Use of Limb Reconstruction External Fixator as a Definitive option in Management of Grade II and Grade III Compound Long Bone Fractures

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Abstract

Background: We intend to determine the utility of the limb reconstruction external fixator as a definitive tool in managing grade II and grade III compound long bone fractures.

Materials and Methods: All patients with Grade II and Grade III complex long bone fractures were evaluated clinically and radiologically before inclusion in this prospective observational cohort study. A minimum of 20 cases were studied after clearance from the Ethics Committee.

Results: In our study, there is a variable wound healing time, with 20% of patients getting their wound healed within 4 weeks and 80% of patients getting their wound healed within 12 weeks. The mean wound healing time was 9.45 ± 5.78 weeks. 18 patients (90%) in the study showed signs of radiological union with a radiographic union scale in tibial fracture score of 2 or 3. Mean bone union time was 18.11 ± 5.24 weeks after injury. According to the Association for the Study and Application of the Methods of Ilizarov (ASAMI) scoring system, the bone results were excellent in 14 (70%) patients, good in 3 (15%) patients, fair in 1 (5%) patient, and poor in 2 (10%) patients. The functional results as per the ASAMI scoring system were excellent in 13 (65%) patients, good in 6 (30%) patients, and poor in 1 (5%) patient. In our study, 11 patients did not encounter any complications. The common complication was pin tract infections. Limb shortening was observed in 45% of patients. 85% of patients had insignificant limb shortening and did not require a shoe raise.

Conclusion: In our study, we achieved excellent to good results in our series by using the limb reconstruction system type of external fixator with fracture union in all the patients in our study. Limb reconstruction external fixators can be used as definitive tools in managing grade II and grade III compound long bone fractures.

Keywords: Limb reconstruction external fixator, Grade II and grade III compound long bone fractures, Wound healing time, Association for the study and application of the methods of ilizarov scoring system, Complication.

Introduction

Gustilo and Anderson categorize compound fractures, associating grade III fractures with severe soft tissue damage, extensive contamination, and bone loss [1]. These grade III compound fractures are considered potentially life-threatening to the limb, presenting specific challenges related to soft tissue healing, infection, non-union, delayed union, and neurovascular involvement [2]. In India, over 4.5 million open fractures occur annually. The yearly rate of open fractures of long bones is estimated at 11.5/100,000 people, with 40% of these fractures affecting the lower limbs, particularly the tibial diaphysis [3]. Internal fixation is often not feasible in such cases and may result in chronic infections, fixation failure, and infected non-union [4]. Hence, we aimed to determine the utility of the limb reconstruction external fixator as a definitive tool in managing grade II and grade III compound long bone fractures in our study.

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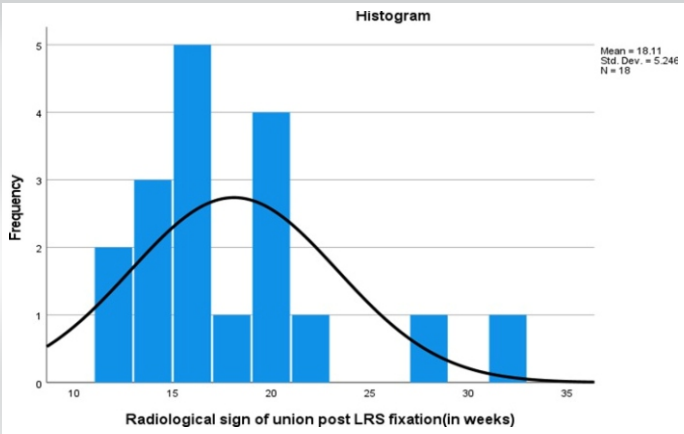

Figure 1: Radiological sign of union post-injury.

