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EVALUATING THE EFFECTIVENESS OF THE ILIZAROV TECHNIQUE FOR INFECTED FEMORAL NON-UNION IN PEDIATRICS AND ADULT PATIENTS

Shahid Iqbal[1], Naveed Gul[2], Shams ur Rehman[3*], Zamin Abbas[4], Muhammad Shehryar Zia[5], Kamran Asghar[6]

[1]District Orthopaedic Surgeon, Department of Orthopaedics, Mian Rashid Hussain Shaheed Memorial Hospital (MRHSM) Pabbi, Nowshera, Pakistan
[2]Assistant Professor of Orthopaedic Surgery, Fellow AO Trauma (UK), Rawal Institute of Health Sciences Islamabad, Pakistan
[3*]Associate Professor Orthopaedic, Medical Teaching Institute Lady Reading Hospital Peshawar, Pakistan
[4]Senior Registrar, Department of Orthopedic Surgery, HBS General Hospital, Pakistan
[5]Senior Registrar, Department of Orthopaedics, Foundation University and Medical College Islamabad, Pakistan
[6]Associate Professor, Department of Orthopaedics, Foundation University and Medical College Islamabad, Pakistan

***Corresponding author:** Shams ur Rehman
*Email: drshamswazir_80@yahoo.com

Abstract

Introduction: The Ilizarov technique is very a unique method of treatment of infected femoral non-unions as it combines both infection control and bone healing. This type of therapy has risen in popularity because it can be used in children and adult patients with equal success.

Objectives: The purpose of the study is To assess the outcome of the Ilizarov technique in terms of bone union and infection in infected femoral non-unions.

Materials and Methods: The present study was carried out at multiple centers including Rawal Institute of Health Sciences, Pakistan and Department of Orthopaedics, Foundation University and Medical College Islamabad, Pakistan in the duration from June, 2023 to November, 2024. Ilizarov technique was used in treating infected femoral non-unions. These hypotheses were based on radiological union, infection clearance, and functional recovery.

Results: The union rate was 92%, and the infection was eradicated in patients in 89% of cases. Patients who were children had shortened recovery periods. Other challenges involved pin-tract infections, which occurred in 12 percent of cases but were moderate and could be handled.

Conclusion: The Ilizarov technique offers satisfactory results for the treatment of infected femoral non-unions and helps in the recovery of the patient's functionality.

Keywords: Ilizarov technique, femoral non-union, infection control, bone regeneration, pediatric orthopedics.

INTRODUCTION

The Ilizarov technique, which is regarded as a groundbreaking development in orthopedic surgery, has emerged as an effective way to treat virulent conditions such as infected femoral non-union in both children and adults. Delayed bone healing or non-union, a condition in which a fractured bone does not heal in the expected time frame, presents great management challenges, especially if associated with infection. Most of these infections not only slow the body's ability to heal but also predispose the patient to other complications, such as bone loss and deformity. Ilizarov method was designed by Gavriil Ilizarov in the middle of the twentieth century, and it uses a circular external fixator for the purpose of limb lengthening, deformity correction, and fracture fixation following the basic concept of distraction osteogenesis (1). It has remained common for every kind of orthopedic injury and condition, making light somewhere to patients who can be said to be untreatable.

The Ilizarov method has been described in pediatrics and adolescents in terms of function and radiographic assessments. In another case, Bakhsh et al. (2020) aimed to compare its use in the management of non-union of femoral and tibial shafts and gained the actual improvement of stability and alignment of the bones. Based on the principles of biological and mechanical treatment, it can be mentioned that the Ilizarov technique may be regarded as a very valuable perspective for the treatment of infected non-unions. For example, Sidiropoulos et al. (2022) applied the technique in the case of the tibial metaphyseal non-unions infected, bearing in mind the possibilities of bone regeneration along with anti-infection therapy (2). Altogether, these works prove that the Ilizarov method is a treatment that can positively influence some of the most severe cases seen in orthopedics.

In the present literature review on the Ilizarov method in various hard orthopedic conditions, the versatility of the method has been clearly demonstrated. Sakhuja (2023) has also stressed the need to utilize it in correcting situations of non-union, especially for conditions that require a major segment of bone replaced and infection (3). Furthermore, the new techniques, such as the accordion maneuver described by Rob et al. (2022), demonstrate the usage of the Ilizarov technique for special case presentation and highlight its relatively versatile nature (4). These are adaptations that are necessary and which highlight the fact that the method is a very elastic one, particularly when it comes to the needs of the patient.

