



COMPARATIVE EVALUATION OF FUNCTIONAL OUTCOMES IN COMPLICATED TIBIAL DIAPHYSEAL FRACTURES: ILIZAROV TECHNIQUE VS. LIMB RECONSTRUCTION SYSTEM

Orthopaedics

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ABSTRACT

Background: Tibial diaphyseal fractures present significant challenges in orthopedic trauma care, especially when complicated by non-union, soft tissue damage, or infection. External fixators, including the Ilizarov technique and Limb Reconstruction System (LRS), are commonly employed to manage these fractures, but their comparative effectiveness in terms of functional outcomes and complications remains underexplored. **Aims & Objectives:** This study aims to compare the functional outcomes and complications between the Ilizarov method and LRS in managing complex tibial diaphyseal fractures, focusing on union rates, clinical outcomes, and associated complications. **Methods:** A total of 30 patients with complicated tibial diaphyseal fractures were included in this prospective and retrospective study conducted from February 2023 to August 2024. Fifteen patients were treated using the Ilizarov method, and 15 received LRS. Functional outcomes were assessed using Tucker's and Johner & Wruh's criteria, and radiological outcomes were evaluated using Fernandez-Estev grading. Complications, including pin tract infections, were recorded using the Checketts-Otterburn classification. Statistical analysis was performed using SPSS, with significance set at $p < 0.05$. **Results:** LRS showed significantly better clinical outcomes, with 100% of patients achieving good Tucker's criteria by 12 months, compared to 26.67% in the Ilizarov group. Radiological union was also superior in the LRS group, with 53.34% achieving Grade 5 union by 12 months, compared to 26.66% in the Ilizarov group. Complications like ankle stiffness and pin tract infections were more common in the Ilizarov group. **Conclusions:** LRS offers better functional and radiological outcomes compared to the Ilizarov method in managing complex tibial fractures, with fewer complications.

KEYWORDS

Tibial fractures; Ilizarov method; Limb Reconstruction System; Tucker's criteria; radiological union.

INTRODUCTION

Tibial diaphyseal fractures, involving the shaft of the tibia, are known to present significant challenges in orthopedic trauma management. These fractures are often characterized by complex morphological patterns such as displacement and comminution, which lead to reduced bony contact and disruption of blood supply, thereby compromising bone healing^{1,2}. The presence of complications like non-union, delayed union, and soft tissue damage further exacerbates the healing process, particularly in open fractures where infection risk is higher^{3,4}. To address these multifaceted challenges, advanced techniques are necessary to promote effective healing while maintaining alignment, length, and function of the limb.⁵

The Ilizarov technique, based on the principle of distraction osteogenesis, has emerged as a transformative method in managing complex tibial fractures. This technique stimulates new bone formation through the gradual separation of bony fragments, promoting both bone and soft tissue regeneration.^{6,7} Conversely, the Limb Reconstruction System (LRS), a simpler external fixator, provides biomechanical stability while allowing for distraction, compression, and stabilization, making it a widely used tool in the management of non-union cases.⁸

This study aims to compare the functional outcomes of the Ilizarov technique and LRS in the management of complicated diaphyseal fractures of the tibia. By evaluating union rates, complications, and overall limb functionality, this research intends to provide critical insights into the relative strengths and limitations of both approaches, ultimately guiding clinical decision-making to improve patient outcomes in orthopedic care.

MATERIALS AND METHODS

This is a retrospective and prospective study conducted from February 2023 to August 2024 at the Department of Orthopaedics, CSS Hospital, Subharti Medical College, Meerut. The study included patients of both genders with complicated diaphyseal fractures of the tibia. All patients provided informed consent before participation, and ethical approval was obtained from the Institutional Ethical Committee of CSS Hospital.

The inclusion criteria encompassed non-united diaphyseal fractures, infected non-union of tibia fractures, severely comminuted fractures, and diaphyseal fractures with soft tissue compromise (Gustillo-Anderson Type 3B). Patients with previously failed treatments of tibial fractures were also included. Exclusion criteria were fractures associated with acute vascular injury, compartment syndrome, or patients who refused to provide consent.

A total of 30 patients were sequentially recruited based on eligibility criteria. Each patient underwent a thorough clinical and radiological evaluation pre-operatively, including assessments of the range of motion (ROM) of adjacent joints, limb shortening, bone defects, fracture site angulation (CORA), and complications such as deformity and pin tract infection. Surgical interventions included either the Ilizarov method or Limb Reconstruction System (LRS), depending on the patient's condition.