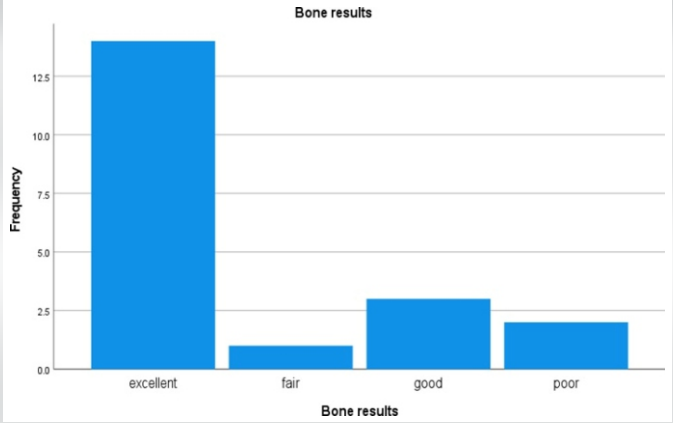

Figure 2: Association for the Study and Application of the Methods of Ilizarov – bone results.

Materials and Methods

All of the patients having Grade II and Grade III complex long bone fractures were evaluated clinically and radiologically before being included in this prospective observational cohort study.

Sample size

This pilot study had a convenience sample size of 20 patients, approved by the Institutional Ethics Committee. Since this was a preliminary observational study without a control arm, a formal sample size calculation was not performed.

Study period

This study includes patients from July 2018 to March 2020.

Participants

Inclusion criteria

Individuals with long bone fractures of grades II and III meet the inclusion criteria.

Exclusion criteria

Patients with immediate life-threatening conditions, closed fractures, and grade I open fractures.

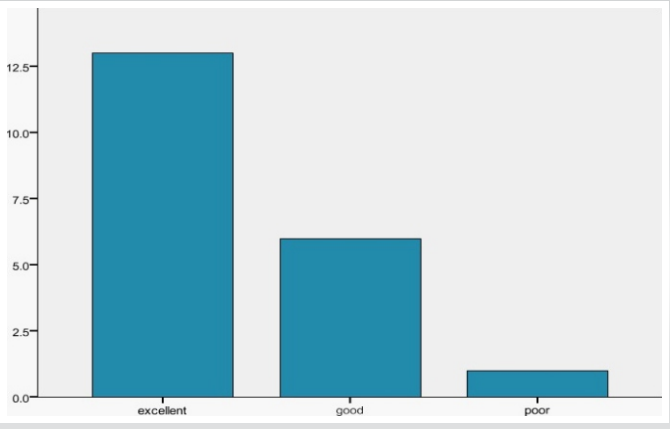

Figure 3: Association for the study and application of the methods of ilizarov—functional results.

Allocation and implementation

After obtaining consent for the study, every patient has to do a pre-intervention investigation profile.

Interventions

A thorough examination was done to rule out other systemic injuries, such as head injury and cardiorespiratory and abdominal status. Patients with hypovolemic shock were treated with intravenous (IV) fluids, such as plasma expanders, dextrose, normal saline, and Ringer's lactate solution. Immediate IV antibiotics and intramuscular tetanus toxoid and tetanus immunoglobulin were given. Meanwhile, airway and breathing were maintained.

Once the patient was hemodynamically stabilized, clinical evaluation and primary wound debridement were done in the operating theatre (OT) under anaesthesia. Wounds were graded according to Gustilo and Anderson's classification. Application of the Limb reconstruction system (LRS) external fixator was carried out in the major OT after investigations and after getting pre-anesthesia fitness for surgery.

Objectives

To study the use of the LRS external fixation for definitive fracture management from injury to soft tissue coverage and fracture healing.

Outcomes

1. Functional outcomes of the patients were evaluated using the Association for the Study and Application of the Methods of Ilizarov (ASAMI) scoring system.
2. The radiographic union scale in tibial fractures (RUST) checks how well the bone is healing by looking at callus formation in four areas using regular X-rays. Each cortex is scored 1–3, with a total score ranging from 4 (no healing) to 12 (complete union).

