

Functional and Radiological Outcomes of Proximal Tibial Fracture with Compromised Skin Condition Treated with Ilizarov External Fixator

Rahul Singh¹, Rupika Singh², Ruchika Singh³

¹Associate Professor, Department of Orthopedics, Mayo Institute of Medical Science, Gadia, Barabanki, UP

²Associate Professor, Department of Dermatology, Mayo Institute of Medical Science, Gadia, Barabanki, UP

³Associate Professor, Department of Radiology, Mayo Institute of Medical Science, Gadia, Barabanki, UP

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Corresponding Author: Dr. Ruchika Singh

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Abstract:

Background: Proximal tibial fractures, complex and biomechanically challenging, become even more formidable with compromised skin conditions. Traditional interventions face limitations in addressing severe soft tissue injuries. Recent advancements highlight the Ilizarov external fixator as a promising alternative, offering dynamic solutions for fractures and soft tissue aspects simultaneously. Despite its established efficacy, there's a gap in literature regarding its application in proximal tibial fractures with compromised skin conditions. This study aimed to assess Ilizarov's use in such fractures and related outcomes.

Methods: This prospective cohort study, conducted at a North Indian tertiary care center from July 2021 to June 2022, focused on patients with proximal tibial fractures treated with the Ilizarov external fixator. Ethical approval was obtained, and 56 eligible participants were consecutively enrolled. The intervention involved Ilizarov external fixator application within 24 hours of admission, tailored to fracture characteristics. Data collection included baseline demographics, intraoperative details, and follow-up assessments using Johner and Wruh's criteria. Statistical analyses employed SPSS version 20.0, presenting results with descriptive statistics and considering a p-value < 0.05 as significant.

Results: In our study, participants had a mean age of 41.72 years, with 73.2% males and 26.8% females. Comorbidities included diabetes mellitus (8.9%) and hypertension (21.4%). Road traffic accidents were the primary mode of injury (69.7%), followed by assault (16.1%) and falls from height (14.2%). Fractures were predominantly on the right side (62.5%), closed (75.0%), with Tscherne's Type 1, 2, and 3 fractures. Gustilo Anderson's classification revealed open fractures: Grade I (35.8%), Grade II (21.4%), Grade III A (21.4%), and Grade III B (21.4%). Fixator duration varied, with 44.6% <15 weeks, 33.9% 15-17 weeks, 16.1% 18-20 weeks, and 5.4% >20 weeks. The mean duration of hospital stay was 12.56 days. Pin tract infections (17.9%), knee stiffness (12.5%), and limb shortening (8.9%) constituted postoperative complications.

Conclusion: In conclusion, our study contributes to the growing body of knowledge surrounding Ilizarov external fixation for proximal tibial fractures with compromised skin conditions. While our outcomes are generally consistent with recent literature, the observed variations warrant continued exploration.

Keywords: Tibia, Fracture, External fixation, Flexion, Complications.

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Introduction

Proximal tibial fractures, characterized by their complex nature and demanding biomechanics, present a formidable challenge in orthopedic trauma care [1]. When compounded by compromised skin conditions, such as those resulting from open fractures or high-energy trauma, these fractures necessitate a nuanced and precise management strategy.

The compromised skin introduces a heightened risk of complications, including infection, delayed wound healing, and compromised functional

outcomes, underscoring the critical importance of selecting an optimal treatment approach [2]. Historically, conventional treatments for proximal tibial fractures with compromised skin conditions comprised a spectrum of interventions ranging from external fixation to internal fixation or a combination thereof [3]. However, these approaches often faced limitations, particularly in addressing the intricate interplay between severe soft tissue injuries and compromised blood supply. Recent advancements in orthopedic trauma care

have turned attention to the Ilizarov external fixator as a promising alternative, offering a dynamic and adaptable solution to concurrently address both the fracture and soft tissue aspects [4].

Originating in the 1950s through the pioneering work of Gavriil Ilizarov, the Ilizarov external fixator has undergone significant refinements and modifications, solidifying its status as a versatile tool in orthopedic practice [5]. Its efficacy in managing complex fractures, limb length discrepancies, and non-unions is well-established. However, despite its potential advantages, there remains a notable gap in the literature regarding its specific application in proximal tibial fractures with compromised skin conditions [6,7].

Recent studies have highlighted the Ilizarov external fixator's capacity to maintain stability and promote bone union while simultaneously allowing for meticulous soft tissue management [8,9]. The circular frame design, combined with its minimally invasive nature, contributes to reduced infection rates and enhanced patient comfort during the recovery period. Moreover, emerging data suggest that the Ilizarov method may offer superior outcomes in terms of range of motion and patient-reported functional improvements compared to traditional approaches in similar fracture scenarios [9,10].

This study aimed to assess the functional and radiological outcomes of patients with proximal tibial fractures and compromised skin conditions treated exclusively with the Ilizarov external fixator. By integrating recent findings and historical context, our study seeks to contribute valuable insights that may shape contemporary treatment paradigms, refine clinical decision-making, and further establish the Ilizarov external fixator as an indispensable tool in addressing the intricate challenges posed by proximal tibial fractures with compromised skin conditions.

Materials and Methods

Study Design: This prospective cohort study was conducted among patients with proximal tibial fractures treated with the Ilizarov external fixator in the department of Orthopaedics at tertiary care centre of North India for a period of 2 years between July 2021 and June 2022. Ethical approval was obtained from the Institutional Ethics Committee prior to the commencement of the study.

