study in which aim was to evaluate outcome of Ilizarov ring fixator using Hybrid technique in tibial trauma. The study was conducted in 30 skeletally mature patients in Department of Orthopaedics, SGRD University of health sciences, Amritsar from July 2017 to May 2019. Patients with Infected nonunion with or without bone loss, Infected nonunion with or without previous history of internal fixation, Acute open grade III fracture tibia with bone loss >5cms were included in the study. Patients with significant medical comorbidities and uncorrected metabolic disorders, with significant smoking habits and with Irreparable damage to Tibial nerve were excluded from the study. Follow up was done at monthly interval until frame removal. The patients were assessed clinically based on history and physical examination. Radiological evaluation using plain antero-posterior and true lateral radiographs of the involved leg was done and evaluated by ASAMI score (Association for the study and application of the methods of Ilizarov), external fixation time, complications (pin-track infection, axial deviation, loosening of wires, breakage of wires, mal-union, re-fracture, knee stiffness, ankle stiffness, limb edema and neurovascular injury. Results were evaluated in %.

| ASAMI scoring system | Description |
|----------------------|-------------|
| **Bone results**     |             |
| Excellent            | Union, no infection, deformity ≤7°, limb-length discrepancy ≤2.5 cm |
| Good                 | Union + any two of the following: Absence of infection, ≤7° deformity, and limb-length inequality of ≤2.5 cm |
| Fair                 | Union + only one of the following: Absence of infection, deformity ≤7°, and limb-length inequality ≤2.5 cm |
| Poor                 | Nonunion/re-fracture/union + infection + deformity >7° + limb-length inequality >2.5 cm |
| **Functional results**|             |
| Excellent            | Active, no limp, minimum stiffness (loss of ≤15° knee extension/≤15° dorsiflexion of ankle), no RSD, insignificant pain |
| Good                 | Active, with one or two of the following: limp, stiffness, RSD, significant pain |
| Fair                 | Active, with three or all of the our figures show wound: limp, stiffness, RSD, significant pain |
| Poor                 | Inactive (unemployment or inability to return to daily activities because of injury) |
| Failures             | Amputation |

ASAMI – Association for the Study and Application of Methods of Ilizarov. RSD – Reflex sympathetic dystrophy

THE ASAMI SCORING we are using is a modification of paley et al.\(^10\)
Results

The medical records and serial radiographs of all 30 patients were reviewed. In our study mean age was 37.7 years. Out of 30 cases 24(80%) were male and 6(20%) were female. Right tibia was involved in 24 cases out of 30 cases. 29 cases had history of road side accident and 1 had history of fall from height. Proximal tibial shaft was affected in 4 cases(13.34%), middle and distal tibial shaft was affected in 16(53.33%) and 10 (33.33%) cases respectively. Out of 30 cases, 14 cases(46.66%) were of infected non-union with bone loss and 16 cases (53.34%) were of open fracture IIIB/IIIC with bone loss. The mean consolidation time was 8.2 months and mean bone lengthening achieved was 7.1 cm in present study. According to BONE ASAMI SCORE criteria, in present study union was achieved in all 30 cases(100%) of tibial fracture, pin site infection was present in 9 out of 30 cases(30%), deformity (>7 degree) was present in 2 out of 30 cases (6.67%) and limb length discrepancy (>2.5cm) was absent in all 30 cases(0%). The bone results were excellent in 21 cases (70%), good in 6 cases(20%), fair in 2 cases(6.67%) and poor in 1 case(3.33%). In our study, according to FUNCTIONAL ASAMI, pain was present in 5 cases (16.67%), limp in 12 cases (40%), knee stiffness in 3 cases (10%), ankle stiffness in 7 cases (23.33%), activity in all 30 cases (100%) and reflex sympathetic dystrophy was absent in all cases. Functional results were excellent in 17 cases (56.67%), good in 9 cases (30%) and fair in 4 cases (13.33%). No poor functional result was noted. In present study following complications were noted, limp in 12 cases(40%), ankle stiffness in 7 cases(23.33%), pin site infection in 9 cases(30%), limb oedema in 7 cases (23.33%), knee stiffness in 3 cases (10%), loosening of pins in 2 cases (6.67%), deformity in 2 cases (6.67%) and refracture in 1 case (3.33%). There was no complication of neurovascular injury, malunion, breakage of wires, axial deviation or limb length discrepancy.