Post-operative follow-ups were conducted at 1, 3, 6, 9, and 12 months to monitor clinical outcomes such as joint mobility, gait, and bone healing, alongside radiological assessments based on Fernandez-Estev grading for fracture union. Complications, including joint stiffness and infections, were recorded using the Checketts-Otterburn Classification for pin tract infections.

Data were statistically analyzed using SPSS version 22.0, and results were expressed as means and standard deviations. A p-value of < 0.05 was considered statistically significant.

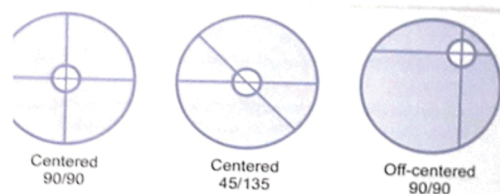


Figure – Wire Configuration

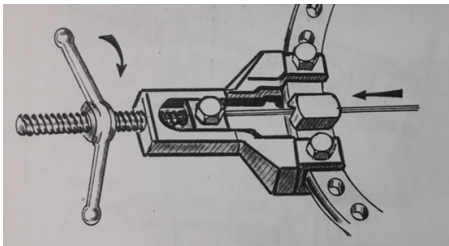


Figure -Wire Tensioner



Figure - ILIZAROV Ring Fixation for infected Non-Union



Figure - Limb Reconstruction System in Tibia

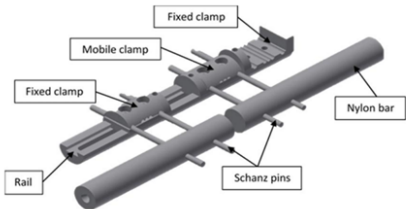
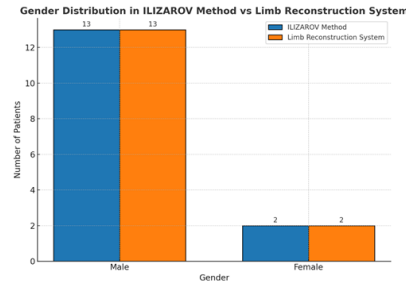


Figure - Parts of LRS Fixator

RESULTS

Table 1 Age and Gender Distribution in Patients Undergoing ILIZAROV Method vs. Limb Reconstruction System

Variable	ILIZAROV Method (N=15)	Limb Reconstruction System (N=15)	Total (N=30)	P Value
Age (Mean ± SD)	33.13 ± 7.55	32.06 ± 6.87	-	0.184
Male	13 (86.66%)	13 (86.66%)	26 (86.66%)	0.161
Female	2 (13.34%)	2 (13.34%)	4 (13.34%)	-



This table summarizes the age and gender distribution of patients treated with the ILIZAROV method and Limb Reconstruction System. The average age in both groups was comparable, and the gender distribution showed a higher proportion of male patients in both groups, with no significant difference observed between them.

Table 2 Evaluation of Tucker's and Johner & Wruh's Criteria in ILIZAROV vs Limb Reconstruction System

Time Point	Tucker's Criteria (ILIZAROV)	Tucker's Criteria (LRS)	Johner & Wruh's Criteria (ILIZAROV)	Johner & Wruh's Criteria (LRS)	P Value
Pre-Operative	Poor: 15 (100%)	Poor: 15 (100%)	Fair: 15 (100%)	Fair: 15 (100%)	1.00
1 Month	Fair: 7 (46.66%), Poor: 8 (53.34%)	Good: 14 (93.33%), Poor: 1 (6.67%)	Fair: 15 (100%)	Fair: 13 (86.67%), Good: 2 (13.33%)	0.001*
3 Months	Good: 1 (6.67%), Fair: 8 (53.33%), Poor: 6 (40%)	Good: 10 (66.66%), Fair: 5 (33.34%)	Good: 15 (100%)	Good: 14 (93.33%), Fair: 1 (6.67%)	0.001*
6 Months	Good: 1 (6.67%), Fair: 14 (93.33%)	Good: 12 (80%), Fair: 3 (20%)	Good: 15 (100%)	Good: 15 (100%)	0.001*
12 Months	Good: 4 (26.67%), Fair: 11 (73.33%)	Good: 15 (100%)	Excellent: 4 (26.67%), Good: 11 (73.33%)	Excellent: 8 (53.34%), Good: 7 (46.66%)	0.001*

This table provides a comprehensive comparison between the ILIZAROV method and Limb Reconstruction System (LRS) using Tucker's and Johner & Wruh's criteria. The LRS consistently showed better outcomes, especially at the 12-month follow-up, where 100% of patients in the LRS group had good results according to Tucker's criteria and 53.34% had excellent results according to Johner & Wruh's criteria.