Table 1: Distribution of patients according to wound healing time

Weeks	Frequency	Percent	Cumulative percent
3	2	10	10
4	2	10	20
5	1	5	25
6	3	15	40
8	5	25	65
12	3	15	80
16	2	10	90
20	1	5	95
24	1	5	100
Total	20	100	

Table 2: Radiological sign of union post-injury

Weeks	Frequency	Percent
12	2	10
14	3	15
16	5	25
18	1	5
20	4	20
22	1	5
28	1	5
32	1	5
Total	18	90
Non union	2	10
Total	20	100

Observations and Results

Wound healing time

In our study, there is a variable wound healing time, with 20% of patients getting their wound healed within 4 weeks and 80% of patients getting their wound healed within 12 weeks. The mean wound healing time was 9.45 ± 5.78 weeks (Table 1).

Radiological sign of union post-injury

In our study, 18 out of 20 patients (90%) showed signs of radiological union with a score of 2 or 3. Mean bone union time was 18.11 ± 5.24 weeks after injury. Up to 80% of the patients showed radiological signs of union within 20 weeks; however, the rest of the 10% of patients had union after 20 weeks, while 10% of patients showed non-union (Table 2 and Fig. 1).

An independent t-test showed that patients with complications had a significantly longer mean union time (21.3 ± 4.5 weeks) compared to those without complications (16.4 ± 4.3 weeks, P = 0.035).

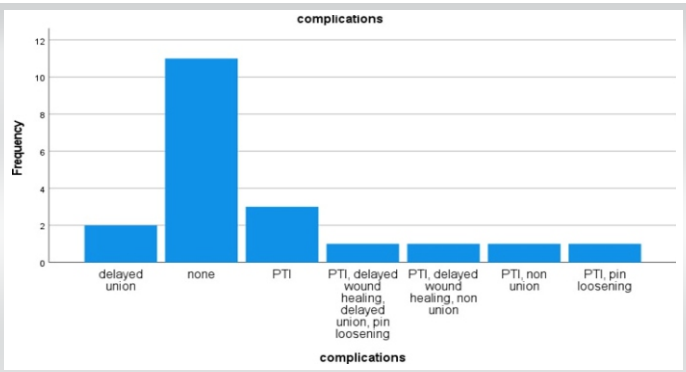

Figure 4: Complications.

Infection control after treatment

In our study, at the end, all of our patients were infection-free; thus, infection control was achieved in all 20 patients (100%).

ASAMI – bone results

Functional outcome was assessed as per ASAMI scoring and further divided into bone results and functional results.

In our study, as per the ASAMI scoring system, the bone results were excellent in 14 (70%) patients, good in 3 (15%) patients, fair in 1 (5%) patient, and poor in 2 (10%) patients (Table 3 and Fig. 2).

ASAMI – functional results

In our study, the functional results as per the ASAMI scoring system were excellent in 13 (65%) patients, good in 6 (30%) patients, and poor in 1 (5%) patient. A chi-square test showed a significant association between poor ASAMI outcomes and the presence of complications (P = 0.021) (Table 4 and Fig. 3).

Complications

In our study, 11 patients did not encounter any complications. The common complications were pin tract infections (in 3 patients, that is 15%) and delayed wound healing (in 2 patients, that is 10%). Pin tract infections were treated with oral antibiotics and modified accordingly after getting a culture and sensitivity report, and in two cases, pins were replaced at other sites because of pin loosening (10%). In 1 patient (5%), pin tract infection and nonunion were present. In 1 patient (5%), pin

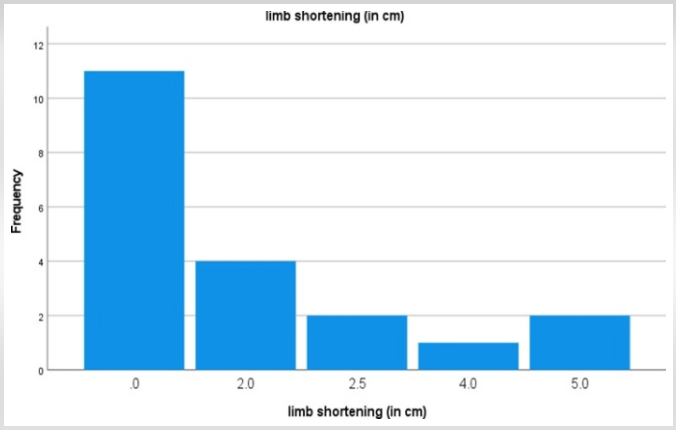

Figure 5: Limb shortening.

tract infection with delayed wound healing, delayed union, and pin loosening was present. In 1 patient (5%), a pin tract infection with delayed healing and nonunion was present (Table 5 and Fig. 4).