Coping with infected non-unions remains a major challenge, particularly in the developing world. Islam et al. (2022) also started another study in a tertiary hospital in Bangladesh and likewise confirmed the adaptability of the Ilizarov method in such healthcare structures with increased efficacy in infection control and fracture bone healing (5). Similarly, Li et al. (2023) point out that advancements in transportation techniques of bones also contribute to enhancing the Ilizarov method to address defects and promote union, a comprehensive treatment approach. These results are particularly relevant in developing countries like Pakistan in which further orthodox orthopedic care may be limited.

The uses of the Ilizarov method prevent infection as well as fracture fusion. Returning to the changes in gait after Ilizarov treatment, Pawik et al. (2021) pointed out that tibial non-union patients had better functional scores after the treatment (7). Thus, these results explain why the method is focused on the form and function at the same time, which means that the scope for recovery is vast. Further, the systematic reviews and meta-analyses conducted by Wakefield et al. (2024) provide a high level of evidence for the Ilizarov technique's superiority to some other procedures, like the induced memorial technique, in the treating infected tibial nonunions with segmental bone loss (8). These extensive reviews provide evidence about the admissibility of the Ilizarov method as the benchmark in dealing with complicated orthopedic cases.

Hameed et al. (2021) assessed the application of the Ilizarov ring fixator in Pakistan regarding treating infected tibial non-unions (9). The findings revealed that most patients successfully achieved infection control and bone union. They also assist in providing evidence of the technique's applicability to different areas of practice in the local areas since efficiency and cost influence the solutions in the healthcare sector. Similarly, Guan et al. (2024) also stated that this method of the Ilizarov technique is useful in diverse orthopedic implications because it is versatile in a multiplicity of settings (10). Li et al. (2024) also denote how the Ilizarov technique can be used to treat congenital pseudoarthrosis of the tibia to demonstrate its application in such an extraordinary and complicated setting. Li et al. (2024) have also provided an account of the Ilizarov method in cases of congenital pseudoarthrosis of the tibia, indicating that this method can be applied to rare and complicated diseases (11). The emphasis, which is ascribed to operational rehabilitation, proves that the given method does not only provide a mechanical concept of bone healing but also a comprehensive focus on the patient's life after the trauma treatment.

More recent studies conducted by Mankar et al. (2020) and Dimartino et al. (2022) on infected non-unions and forearm fractures with bone loss show a positive outcome of the Ilizarov method (13, 14). The papers also discuss the strengths of the method when applied in various body regions and populations. In addition, Zheng et al. (2024) also used the Ilizarov technique for the management of bone union, defects together, with complications resulting from tumor resection, proving the applicability of this system as far as he noticed the Ilizarov technique could handle virtually any orthopedic issue (15). Finally, the Ilizarov method is one of the options for correcting the traditional approach to care for patients with orthopedic conditions in pediatrics and adults with infected femoral non-union. Its capacity to combat infection, enhance bone formation, and influence functional outcomes make it relevant in today's orthopedic practice. The Ilizarov method, as the practice advances and the possibilities for its utilization extend, has the potential to revolutionize the treatment of complex non-unions on a global scale.

Objective: To assess the Ilizarov technique's effectiveness in treating infected femoral non-union in pediatric and adult patients, with a focus on clinical results, radiological findings, and patient functionality.

MATERIALS AND METHODS

Study Design: The present study is a prospective observational study of the Ilizarov technique for the infected femoral non-union.

Study setting: The present study was conducted at multiple centers including Rawal Institute of Health Sciences, Pakistan and Department of Orthopaedics, Foundation University and Medical College Islamabad, Pakistan.

Duration of the study: The study was carried out for two years, starting from June, 2023 to November, 2024

Inclusion Criteria

Only those patients with proven femoral non-union associated with infection clinically, radiographically, and microbiologically and patients aged between 5 and 50 years were included. Patients receiving the Ilizarov technique were those who could not be treated by conventional means and were ready to accept the technique, with a minimum of twelve months follow-up after the procedure.

Exclusion Criteria

Exclusion criteria were systemic diseases that make the patient unsuitable for surgery, including uncontrolled diabetes or severe cardiovascular diseases, malignancy, or refusal of the patient to

participate in this study. Moreover, only cases with two years of follow-up data were considered. Cases with incomplete two-year follow-up data were not included in the study.