Table 3 Comparison of Radiological Union using Fernandez-Estev Grading Between Ilizarov Method and Limb Reconstruction System

Time Period	Grade	Ilizarov Method (N=15)	Limb Reconstruction System (N=15)	P-value (Kruskal Wallis Test)
Pre-operative	Grade 1	15 (100%)	15 (100%)	1.00
1 month	Grade 2	15 (100%)	15 (100%)	1.00
3 months	Grade 3	15 (100%)	15 (100%)	1.00
6 months	Grade 3	15 (100%)	15 (100%)	1.00
12 months	Grade 4	11 (73.34%)	7 (46.66%)	0.034*
12 months	Grade 5	4 (26.66%)	8 (53.34%)	

This table compares the radiological union outcomes between the Ilizarov method and the Limb Reconstruction System using the Fernandez-Estev grading system. At 12 months, significant differences were observed in Grade 4 and Grade 5 radiological unions, with the Limb Reconstruction System showing a higher proportion of Grade 5 union compared to the Ilizarov method (P = 0.034* for Grade 4).

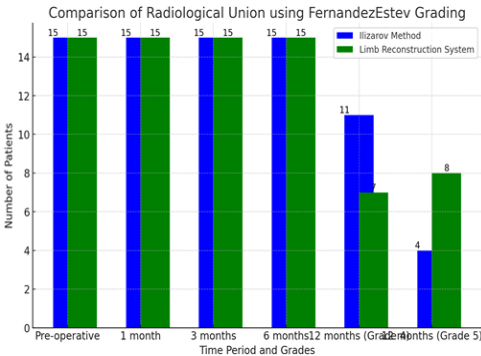
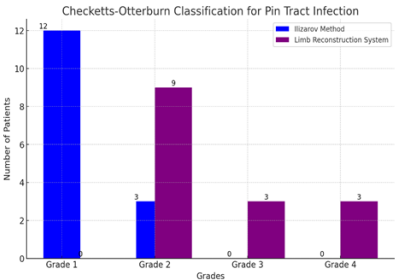


Table 4 Checketts-Otterburn Classification for Pin Tract Infection: Comparison between Ilizarov Method and Limb Reconstruction System

Grade	Ilizarov Method (N=15)	Limb Reconstruction System (N=15)	P-value (Chi square test)
Grade 1	12 (80%)	-	0.0482*
Grade 2	3 (20%)	9 (60%)	-
Grade 3	-	3 (20%)	-
Grade 4	-	3 (20%)	-

This table compares the distribution of pin tract infections classified by the Checketts-Otterburn system in patients treated with the Ilizarov method and the Limb Reconstruction System. Grade 1 infections were more common in the Ilizarov group (80%), while higher-grade infections (Grade 2, 3, and 4) were observed more frequently in the Limb Reconstruction System group. The difference in Grade 1 infections was statistically significant with a P-value of 0.0482



Illustrative Cases

Case I – This is a case of Bhavna Sharma, a 39-year-old homemaker, who presented with a 3-month history of pain and deformity in her right leg and ankle.

Variables	Pre-operative	Post-operative 1 Month	Post-operative 3 Months	Post-operative 6 Months	Post-operative 12 Months
Tucker's criteria	POOR	POOR	POOR	FAIR	FAIR
John and Wruh's criteria	FAIR	FAIR	GOOD	GOOD	GOOD
Fernandez-Estev grading	GRADE 1	GRADE 2	GRADE 3	GRADE 3	GRADE 4
Deformity/Joint stiffness/shortening	ANKLE STIFFNESS	ANKLE STIFFNESS	ANKLE STIFFNESS	ANKLE STIFFNESS	ANKLE STIFFNESS
Checketts-Otterburn Classification for Pin Infection	NONE	NONE	GRADE 2	GRADE 2	GRADE 2

This data shows that the progression of clinical and radiological criteria over time. Tucker's and John and Wruh's criteria show improvements postoperatively, particularly at the 6 and 12-month marks. Similarly, radiological union, as measured by Fernandez-Estev grading, demonstrated a significant progression from Grade 1 preoperatively to Grade 4 by 12 months. Ankle stiffness persisted postoperatively, along with some patients showing Grade 2 pin tract infections.