Limb shortening

In 11 cases, no shortening was seen, while in 9 cases, mb shortening was present, which was compensated to some extent by raised footwear.

Limb shortening was observed in 9 patients (45%), with a mean shortening of 1.35 ± 1.75 cm. 85% of patients had insignificant limb shortening and did not require a shoe raise (Table 6 and Fig. 5).

Discussion

Compound long bone fractures have been more common recently as a result of an increase in road traffic accidents related to vehicle traffic. According to estimates, there are 11.5 open fractures of long bones/100,000 persons each year, with 40% of these fractures occurring in the lower extremities, most frequently at the tibial diaphysis [5]. To recuperate or to get rid of the infection, these patients typically have multiple surgical treatments. Skin, muscle pedicle, or bone grafting may be necessary for this. Even after treatment, common side effects can include soft tissue atrophy, disuse osteoporosis, joint stiffness, deformity, and limb length disparity [6]. The limb reconstruction system is a telescopic apparatus that can be unlocked to provide load sharing or secured for rigid fixation. Because of its portability and ease of use for daily tasks, the fixator is more widely accepted despite its high cost. The unilateral nature of the pins makes it easier for patients to move their joints, giving it an advantage over the Ilizarov external fixator. Because of the device's stiff structure, weight bearing can begin early. To treat nonunion, it enables the dynamization of the fracture site [7].

Table 4: ASAMI – functional results

Functional results	Frequency	Percent	Valid percent	Cumulative percent
Excellent	13	65	65	65
Good	6	30	30	95
Poor	1	5	5	100
TOTAL	20	100	100	

ASAMI: Association for the study and application of the methods of ilizarov

Table 3: ASAMI – bone results

Bone results	Frequency	Percent	Valid percent	Cumulative percent
Excellent	14	70	70	70
Fair	1	5	5	75
Good	3	15	15	90
Poor	2	10	10	100
Total	20	100	100	

ASAMI: Association for the study and application of the methods of ilizarov

Twenty percent of the patients in our study had their wounds healed in 4 weeks, while 80% had them healed in 12 weeks. This indicates that wound healing times vary. The average time it took for wounds to heal was 9.45 ± 5.78 weeks. The amount of soft tissue damage determines how long it takes for a wound to heal. Variability arises from the type of open fracture, the patient's age and nutritional health, as well as other factors, including the type of flap reconstruction used, wound condition, and the presence of infection. The study's findings were comparable to those of Patil et al. and Cho et al. [8, 9, 10, 11].

Four weeks following discharge, an X-ray of the afflicted area was taken for our study, and the patient was requested to return every 2 weeks for follow-up. Patients who were infected or had significant soft tissue loss were admitted for longer. To facilitate fracture consolidation later on, LRS was dynamicized, and the patient was allowed to bear their entire weight. The LRS was taken out once the fracture had hardened. Radiologically, fracture union was rated with an RUST score of 2 or 3, which is similar to the study of Gokul Nath, which had a mean RUST score of 2.6 out of 3 [12]. Ajmera et al., Pal et al., and Mahajan and Mangukiya conducted investigations that were similar to the mean period taken for radiological evidence of union, which was 18.11 ± 5.24 weeks. The previous union was attributed to the Schanz pin's wide diameter, tapering shape, and low pitch, which allowed it to hold the cortical bone more securely with each turn [13, 14, 15].