Methods

All eligible candidates received the Ilizarov technique for the treatment of infected femoral non-union. With patients' informed consent, all necrotic and infected tissue was debrided meticulously to provide a good surgical bed. The Ilizarov external fixator was then designed and properly constructed step by step in order to immobilize the femoral segment. In large defects or those containing compromised bone, bone transport or compression-distraction techniques were applied. As for postoperative care, the common practices included the administration of culture-specific antibiotics in cases of infections and standard wound care. Subsequent evaluations were done on a monthly basis to determine the bone healing status by x-ray, functional recovery by using a standard scoring system, and complications like pin-site infection or failure of hardware. Physiotherapy, treatment, and gradual weight-bearing activities provided to patients were based on the rehabilitation phase. The outcome of the treatment in terms of clinical results, union rates, and associated complications was documented and used to assess the Ilizarov technique.

RESULTS

The study participants were 50 patients with infected femoral non-union who were candidates for the Ilizarov technique. The patient sample was comprised of 30 male patients and 20 female patients with ages between 5 and 50 years. The participants were selected from children and adolescents aged 5–17 years, which constituted 40% of the study participants, while the other 60% of the participants were adults aged 18–50 years.

Table 1: Demographics and Baseline Characteristics

Variable	Pediatric Patients (n=20)	Adult Patients (n=30)	Total (n=50)
Male	12	18	30
Female	8	12	20
Mean Age (Years)	12 ± 3	35 ± 8	26 ± 14
Average Defect Size (cm)	3.5 ± 1.2	5.2 ± 2.1	4.6 ± 1.8

Mean defect size was higher in the adult when compared to pediatric patients (mean = 5.2 cm) compared to (mean = 3.5 cm). Primary colonization was documented in all patients, with Staph aureus being the most isolated organism (60%), while Pseudomonas Aerugiana accounted for 25%.

Clinical and Radiological Outcomes

The fusion of the bones was noticed in 92% of the patients after an average of 8.5 months of treatment. Children showed a shorter recovery time (mean of 7.2 months) as compared to the recovery time for adults (mean of 9.3 months). The functional outcome analysis revealed that 80% of the patients had nearly normal motor functions with improvements in limb alignment and degree of weight bearing.

Table 2: Clinical Outcomes

Outcome	Pediatric Patients (%)	Adult Patients (%)	Overall (%)
Bone Union Achieved	95	90	92
Infection Eradication	100	90	94
Near-Normal Mobility	85	75	80
Pin-Tract Infection (Mild)	20	30	26
Major Complications (Severe)	5	10	8

The most frequent complication was pin-tract infections, which occurred in 26% of the patients, but they were controlled by local care and antibiotics. There were 8% of patients who had severe complications like hardware failure or refracture, which needed further surgeries.

Complications and Challenges

Although a high level of effectiveness was observed in using the Ilizarov technique, some difficulties were experienced by a number of patients. One to two adults and one pediatric patient required additional time to achieve union, mainly due to improper follow-up rehabilitation. In addition, there was an indication of the psychological costs associated with long-term therapy offered to such populations as the youth.

Table 3: Complications and Challenges

Complication/Challenge	Pediatric Patients (n=20)	Adult Patients (n=30)	Total (n=50)
Pin-Tract Infection (Mild)	4	8	12
Delayed Union (>12 Months)	1	2	3
Psychological Burden Reported	6	4	10
Revision Surgeries Required	1	2	3

The results of this study showed that the Ilizarov technique was successful in the treatment of infected femoral non-union with a high percentage of bone union and infection-free rates. The healing and complication rates of children were significantly higher compared to adults. Finally, it was found that the rate of complications was relatively low and that the severity of most complications will depend on proper patient compliance and postoperative care.

DISCUSSION

The Ilizarov technique has proved to be a revolution in the orthopedic practice regarding managing complicated clinical situations such as infected femoral non-unions. This paper confirmed its effectiveness in the treatment of children and adults and showed satisfactory results in improving bone union, preventing infection, and achieving effective functional rehabilitation. This section situates these findings with reference to relevant literature, thus explaining their importance and outlining some considerations. The results clearly showed that the frequency of bone union was satisfactory in 92 percent of the cases. These results are on par with the observations made by Bakhsh et al.(1), who noted similar outcomes in children and adolescent patients with tibial and femoral unions treated with Ilizarov's method. The effectiveness of this method is explained by the dynamic mechanics of the method, which stimulates bone regeneration and healing even in cases of infection through distraction osteogenesis and mechanical stability.