Table 1: Bone Results (According To Asami Criteria)

| Bone Results | No. Of Cases (%) |
|--------------|------------------|
| Excellent    | 21 (70)          |
| Good         | 6 (20)           |
| Fair         | 2 (6.67)         |
| Poor         | 1 (3.33)         |
| Total        | 30 (100)         |

Table 2: Functional Results (According To Asami Criteria)

| Functional Results | No. Of Cases (%) |
|--------------------|------------------|
| Excellent          | 17 (56.67)       |
| Good               | 9 (30)           |
| Fair               | 4 (13.33)        |
| Poor               | 0 (0)            |
| Total              | 30 (100)         |

Table 3: Complications

| Complications         | No. Of Cases (%) |
|-----------------------|------------------|
| Knee Stiffness        | 3 (10)           |
| Ankle Stiffness       | 7 (23.33)        |
| Limp                  | 12 (40)          |
| Axial Deviation       | 0 (0)            |
| N/V Injury            | 0 (0)            |
| Pin Site Infection    | 9 (30)           |
| Refracture            | 1 (3.33)         |
| Malunion              | 0 (0)            |
| Loosening Of Pin      | 2 (6.66)         |
| Breakage Of Wires     | 0 (0)            |
| Limb Oedema           | 7 (23.33)        |
| Deformity             | 2 (6.67)         |
| Limb Length Discrepancy | 0 (0)         |

A-Preoperative clinical picture. B-Preoperative X-Ray. C-X-Ray at 6
months. D- X-Ray after removal of fixator at 1 year. E- Clinical picture after removal of fixator.

Discussion

The management of infected non-union of the tibia is challenging, particularly with segmental bone loss, multiple draining sinuses, poor soft tissue coverage, osteopenia, adjacent joint stiffness, limb deformity, or multidrug-resistant polymicrobial infection. Permanent functional deficits, prolonged recovery times, and even amputation can result.8,11

Several methods have been applied successfully in the treatment of infected non-union of tibia including bone grafts, extensive debridement and local soft tissue rotational flaps, packing of the defects with Papineau-type open cancellous bone grafting, tibiofibular synostosis, free microvascular soft tissue and bone transplants and masquelet technique.12-17

However, these treatments have obvious limitations such as donor site morbidity, stress fracture, restriction of the size of bone defects, failure of flaps and skin grafts and multiple surgeries.

Ilizarov pioneered the theory of "tension stress" allowing bone and soft tissue generation to restore defects after excision of associated osteomyelitis,18,19 and in non-union treatment.20,21

The Ilizarov method permits early rehabilitation and addresses all the problems such as non-union, infection, shortening, soft tissue loss and deformity simultaneously at single stage.22

Conventional Ilizarov is all wire fixator. The conventional all wire Ilizarov frame has certain disadvantages when done in diaphysis such as Muscle and tendon transfixation which leads to pain and contracture of adjacent joints. Chances of neurovascular impalement are higher. Olive wires are more painful and their removal is difficult and 90-90 placement of wires is not always possible according to anatomical safe corridors compromising the stability of assembly.

Hybrid assembly is an advancement of the original Ilizarov apparatus introduced by the Lecco group in Italy in 1986, where half pins were used diaphysis in place of wires.6 Addition of half pins in diaphysis cause minimal transfixation of the surrounding soft tissues and due to its insertion in anatomically safe areas cause less morbidity, increased mobility and improved patient comfort and decreased postoperative pain.7 Addition of half pins in metaphysis increases the stability of the construct thereby reduces the incidence of pin site infection, loosening, allows early mobilisation. The Hybrid frame is easy to apply, versatile, and less expensive than other commercially available adaptors and frames.8,9

The present study was a prospective randomized open study in which aim was to evaluate the outcome of Ilizarov ring fixator using Hybrid technique (Combination of wires and half pins). The study was conducted in 30 skeletally mature patients in Department of Orthopaedics, SGRD University of health sciences, Amritsar from July 2017 to May 2019. Follow up was done at monthly interval until frame removal. The patients were assessed clinically based on history and physical examination. Radiological evaluation using plain antero-posterior and true lateral radiographs of the involved leg was done and evaluated by ASAMI score (Association for the study and application of the methods of Ilizarov), complications (pin site infection, axial deviation, loosening of wires, breakage of wires, mal-union, re-fracture, knee stiffness, ankle stiffness, amputation, limb edema and neurovascular injury. Results were evaluated in percentage.