The ASAMI grading system was used to assess how well the treatment worked, dividing the results into two groups: bone results and functional results. According to the ASAMI score, 14 patients (70%) in our study had outstanding bone results, three

Table 5: Complications

Complications	Frequency	Percent	Valid percent	Cumulative percent
Delayed union	2	10	10	10
None	11	55	55	65
PTI	3	15	15	80
PTI, delayed wound healing, delayed union, pin loosening	1	5	5	85
PTI, delayed wound healing, non-union	1	5	5	90
PTI, non union	1	5	5	95
PTI, pin loosening	1	5	5	100
Total	20	100	100	

PTI: Pin tract infection

patients (15%) had good bony outcomes, one patient (5%) had acceptable bone outcomes, and two patients (10%) had bad bone outcomes. The findings of Bony's study were similar to those of Ajmera et al. and Mahajan and Mangukiya [13, 14]. Thirteen patients (65%) in our study had outstanding functional outcomes, six patients (30%) had good functional outcomes, and one patient (5%) had poor functional outcomes based on their ASAMI score. These findings are similar to the functional outcomes of Pal et al. (75%) and Mahajan and Mangukiya (80%) [14, 15].

Pin tract infection was the most frequent complication in our study, occurring in 7 patients (35%), and was similarly the most prevalent in Ajmera et al. (20%) [13]. In two individuals, pin loosening was discovered. 15% of the cases experienced a delay in healing, which backs up what Ajmera et al. and Tekin et al. found: using LRS leads to fewer delays in healing or nonhealing [13, 16].

Therefore, LRS has shown itself to be a valuable technique in our study for the primary and conclusive management of compound long bone fractures. Our findings contrast with those of Aslan et al. [17], who conducted a retrospective study involving 19 patients and found that internal fixation /intramedullary nailing yielded better results than external fixation (Ilizarov) for managing open fractures. This might be due to the cumbersome and static fixation by the Ilizarov method.

Gill et al. [18] used a step-by-step surgical approach where they first applied external fixation to treat open grade III fractures, and then after 2 weeks, they performed definitive tibial interlocking. Similar to our findings, union was attained in 92% of Grade IIIb fracture cases, with an average union length of 24 weeks. In addition, three of the 84 patients had nonunion, six needed dynamization, and fourteen needed more treatments to achieve bony union. Therefore, a single-stage treatment employing LRS as a final method for fixing grade II and III compound long bone fractures can be used to minimize the time, complexity, cost load, and complications associated with numerous surgeries.

Table 6: Limb shortening

Limb shortening (in cm)	Frequency	Percent	Valid percent	Cumulative percent
0	11	55	55	55
2	4	20	20	75
2.5	2	10	10	85
4	1	5	5	90
5	2	10	10	100
Total	20	100	100	

The study is limited by a small sample size, reducing statistical power and generalizability. The absence of a control group and its single-center design further limit comparative analysis and external validity. Short-term follow-up prevented the assessment of long-term outcomes, such as refracture or hardware failure. In addition, the use of subjective scoring systems introduces potential observer bias. Future multicenter studies with larger cohorts and longer follow-up are recommended to validate these findings.

Limitations of our study include a small sample size, pilot nature of the study, the lack of a control group, single-center scope, and short-term follow-up, restricting generalizability and long-term outcome assessment. ASAMI scores without blinded assessment may have introduced observer bias and that future studies should incorporate validated patient-reported outcome measures, such as EQ-5D or SF-36, cost-effectiveness analyses, and standardized definitions (e.g., "insignificant limb shortening" defined as <2 cm). Other limitations include the lack of standardized soft-tissue management protocols, detailed infection control measures, and structured physiotherapy regimens in our study. Subgroup analyses (e.g., by fracture grade, comorbidities) were not feasible due to the limited sample and recommend larger multicenter studies with longer follow-up for more robust conclusions.

Conclusion

Based on the outstanding to good results from our series using the LRS type of external fixator, which achieved fracture union in all study patients, we recommend external fixators as the preferred method for fixing open tibia fractures, especially in cases of comminuted and severe Gustilo-Anderson type III injuries. Efficient ways to manage infection include proper primary wound debridement within 24 h and fracture repair with an LRS-type external fixator as soon as feasible after ruling out other life-threatening disorders. One final, cost-effective procedure that can also be employed for bone lengthening and transportation is fixation using LRS. By lowering hospital stays and associated costs, LRS saves patients' time.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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