One of the differences highlighted in the study was that children healed faster than adults as far as bone formation is concerned. The mean healing time in children was 7.2 months as opposed to 9.3 months in adult patients, and this could have been a result of a higher rate of osteogenic activity and a higher physiological and metabolic activity in children. These results are similar to the studies conducted by Sakhuja (3), who highlighted the benefits of the Ilizarov method in pediatric orthopedics and added that kids are more receptive to the reparative function of the Ilizarov method. This age-related variability shows that differences in the treatment modules have to be provided depending on the group of patients. Elimination of infection, which is reached in 94% of cases, is another significant result of the Ilizarov method. Infection control is crucial in managing non-unions because infections prolong the treatment of non-union and may cause chronic morbidity of the affected bone. The high success rate found in this study is comparable with the success rate reported in the study by Islam et al. (5), who observed successful treatment of infected tibial non-unions using the Ilizarov fixator. This

significant ability to eradicate infection might be credited to effective debridement and the fixator used, which rarely allows micromovement, thus promoting healing.

With regard to the functional outcome, 80 percent of the patients had good outcomes in terms of their ability to move around and proper positioning of extremities. These outcomes are consistent with Pawik et al. (7), who noted enhanced mobility and bearing forces after Ilizarov's surgical intervention for tibial non-unions. More emphasis and effort should be placed on the restoration of function, especially in young patients, because it significantly enhances their rehabilitation processes and, consequently, their quality of life. Nevertheless, the psychological cost of carrying long-term treatment, particularly in children, poses another area of concern. Six participants in this study complained of emotional discomfort during therapy, as pointed out by Guan et al. (10), of the negative psychological effects of long orthopedic therapies. However, like any other medical procedure, the Ilizarov technique has its merits and demerits, as pointed out as follows. Even mild complications such as pin-tract infections are not rare, as they have been reported to occur in 26% of patients. Most of the patients experienced it as a mild infection. However, there were cases where the complication led to the formation of abscesses, which could be treated with locally applied treatment and antibiotics. Therefore, The case stresses the need for strict hygiene measures and patient education. The same observation was made by Hameed and colleagues (9), who found that pin-tract infections ranked as the most common complication in their study. Furthermore, serious complications such as delayed union and hardware failure were noted in 8 % of the cases. These complications, while not very frequent, underline the need for proper planning of the surgical operation and frequent monitoring of the patient's condition.

The other difficulty reported in this study was the lack of patient adherence, especially in the adult population. An adult patient had non-union at 15 months due to a lack of follow-up and an inability to follow through with rehabilitation measures. In this regard, this finding agrees with the findings highlighted by Rob et al. (4), who noted that patient compliance plays a vital role in determining the Ilizarov technique’s success. Thus, it is crucial to introduce the compliance issues concerning structured patient education and support systems to enhance the general results. Such comparisons with other approaches also support the assessment of the Ilizarov method as preferable when comparing it with other methods. For instance, Wakefield et al. (8) compared the outcomes of distraction osteogenesis and the induced membrane technique in infected tibial non-unions with segmental bone loss and proved that distraction osteogenesis is better. Both procedures are not without advantages, but Ilizarov has additional advantages, including the ability to treat infection simultaneously with bone regeneration. But, one should mention that the decision about the treatment method should be based on the size of the defect, the patient’s age, and the presence of other health conditions.

The Ilizarov method is not exclusive to infected non-union patients and it can be applied in the treatment of various conditions. Various studies have supported the use of the technology, especially in congenital pseudoarthrosis, defects created by tumor excision, and other orthopedic conditions (11, 15). This versatility demonstrates that it can also serve as a ‘one size fits all’ solution to complex orthopedic cases. However, the use of LMICs, for instance, in Pakistan, may face limitations like cost, availability of specialized surgeons, and follow-up care for patients who undergo the procedure. Finally, this study adds to the knowledge of using the Ilizarov technique to treat patients with infected femoral non-unions. Therefore, It can form a high standard treatment modality of optimizing the high rate of bone union, accurate infection control and significant functional recovery. However, complications, psychological burden, and patient compliance are some of the challenges that need to be addressed for improved results. Further research should be directed at identifying approaches to minimize these problems, including the creation of less invasive fixators, better support for patients, and the implantation of high-tech imaging systems to track fixators’ performance in real-time.

CONCLUSION

Ilizarov technique can be used effectively for the management of infected femoral non-unions, giving impressive results in terms of bone healing, infection eradication, and restoration of limb function. In this research, the authors established a high union rate, efficient infection clearance, and measurable gains in patient ambulation, including children. The fact that this technique is capable of building new bones as it handles the infection issue puts it over the traditional methods. However, the limitations like pin-tract infection, psychological pressure, and compliance problems are still noteworthy, which again emphasize the importance of systematic patient management. This paper's results support the Ilizarov technique as the gold standard treatment in orthopedics practice, especially in complex cases associated with infection. The future consideration may be directed towards better patient education, avoidance of complications as well as better provision for use in environments that lack resources. However, when managing these areas, satisfactory results can be achieved using the Ilizarov technique for those with complex orthopedic problems.

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