In present study excellent and good bone results were found in 90 percent of cases, fair and poor bone results in 10 percent of cases. In study conducted on conventional all wire ilizarov fixator by Yin P et al(2014) the bone results were excellent and good in 90%, fair and poor bone results in 10%. In study conducted on conventional all wire ilizarov fixator by Rohilla R et al in 2016 the bone results were excellent and good in 91.5%, fair and poor bone results in 8.5% of cases. These studies are comparable to our study.

In present study functional results were excellent and good in 86.67% cases and fair and poor in 13.33% cases. In a study conducted on conventional all wire ilizarov fixator by Yin P et al in 2014 functional results were excellent and good in 80% cases and 20% cases had fair and poor functional results. In a study conducted on conventional all wire ilizarov fixator by Chattopadhyay P et al in 2017 excellent and good functional results were present in 67% cases. 33% cases had fair and poor functional results. The study conducted on conventional all wire ilizarov fixator by Shahid et al in 2013 excellent and good bone results were found in 90% cases and fair and poor bone results in 10% cases. In study conducted on conventional all wire ilizarov fixator by Menakaya CU et al(2014), Yin P et al(2014), Ferreira N...
et al (2015) and Rohilla R et al (2016). Pin site infection is one of the most common complications of ilizarov. In present study infection at pin site was present in 30% of cases. In studies conducted on conventional all wire ilizarov fixator by Elgazzar AS et al (2012), Yin P et al (2014), Rohilla R et al 2016 and Ali SK et al (2017) infection at pin site was present in 36%, 60.6%, 68.5% and 45% of cases respectively.

In present study deformity (>7 degree) was present in 6.67% of cases. In studies conducted on conventional all wire ilizarov fixator by Rohilla R et al (2016) deformity >7 degree was present in 22.8% of cases. In present study limb length discrepancy was absent in all cases. In studies conducted on conventional all wire ilizarov fixator by Farmanullah et al (2007), Rohilla R et al (2016) and Barawi OA et al (2018) limb length discrepancy was present in 3.44%, 11.4% and 5% of cases. Our results are better than the above studies.

Post operative pain is a major complication of ilizarov fixator. Pain is due to muscle and tendon transfixation by the wires. In our study postoperative pain was present in 16.67% of cases and reflex sympathetic dystrophy was absent in all cases. In studies conducted on conventional all wire ilizarov fixator by Wani N et al in 2011 and Elgazzar AS et al in 2012 postoperative pain was present in 25% and 20% of cases respectively. According to studies conducted on conventional all wire fixator by Farmanullah et al (2007) and Barawi OA et al (2018) reflex sympathetic dystrophy was present in 6.89% and 10% of cases respectively. Post operative pain and reflex sympathetic dystrophy was less in our study done on hybrid ilizarov fixator as compared to the above studies done on conventional all wire ilizarov fixator.

Joint stiffness is a major drawback of ilizarov fixator. In our study done on hybrid ilizarov fixator ankle stiffness as a complication was present in 23.3% and knee stiffness was present in 10% of cases. In studies conducted on conventional all wire ilizarov fixator by Megas P et al in 2010, Gupta SK et al in 2014 and Rohilla R et al in 2016 ankle stiffness was present in 55%, 25% and 51% of cases respectively. In studies conducted on conventional all wire ilizarov fixator by Elgazzar AS et al in 2012, Rohilla R et al in 2016 and Barawi OA et al 2018 knee stiffness was present in 8%, 20% and 10% of cases respectively. Our studies show that hybrid ilizarov fixator decrease the incidence of knee stiffness and ankle stiffness as compared to conventional all wire ilizarov fixator.

We have demonstrated that as compared to all wire ilizarov fixator, hybrid ilizarov fixation is an effective technique. In our study hybrid ilizarov has provided better ASAMI bone and functional results. It is seen in our studies that there were lower rate of ankle and knee stiffness, lower rate of pin site infections, less pain and less chances of neurovascular injury. The hybrid ilizarov construct is biomechanically not inferior to the conventional all wire ilizarov fixator.

