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Management of fracture non-union long bones by limb reconstruction devices

Praveen Garg[1], Tanmay Bajpai[2], Rajeev Saxena[3]

[1]Associate Professor, [2]Junior Resident, Department of Orthopaedics, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India, [3]Associate Professor and Head, Department of Microbiology, Maharshi Devrha Baba Autonomous State Medical College, Deoria, Uttar Pradesh, India

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ABSTRACT

Background: The limb reconstruction system (LRS), rail road fixator, and Ilizarov fixator are used to treat open fractures with bone loss and infective non-union of long bones. It benefits the fracture site by permitting distraction, compression, and further enhancing micromotion at the level of fracture site which plays an important part in healing. The LRS is a straightforward, unidirectional arrangement that provides exceptional strength and rigidity. The limb rebuilding procedure has proven to be an effective treatment option in instances of fracture infective non-union of long bones. **Aims and Objectives:** This study is to evaluate and to observe the use of limb reconstruction devices (such as the Ilizarov fixator and the rail road fixator) in the treatment of open fractures with bone loss and infective non-union of long bones. **Materials and Methods:** Twenty patients (15 males and five females) with fracture non-union of long bones were involved in this study after taking permission from ethic committee and consents from all 20 individuals. These patients then underwent thorough debridement and resection of non-viable bone ends with the application of limb reconstruction devices which were then followed by bone transport to fill the bone gap. This was done by means of Ilizarov in 13 patients and by rail road fixator in the remaining seven patients. The average time of union and complications were evaluated. **Results:** Mean duration of fracture union was 7.9 months. While one patient had failure resulting in non-union, other 19 patients achieved union by limb reconstruction devices. Majority of the cases had no complications. Mean period of hospital stay for Ilizarov was 68.13 days and for rail road fixator 53.17 days. After applying independent "t-test," no statistically significant differences were observed in fracture union duration between Ilizarov and rail road fixator, since the calculated P value was observed to be >0.05. Mean union of Ilizarov and rail road fixator application was found to be 7.6 months and 8.2 months, respectively. **Conclusion:** Limb reconstruction devices in our present study can be utilized as an effective way to tackle infective non-union of long bones and open fracture with bone loss for achieving better stabilization. Both Ilizarov and rail road fixator perform a crucial role in causing early mobilization of the patient and also in fracture union by distraction osteogenesis.

Key words: Distraction osteogenesis; Ilizarov; Rail road fixator

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INTRODUCTION

According to a panel of the USFDA, non-union is defined as "when a minimum of 9 months has passed since the injury and the fracture has shown no apparent indications of healing for 3 consecutive months."[1] In fracture non-union, the healing process has come to a halt. Failure to achieve bony union by 6 months post-injury is one example. External fixation is a surgical procedure used in stabilization and provides anatomical alignment of fractured fragments of bone.[2]

Road traffic accidents are very common and result in increase in fractures of long bones,[3] with the increased occurrences of high-velocity trauma,[4] non-union of long

Address for Correspondence:
Dr. Tanmay Bajpai, Junior Resident 3 year, Department of Orthopaedics, Rohilkhand Medical College and Hospital, Bareilly - 243 006, Uttar Pradesh, India. **Mobile:** +91-9144225373. **E-mail:** bajpai.tanmay@gmail.com

bones causes great deal of bone loss which is a difficult condition that requires immediate care.

Fracture non-union of long bones is especially common in open, comminuted type of fracture that has been immobilized for too long. Atrophic (avascular), oligotrophic, pseudarthrosis, and hypertrophic are the most common classifications (hypervascular) because the osteogenic stimulation is still there in hypertrophic non-union and requires only stability to unite. The osteogenic stimulus is still absent in avascular non-union, therefore, stability and a fresh cancellous bone transplant are frequently required for the union of bone to occur. The osteogenic stimulus for atrophic non-unions is delivered by a corticotomy around the non-union site with the help of distraction osteogenesis which greatly improves the blood supply to the are. The osteogenic stimulus for atrophic non-unions is delivered by a corticectomy around the non-union site with the help of distraction osteogenesis which greatly improves the blood supply in this area. Non vascularized fibula strut graft is a common treatment approach for non union long bones fractures.

Aims and objectives

This study is to evaluate and to observe the use of limb reconstruction devices (such as the Ilizarov fixator and the rail road fixator) in the treatment of open fractures with bone loss and infective non-union of long bones.

