A study of management of non union of long bone fractures by limb reconstruction system

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Abstract

Background: Management of non unions is difficult due to the presence of infection, deformities, shortening and multiple surgeries in the past. Non union are traditionally managed by illizarov fixation. All the procedures used to treat non union have their own set of complications like shortening, soft tissue infections, multiple surgeries, chronic infection, increased morbidity, increased hospital stay. We conducted a study on 20 patients long bone with non-union treated with Limb reconstruction system(LRS).

Material and Method: We treated 20 patients of non union long bones with limb reconstruction system (LRS). In this study 18 were male and 2 were female. All patients were operated under spinal-epidural anaesthesia in supine position. Patients were evaluated at pre op and post op follow up period with serial radiography on 6 weeks 12 weeks 6 months and 9 months. Initially 12 patients that presented with infected implant were managed with implant removal radical debridement and fixation with LRS. In 8 cases corticotomy and lengthening was done. Average duration of treatment was 9 months. Outcome was evaluated with ASAMI scoring system.

Result: The union occurred in 90% patients and eradication of infection in 95% patients, We had 80% excellent,10% good and 10% poor bony union results according to ASAMI scoring system and Functional outcome was excellent in 80% patients, good in 10% and failure in10% cases using ILIZAROV functional scoring system.

Conclusion: LRS is a good alternative to the illizarov fixation in the management of infected and non infective non-union of long bone. It is less cumbersome, uniplanar and surgeon friendly.

Keywords: Corticotomy, non-union, limb reconstruction system, surgical and functional outcomes

Introduction

Incidence of fractures of long bones is increasing day by day due to increased road traffic accidents and other domestic accidents leading to increased incidence of non-union [1]. The most important complication following an open fracture is delayed union/non-union. They contribute to about 10-20% of fracture treatment complication. Today open fractures with infection are perhaps the most common causes of non-union. Infected non-union is associated with multiple problems like osteomyelitis, bone and soft tissue distortion and loss, sinuses, osteopenia, joint stiffness and multidrug resistance and at times multi bacterial infection [2]. Management of these complex non-union in the presence of infection, angular deformity, limb length discrepancy and also multiple previous surgeries is a challenging orthopaedic task, that the surgeon faces [3].

Non-union is diagnosed, until clinical or radiographic evidence shows healing has ceased and that union is highly improbable. Nonunion is defined as “established when a minimum of 9 months has elapsed since injury and the fracture shows no visible progressive signs of healing for 3 consecutive months” [2].

Various modalities of treatment for nonunion of long bones described are extensive debridement, microvascular soft tissue flaps, external fixation with bone graft, Ilizarov ring fixator, bone transport through external fixator over nail and limb reconstruction system (LRS) [4]. Ilizarov ring fixator and LRS are the implants that can serve the above purpose [5] Ilizarov ring fixator and limb reconstruction system are common modalities and are single stage procedure. Correction of deformity and limb length discrepancy is possible with these along with excellent control of infection and facilitates bone union.
Weight bearing can also be initiated during treatment. Compared to LRS, Ilizarov fixator is cumbersome to the patient, painful and relatively difficult to mount.

The Limb Reconstruction System (LRS) is a series of modular monolateral external fixators to be used in reconstructive procedures for the treatment of limb length discrepancy, bone loss, open fractures, non-union and angular deformities.

The innovation in the Advanced LRS has produced improved efficiency, increasing its ease of application in deformity correction, joint contracture and bone transport with short segments. This has expanded the available choices for the surgeon as there is now a system of external fixation for the effective treatment of deformity and bone defects that is better tolerated by the patient [6]. It also allows dynamization of the fracture site, which is the essential principle in the treatment of non-union [7].

This study was conducted to assess the union rates, infection control, lengthening and the complications associated with the LRS.

Materials and Methods

This is a prospective case study to evaluate the efficacy, radiological union and functional outcome by using limb reconstruction system (LRS) method in the treatment of complex long bone non-union with or without segmental bone loss and with or without active indolent infection. This Study was conducted at the Department of Orthopaedics, Bashweshwar Teaching and General Hospital, attached to Mahadevappa Rampure Medical College Kalaburagi and from 1st October 2019 to 31st March 2021.

We included 20 cases of complex nonunion of long bones (13 were tibia, 7 were femur) fig 1, which were diagnosed clinically and radiologically which satisfied the inclusion criteria.

Inclusion criteria

1. Clinically and radiologically diagnosed cases of Nonunion of fracture of long bones.
2. Both infective & non-infective nonunion of long bone fractures are included in the study.
3. Previously treated non-union which failed to unite by any other methods like Ilizarov are also included.