Figure 1 – Clinical Picture



Figure 2– Clinical Picture with Knee bending



Figure 3 - Post operative weight bearing using Patellar tendon bearing cast

Case II – This is an another case of Mr. Kaiyum, a 40-year-old driver who had right leg pain, deformity, weight-bearing inability, and a discharging sinus for 8 months, managed with open reduction external fixation, corticotomy, and bone transport using the Limb Reconstruction System

Variables	Pre-operative	Post-operative 1 Month	Post-operative 3 Months	Post-operative 6 Months	Post-operative 12 Months
Tucker's criteria	POOR	GOOD	FAIR	GOOD	GOOD
John and Wruh's criteria	FAIR	FAIR	GOOD	GOOD	EXCELLENT
Fernandez-Estev grading	GRADE 1	GRADE 2	GRADE 3	GRADE 3	GRADE 5
Deformity/Joint stiffness/shortening	NONE	NONE	GRADE 2	GRADE 2	GRADE 2
Checketts-Otterburn Classification for Pin Infection	NONE	NONE	NONE	NONE	NONE

This data illustrates that the progression of clinical and radiological outcomes over the pre- and post-operative periods. Tucker's and John and Wruh's criteria showed significant improvements from pre-operative poor and fair ratings to good and excellent outcomes at 12 months. Radiological union, based on Fernandez-Estev grading, improved from Grade 1 pre-operatively to Grade 5 at 12 months. The complication of ankle stiffness was noted alongside occasional Grade 2 pin tract infections.



Figure 4 - Complete Range of Motion with LRS fixator**Figure 5 - Weight bearing with LRS fixator**

DISCUSSION

Tibial fractures, particularly those caused by high-velocity trauma and road traffic accidents, present a significant challenge in orthopedic trauma care. Various treatment options, including external fixators like the Limb Reconstruction System (LRS) and Ilizarov method, are commonly used to manage complex open fractures. While intramedullary nailing carries a higher risk of deep infection and nonunion, external fixators offer better soft tissue management. The LRS allows for immediate weight-bearing, similar to intramedullary fixation, and facilitates limb preservation, although it can lead to complications like pin loosening and pin tract infections.

Clinical outcomes based on Tucker's criteria showed that the LRS group consistently outperformed the Ilizarov method. At 1 month, 93.33% of patients in the LRS group had good Tucker's outcomes, compared to none in the Ilizarov group. By 12 months, 100% of LRS patients achieved good results, while only 26.67% of Ilizarov patients showed the same. Studies by **CP Pal et al.⁹** and **Lone AH et al.¹⁰** found similarly positive outcomes for LRS-treated patients, with 75% and 60% achieving good functional results, respectively. In contrast, **Wani et al.¹¹** reported 80% of Ilizarov-treated patients with excellent outcomes but no poor results.

Radiological union, assessed using Fernandez-Estev grading, was comparable between the two groups until 6 months. However, by 12 months, 53.34% of LRS patients achieved excellent radiological union, compared to 26.66% of Ilizarov patients. These results are in line with **CP Pal et al.⁹**, where 68.75% of LRS patients showed radiological union within 5-8 months, and **Lone AH et al.¹⁰**, who reported 75% of LRS patients achieving excellent radiological outcomes, compared to 55% in the Ilizarov group.

Regarding complications, 20% of LRS patients had ankle stiffness, compared to 40% of those in the Ilizarov group, and knee stiffness was more common in the Ilizarov group. Pin tract infections were also lower in the LRS group, with no cases of Grade 4 infections, while 20% of Ilizarov patients developed this complication. These findings are consistent with studies like that of **CP Pal et al.⁹**, which reported higher complication rates, including pin tract infections, in Ilizarov-treated patients. Overall, LRS provides better clinical, radiological, and functional outcomes with fewer complications compared to the Ilizarov method.

Recommendations

Further studies with larger sample sizes and longer follow-up periods are recommended to validate the findings and assess the long-term outcomes of both the Ilizarov method and LRS. Additionally, exploring patient-reported outcomes and quality of life measures could provide a more comprehensive evaluation of functional recovery.

Limitations

This study is limited by its relatively small sample size and short follow-up duration, which may affect the generalizability of the results. Additionally, the retrospective nature of part of the data may

introduce bias in patient selection and outcome reporting.

CONCLUSION

The Limb Reconstruction System (LRS) should be considered for managing complex tibial fractures. There were no significant differences in pre-operative factors like age and gender between patients treated with the Ilizarov method and LRS. However, LRS showed better clinical outcomes, particularly in Tucker's and Johner & Wruh's criteria. Complications such as ankle stiffness and higher-grade pin tract infections were more frequent in the Ilizarov group. The benefits of LRS, including facilitating radiological union and improved functional outcomes, outweigh its minor complications.

Conflict of Interest: The authors declare no conflicts of interest.

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Consent: Written consent from participants has been obtained and preserved.

Ethical Approval: Ethical approval was obtained and documented as per institutional guidelines.

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