MATERIALS AND METHODS

It is a prospective study which was conducted on 20 patients (15 males and five females) with patients suffering from fracture infective non-union of long bones from November 2019 to October 2020. Patients were categorized with the following inclusion and exclusion criteria:

The study was pre-approved by the Institutional Ethics Committee for the final permission.

Inclusion criteria

The following criteria were included in the study:

- Cases of non-union long bones fracture according to the USFDA.
- Patients willing for Ilizarov fixator ring or rail road fixator.

Exclusion criteria

The following criteria were excluded from the study:

- Recent fractures.
- Patient refusing for procedure.

Procedure

Patients were investigated and evaluated before application of limb reconstruction devices and X-rays of affected limb of AP and lateral views were taken. The criteria taken for non-union were a minimum period of 9 months with no signs of union seen consecutively for 3 months both clinically and radiologically.

After the application of limb reconstruction devices and performing corticotomy, mechanical induction of new bone occurs between vascular bony surfaces that are gradually pulled apart by gradual distraction which starts after 7 days at the rate of 0.25 mm/6 hourly daily that means 1 mm in 24 h. Corticotomy helps in cutting only the cortical surface thus preserving the medullary canal, nutrient vessels, endosteum, and periosteum.

Postoperatively, patients weight-bearing was allowed from the beginning. Follow-up X-rays were taken at immediate post-operative period, 3 weeks and further at 6 weeks interval till fracture union. Union was confirmed on X-ray, and after the union, limb reconstruction devices were removed. The patient was further followed for the next 3 months after the union. All patients were assessed on the basis of union outcome and duration of application of limb reconstruction device.

Statistical analysis

After applying independent "t-test," no statistically significant differences were observed in fracture union duration between Ilizarov and rail road fixator, since the calculated *P* value was observed to be greater than 0.05. Mean union of Ilizarov and rail road fixator application was found to be 7.6 months and 8.2 months, respectively.

RESULTS

Results of 20 patients included in this study (n=20), were assessed.

Mean age was measured to be 32.2 years.

Out of 20 patients, male: female ratio was around (15:5). Majority of the cases in our study belonged to middle socioeconomic strata (i.e., 12 cases out of 20 patients).

Average mean period of stay in hospital for Ilizarov was 68.13 days and for rail road fixator 53.17 days.

In our study of 40 patients, range of motion at knee joint during flexion (Table 1) was of 15–120° in majority of cases (60%).

Mean duration of fracture union (Table 2) was 7.9 months with standard deviation of 1.78.

Out of 20 cases, pin-tract infection was found in 8.75% of cases (3), one patient had malunion, and four patients had

Table 1: Range of motion at knee joint during flexion

Range of motion (degree)	Number	Percentage
10–110.0	7	17.5
0–115.0	9	22.5
15–120.0	24	60.0
Total	40	100.0

Table 2: Facture union duration in Ilizarov and LRS fixation

Facture union (months)	Number of cases	Mean	Std. deviation	Std. error mean	P value
Ilizarov	13	7.652	1.7992	0.3752	0.267
LRS	07	8.294	1.7594	0.4267	

LRS: Limb reconstruction system

Table 3: Complications

Complication	Number of cases	Percentage
Nil	8	37.5
Malunion	2	7.5
Pin loosening	2	10.0
Pin-tract infection	3	17.5
Non-union	1	5.0
Delayed union	4	22.5
Total	20	100.0

delayed union. Majority of the cases had no complications (Table 3).

DISCUSSION

Management of infected non-union is aimed to control the infection and to promote union at the fracture site with a proper alignment of the fracture fragments along with the maintenance of normal length and restoration of movements at the adjacent joints and getting a fully functional and painless limb. The segment of infected bone was resected till the bleeding ends appear (paprika sign).