Exclusion criteria

1. Pediatric non-union.
2. Pathological fractures.
3. Non-union with Pregnancy.

Post op protocol

A Starting from post operative day 1 care was taken for pain management, intravenous antibiotics which were initiated on the day of surgery were continued for 5 days and meticulous care was taken about the pin tract dressing and in case of septic non-union the sample which was sent for culture and sensitivity antibiotics were changed according to MIC value and were continued for 3weeks. Postoperative shortening was noticed and measured then depending upon that period of distraction was decided.

Active and passive mobilisation of the adjacent joint were encouraged the day following surgery, ambulation and partial weight baring was started on second or third postoperative day depending on patient’s compliance, pain, local soft tissue condition and quality of bone, the fixator was always applied to the lateral aspect for femur and medial aspect of the tibia.

Distraction was initiated on POD 7. The distraction procedure was taught by the surgeon to the patient. The aim was to achieve a distraction of 1mm per day and this was accomplished by making a quarter of a turn of the distraction key at fourth hourly intervals, during the waking hours (viz.: 8.00 am, 12.00 pm, 4.00 pm and 8.00 pm). Thus a 360 degrees rotation of the distraction key translates into a 1mm distraction.
Ilizarov functional score follow up

| Functional | Description                                                                 |
|-----------|-----------------------------------------------------------------------------|
| Excellent | Active, no limp, minimum stiffness (loss of < 15 knee extension/ < 15 dorsiflexion of ankle), no reflex sympathetic dystrophy (RSD), insignificant pain |
| Good      | Active, with one or two of the following: limp, stiffness, RSD, Significant pain |
| Fair      | Active, with 3 or all of the following: limp, stiffness, RSD, significant pain |
| Poor      | Inactive (unemployment or inability to perform daily activities because of injury) |
| Failures  | Amputation                                                                   |

Asami bone union

| Bone Results | Description                                                                 |
|--------------|-----------------------------------------------------------------------------|
| 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         | Non union/refracture/union + infection + deformity > 7 + limb length inequality > 2.5cm |

Fig 2: Preoperative radiograph of 60 years old infected nonunion tibia

Fig 2.1: X ray radiograph of post operative 9 months showing adequate callus

Fig 2.2: X ray radiograph of post implant removal after 1 year

Fig 2.3: Clinical picture of the patient after removal

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The patient was taught to do pin tract dressings. Thus prior to discharge the patient is ambulant, knowledgeable about the distraction method and also trained on self-care of the pin tracts which is usually done with sterilium.

Patient was discharged on pod12 with the advice that if there is any abnormal pain, numbness or tingling distal to the fixator, the distraction procedure should be stopped forthwith and resumed after 48 hours in increments of two turns, 3 turns and 4 turns over a period of 7 days. Should upon resumption of distraction, if there be any recrudescence of pain or numbness, patient is advised to report immediately to the hospital. Patient was asked to follow up at 3, 6, 12 and 24 weeks, check x ray was taken at each follow up appointment. Once radiological union of fracture site and at the same time corticotomy if done the site of the corticotomy was assessed. LRS was removed as a day care procedure at minor operation theatre under intravenous sedation.

The functional and Bone union outcome was assessed using ASAMI Scoring system. [8]
Fig 3.1: Preoperative clinical and X ray radiograph 27yrs old male with distal femur non union with infected implant insitu

Fig 3.2: X ray radio graph of immediate post op day 1

Fig 3.3: X ray radiograph of post op 6 months

Fig 3.4: X ray radiograph of post implant removal

Fig 4.1: X ray radiograph of patient 32 yrs old rt midshaft tibia fibula open fracture

Fig 4.2: X-ray radiograph of patient post operative day1

Fig 4.3: Xray radiograph of post op 3 months showing corticotomy at metaphyseal region with distraction and compression at fracture site
Fig 4.4: X ray radiograph of post op 6 months showing corticotomy at metaphyseal region with distraction and compression at fracture site

**Results**

The final outcome was calculated in 20 cases for which final follow up was available out of 20 cases we were able to achieve union in 18 patients.