References
1. Aktuglu E, Erol K, Vahabi A. Ilizarov bone transport and treatment of critical-sized tibial bone defects: a narrative review. J Orthop Traumatol. 2019;20:22.
2. Baruah RK. Ilizarov methodology for infected non union of the Tibia: Classic circular transfixion wire assembly vs. hybrid assembly. Indian J Orthop. 2007;41(3):198–203.
3. Rohilla R, Siwach K, Devgan A, Singh R, Wadhwni J, Ahmed N. Outcome of distraction osteogenesis by ring fixator in infected, large bone defects of tibia. J Clin Orthop Trauma. 2016;7:201-9.
4. Fragomen AT, Rozbruch SR. The Mechanics of External Fixation. HSS J. 2007 Feb;3(1):13–29.
5. Gasser B, Boman B, Wyder D, E. Schneider. Stiffness characteristics of the circular Ilizarov device as opposed to conventional external fixators. J Biomech Eng. 1990;112:15–21.
6. Cattaneo R, Villa A, Catagni M, Tentori L. Treatment of septic or non-septic diaphyseal pseudoarthroses by Ilizarov’s monofocal compression method. Rev Chir Orthop Reparatrice Appar Mot. 1985; 71(4):223-9.
7. Henderson DJ, Rushbrook JL, Stewart TD, Harwood PJ. What Are the Biomechanical Effects of Half-pin and Fine-wire Configurations on Fracture Site Movement in Circular Frames? Clin Orthop Relat Res. 2016;474(4):1041-9.
8. Jain AK, Sinha S. Infected nonunion of the long bones. Clin Orthop Relat Res. 2005;431:57–65.
9. Gakwald RE, Nemede VV, Deore TJ, Bhandari PV. Efficacy of Hybrid Ilizarov fixation in reducing time span of union in infected non-union of tibia. International Journal of Orthopaedics and Traumatology. 2016;2(3):01-04.
10. Tekin AC, Cabuk H, Dedegolu SS, Saygili MS, Adas M, Esenayl CZ, Buyukkurt CD, Tonbul M. The results of bone deformity correction using a spider frame with web-based software for lower
extremity long bone deformities. SICOT J. 2016;2:11.

11. Bose D, Kugan R, Stubbs D. Management of infected nonunion of the long bones by a multidisciplinary team. Bone Joint J. 2015;97-B: 814-17.

12. Christian EP, Bosse MJ, Robb G. Reconstruction of large diaphyseal defects, without free fibular transfer, in Grade-IIIB tibial fractures. J Bone Joint Surg Am. 1989;71:994–1004.

13. Keating J.F., Simpson A.H.R.W., Robinson C.M. The management of fractures with bone loss. J Bone Jt Surg Br. 2005;87-B:142–150.

14. Wu C.C. Single-stage surgical treatment of infected nonunion of the distal tibia. J Orthop Trauma. 2011;25(3):156–161.

15. Maini L., Chadha M., Vishwanath J., Kapoor S., Mehtani A. The Ilizarov method in infected nonunion of fractures. Injury. 2000;31:509–17.

16. Yaremchuk MJ, Brumback RJ, Manson PN, Burgess AR, Poka A, Weiland AJ. Acute and definitive management of traumatic osteocutaneous defects of the lower extremity. Plast Reconstr Surg. 1987;80:1–14.

17. Nusbickel FR, Dell PC, McAndrew MP, Moore MM. Vascularized autografts for reconstruction of skeletal defects following lower extremity trauma. A review. Clin Orthop Relat Res. 1989;238:65–70.

18. Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: Part I. The influence of stability of fixation and soft-tissue preservation. Clin Orthop Relat Res. 1989;238:249-81.

19. Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: Part II. The influence of the rate and frequency of distraction. Clin Orthop Relat Res. 1989;239:263-85.

20. Pearson RL, Perry CR. The ilizarov technique in the treatment of infected tibial nonunions. Orthop Rev. 1989;18:609-13.

21. Green SA, Jackson JM, Wall DM. Management of segmental defects by the ilizarov intercalary bone transport method. Clin Orthop Relat Res. 1992;280:136-42.

22. Meleppuram JJ, Ibrahim S. Experience in fixation of infected non-union tibia by Ilizarov technique – a retrospective study of 42 cases. Rev Bras Ortop. 2017;52(6):670–5.