Ilizarov distraction osteogenesis has typically been used to treat complicated non-union of long bone fractures with significant defects and infection, according to the studies done by Dendrinos et al., and Lynch et al.[6-8]

However, in our present study, as shown in Figures 1 and 2 we showed the intricacy and technical difficulties of the Ilizarov procedure, as well as the time and for a successful outcome and the possibility for multiple problems which have curtailed its popularity as seen before in the study by Paley et al.[9] In this context, LRS refers to an uniplanar dynamized external fixator, which is a light weight, simple to assemble frame with a short learning curve and is based on the same Ilizarov fundamental concept as studied by Ramos et al.[10]

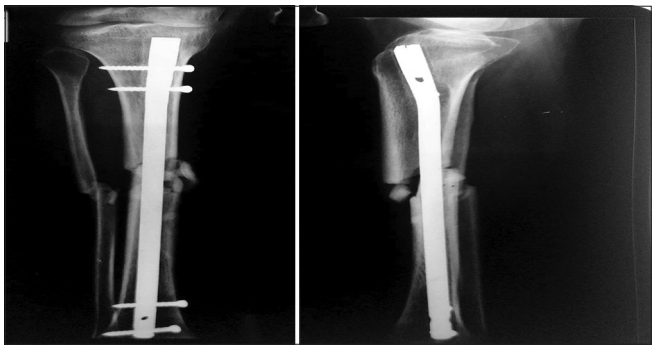

Figure 1: Pre-operative X-ray images of infective non-union with implant *in situ*

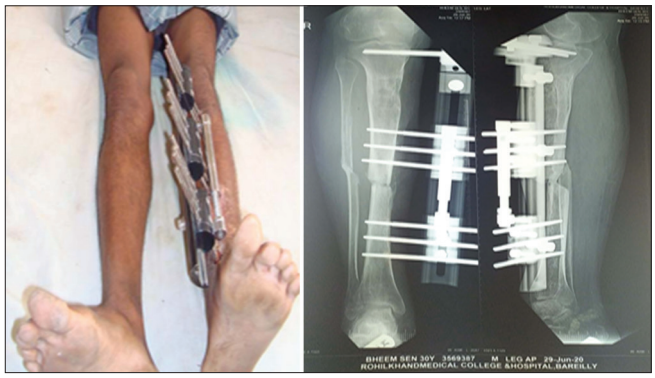

Figure 2: Post-operative 6 months follow-up X-ray image

In the present study, hospital stay period has been found to be 7.9 months which is nearly same as the study done before by Rose et al., Sangkaew et al., and Magadum et al.[11-13]

In the study, the evidence of the effectiveness of this approach may be seen in the successful outcomes obtained by Ilizarov fixator which were same as it has been earlier studied by Saleh and Royston.[9] Yet, problems such as loosening of pin and pin-tract infection were observed, as were also seen before by Ramos et al.[10]

In our present study, post-operative findings after the fracture union with regard to the mean flexion at knee joint was of 120 degrees in majority of cases (60%) and 0 degrees during extension which was similar to study conducted by Tornetta et al.[14]

In the present study, road traffic accident was the cause of injury in all our cases which is comparatively similar to previously conducted study by Kouassi et al.,[15] that the majority (95%) of the cases were of road traffic accident.

In our study, tibia was typically most commonly involved bone in fracture non-union, accounting for 52.5% of cases which was similar to previously conducted study by Js et al.,[16] that the fractures of tibia are quite common.

Limitations of the study

The present study has some limitations. The sample size was small. The patient selection criteria for the above study is arbitrary.

CONCLUSION

Achieving better stabilization requires limb reconstruction devices which play a crucial part in managing open fracture with bone loss and also fracture infective non-union of long bones. Limb reconstruction provides early mobilization and fracture union by distraction osteogenesis. Mean union of Ilizarov and LRS application was 7.6 months and 8.2 months, respectively, with few complications like pin-tract infections. Bulkiness of the fixator was a drawback for patient discomfort. Long-term follow-up was also not possible for majority of the patients. Both rail road fixator and Ilizarov help in achieving union and regaining function of the affected limb. It can be concluded that more studies and a large sample size are still required to establish more appropriate and conclusive data.

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Authors Contribution:
TB- Concept and design of the study, prepared first draft of manuscript; **PG-** Interpreted the results; reviewed the literature and manuscript preparation; and **RS-** Concept, coordination, statistical analysis and interpretation, preparation of manuscript, and revision of the manuscript.

Work attributed to:
Rohilkhand Medical College and Hospital, Bareilly - 243 006, Uttar Pradesh, India.

Orcid ID:
Dr. Praveen Garg - https://orcid.org/0000-0002-2497-1130
Dr. Tanmay Bajpai - https://orcid.org/0000-0001-8765-9067
Dr. Rajeev saxena - https://orcid.org/0000-0001-9611-3808

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