**Table 1:** Age wise distribution of patients

| Age in years | Number of patients | Percentage |
|--------------|--------------------|------------|
| 21-30        | 6                  | 30.0       |
| 31-40        | 2                  | 10.0       |
| 41-50        | 3                  | 15.0       |
| >50          | 9                  | 45.0       |
| Total        | 20                 | 100.0      |
| Mean ± SD    | 44.65 ± 13.05      |            |

**Table 2:** Gender wise distribution of patients

| Gender  | Number of patients | Percentage |
|---------|--------------------|------------|
| Males   | 18                 | 90.0       |
| Females | 2                  | 10.0       |
| Total   | 20                 | 100.0      |

**Table 3:** Nonunion of facture bone side wise distribution of patients

| Side    | Number of patients | Percentage |
|---------|--------------------|------------|
| Right   | 14                 | 70.0       |
| Left    | 6                  | 30.0       |
| Total   | 20                 | 100.0      |

**Table 4:** Initial fracture type wise distribution of patients

| Initial fracture type | Number of patients | Percentage |
|-----------------------|--------------------|------------|
| Closed                | 16                 | 80.0       |
| Open                  | 4                  | 20.0       |
| Total                 | 20                 | 100.0      |

**Table 5:** Distribution of patients according to type on nonunion of bone

| Type on nonunion | Number of patients | Percentage |
|------------------|--------------------|------------|
| Septic           | 14                 | 70.0       |
| Aseptic          | 6                  | 30.0       |
| Total            | 20                 | 100.0      |

**Table 6:** Corticotomy wise distribution of patients

| Corticotomy | Number of patients | Percentage |
|-------------|--------------------|------------|
| Yes         | 8                  | 40.0       |
| No          | 12                 | 60.0       |
| Total       | 20                 | 100.0      |

**Table 7:** Type of treatment modality wise distribution of patients

| Type of treatment modality | Number of patients | Percentage |
|----------------------------|--------------------|------------|
| Compression                | 12                 | 60.0       |
| Distraction with compression| 8                  | 40.0       |
| Total                      | 20                 | 100.0      |

**Table 8:** Average time of union wise distribution of patients

| Time of union in wks. | Number of patients | Percentage |
|-----------------------|--------------------|------------|
| 30-36 weeks           | 15                 | 75.0       |
| 37-50 weeks           | 4                  | 20.0       |
| >50 weeks             | 1                  | 5.0        |
| Total                 | 20                 | 100.0      |
| Mean ± SD             | 37.4 ± 5.83        |            |

**Table 9:** Distribution of patients according to long bone union results as per ASAMI scoring

| Long bone union results (as per ASAMI Scoring) | Number of patients | Percentage |
|-----------------------------------------------|--------------------|------------|
| Excellent                                     | 11                 | 55.0       |
| Good                                          | 4                  | 20.0       |
| Fair                                          | 3                  | 15.0       |
| Poor                                          | 2                  | 10.0       |
| Total                                         | 20                 | 100.0      |

**Table 10:** Distribution of patients according to functional outcome of the study

| Functional outcome (ASAMI Scoring categories) | Number of patients | Percentage |
|-----------------------------------------------|--------------------|------------|
| Excellent                                     | 9                  | 45.0       |
| Good                                          | 8                  | 40.0       |
| Fair                                          | 1                  | 5.0        |
| Poor                                          | 2                  | 10.0       |
| Total                                         | 20                 | 100.0      |

**Table 11:** Complications wise distribution of patients

| Complications | Number of patients | Percentage |
|---------------|--------------------|------------|
| Pin tract infection | 4              | 20.0       |
| Knee stiffness     | 3                | 15.0       |
| Limb length discrepancy | 1             | 5.0        |
| No complications  | 12                | 60.0       |
| Total            | 20                | 100.0      |

In the 18 months of study period we could enrol 20 patients who satisfied our inclusion criteria. Of these 20 patients, there were 90% (n = 18) males and 10% (n = 2) females (table 2). There was a preponderance of right sidedness of the fracture non-union at (table 3)70% (n = 14) and left sidedness at 30% (n=6), 20 non-union of fracture of long bones, 13 (65.0%) of patient’s bone involved was tibia, 7 (35.0%) of patients bone involved was femur, among these 20 cases the primary fracture was a closed fracture non-union in 80% (n =16) and only 20%(n=4) were open (table 4). Again majority of the injuries 70% (n=14) were as a result of road traffic accident. In the study, maximum number 9 (45.0%) of patients initial mode of treatment was IMIL, followed by 6 (30.0%) of patients initial mode of treatment was plate.
In our Study we observed, maximum number 14 (70.0%) of patients type on non-union of bone was septic and 6 (30.0%) of patients type on non-union of bone was aseptic(table 5). And only 9 (45.0%) of patients had done bone grafting.

Out of 20 cases 12 (60.0%) of patients type of treatment modality was compression and 8 (40.0%) of patients type of treatment modality was distraction with compression(table 7). Study reveals that, maximum number of patients 15 (75.0%) were taken the average time of union was 30-36 weeks, followed by 4 (20.0%) of patients were taken the average time of union was 37.50 weeks(table 8). Study reveals that, the long bone union results based on ASAMI Scoring; 11 (55.0%) of patients long bone union was Excellent, 4 (20.0%) of patients long bone union was Good, 3 (15.0%) of patients long bone union was Fair and 2 (10.0%) of patients long bone union was Poor (table 8). During course of study 12 (60.0%) patients doesn’t have any complications and 8 (40.0%) of patients had the complications, out of them 4 (20.0%) of patients had the complication of pin tract infection for which regular dressing with povidine iodine and care was taken shanz pin not to get loosened, 3 (15.0%) of patients had the complication of knee stiffness these patients were allowed for regular knee physiotherapy and patient were thought about knee exercise regularly to be done in home and 1 (5.0%) of patients had complication of limb length discrepancy (table 11) as patient had early weight bearing for which patient was readmitted and metaphyseal corticotomy was done and limb length was assessed.

Discussion
Fractures of long bones have increased due to rise in road traffic accidents. Non-union is a difficult clinical problem it may have a devastating effect on patient’s social and financial state, these fractures in many instances, go for complex non-unions, some requiring prolonged treatment and sometimes even multiple surgeries. These patients are usually operated upon several times either to gain stabilisation and healing. In the instance of the original fracture being open, the chances are that we have to deal with an infective non-union. Indolent infection are almost invariably present also with other complications such as deformity, limb shortening, adjacent joint stiffness, disuse atrophy of the muscles and disuse osteoporosis of the injured bone.

Ilizarov distraction osteogenesis is commonly used for managing complex non-union of long bone fractures associated with large defect and infection. \[1, 10-12\]

But the disadvantages in it lie with the fact that they are cumbersome heavy and complicated, from the patients point of view \[13\]. Ilizarov technique has been tempered by its complexity and technical difficulty, the commitment of time and resources required for good result and the potential for numerous complications.

LRS is uniplanar dynamic external fixator that is light weight, has short learning curve and is based on same basic principle of Ilizarov. It provides stable external fixation with ability to do limb lengthening by bone transport. LRS is mechanically very stable because of the robust construct and variable spread of fixation by the use of sliding clamp. The limb reconstruction system allows also for dynamization of the fracture site with micro motion which is the essential component in the treatment of fracture non unions \[14\]. But it is difficult to correct three-dimensional deformities with uniplanar external fixator LRS unlike Ilizarov fixator.

Our study outcome was assessed with ASAMI scoring system. For 11 patients bone results were excellent, 4 patients good, 3 patient had fair result and 2 patient had poor result.

Regarding functional outcome 9 had excellent score, 8 good score and 1 patient had poor but there were no failure cases. Comparisons of present study with other studies in the literature are given in table below.

| Bone results | Present study | Hashmi et al. \[15\] | Hiranya et al. \[16\] | Nirup et al. \[17\] |
|--------------|---------------|----------------|----------------|----------------|
| Excellent    | N %           | N %           | N %           | N %           |
| Good         | 11 55         | 67 61         | 22 79         | 12 35.2       |
| Fair         | 04 20         | 38 35         | 03 11         | 17 50          |
| Poor         | 02 10         | 00 00         | 03 10         | 00 00          |

| Functional results | Present study | Hashmi et al. \[15\] | Hiranya et al. \[16\] | Nirup et al. \[17\] |
|--------------------|---------------|----------------|----------------|----------------|
| Excellent          | N %           | N %           | N %           | N %           |
| Good               | 08 40         | 55 45         | 14 50         | 17 50          |
| Fair               | 01 05         | 04 03         | 00 00         | 02 5.8         |
| Poor               | 02 10         | 00 00         | 00 00         | 00 00          |
| Failure            | 00 00         | 05 05         | 03 10         | 00 00          |

Summary and Conclusion
Due to increased road traffic accidents and other domestic accidents causing long bone fracture leading to increased incidence of nonunion.\[1\] External fixators are the choice of treatment when the nonunion is associated with soft tissue loss and bone loss along with infection at the nonunion site. The innovation in the Advanced LRS has produced improved efficiency; increasing its ease of application in deformity correction, joint contracture and bone transport with short segments, it’s a type of advanced monoplanar external fixator with many benefits. Soft tissue procedures like skin grafting, myocutaneous, muscle pedicle flap repair can be easily accompanied with external fixator in position. Simultaneously it can be used for compression of the fracture gap or site and secondary limb lengthening by proximal corticotomy and compression and distraction techniques can be accompanied with the LRS external fixator to achieve union and eradication of infection.

To conclude, we included 20 patients of long bone nonunion treated with LRS, We are of the opinion that in nonunion with bone loss and in cases with extensive soft tissue damage, limb reconstruction system is a good choice to save the limb, achieve union and restore limb length. Patient can be allowed early weight bearing without any adverse effect on bone union, alignment and quality of regenerate. It is an alternative to Ilizarov fixation in management of complex nonunion of long bones.

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