Patient Selection: Patients meeting the inclusion criteria were consecutively enrolled after obtaining informed written consent. Inclusion criteria encompassed individuals aged [18-75] years with proximal tibial closed fractures (Tscherné's classification Type 1, 2, and 3) and associated

compromised skin conditions, or open fractures (Gustilo-Anderson Type I, II and III), or high-energy trauma leading to soft tissue compromise. Exclusion criteria included patients with contraindications to Ilizarov external fixation, pre-existing conditions affecting bone healing, and those unwilling or unable to participate in follow-up evaluations. During period study a total of 56 eligible participants were enrolled.

Intervention: All eligible patients underwent treatment with the Ilizarov external fixator within 24 hours of admission. The surgical procedure was performed by experienced orthopedic surgeons familiar with Ilizarov techniques. The Ilizarov frame configuration was tailored based on fracture characteristics, with due consideration to achieve adequate stabilization while allowing for optimal soft tissue management. Pin sites were carefully chosen to minimize the risk of complications, and the Ilizarov fixator was applied using standard surgical techniques.

Data Collection: Baseline demographic information, including age, gender, mechanism of injury, and fracture classification, was recorded for each participant. Preoperative radiographs and CT scans were utilized to assess the fracture patterns and soft tissue involvement. Intraoperatively, surgical details, including Ilizarov frame configuration, number of pins, and any intraoperative complications, were documented.

Follow-Up: All participants were followed up for a minimum of 12 months postoperatively. Any deviations from the follow-up schedule or unexpected events were documented and analyzed. Reasons for patient dropout or non-compliance were investigated and reported.

Outcome Measures: Clinical assessments were conducted at regular intervals (e.g., 6 weeks, 3 months, 6 months, and 12 months) postoperatively. Clinical and radiological outcomes were assessed using Johner and Wruh's criteria.

The Johner and Wruh's criteria for clinical assessment included Pain (Evaluated subjectively by the patient, considering the presence and intensity of pain during weight-bearing or specific movements) and Function (Assessed based on the patient's ability to perform activities of daily living and weight-bearing functions without significant limitations).

For radiological assessment included Fracture Healing (Evaluated based on radiographic evidence of callus formation, cortical bridging, and absence of visible fracture lines) and Alignment (Assessed by comparing post-treatment radiographs to normal anatomical alignment) (Figure 1).

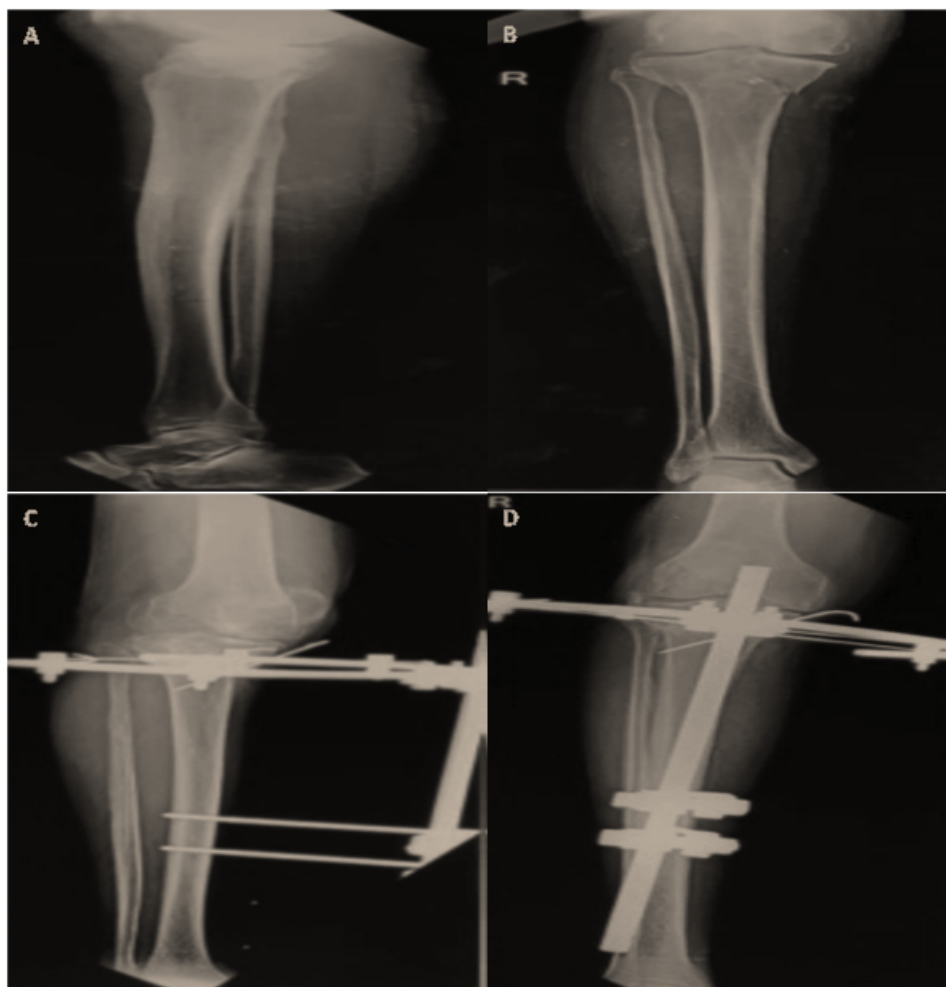


Figure 1: 1A and 1B: Right side preoperative X ray. 1C and 1D: Right side postoperative X ray showing complete union at the fracture site at three months follow-up

Statistical Analysis: Data were recorded on MS excel spreadsheet, and statistical analyses were performed using SPSS version 20.0. Descriptive statistics were employed to summarize demographic data and baseline characteristics. Continuous variables were presented as means with standard deviations. Categorical variables were expressed as frequencies and percentages. A p-value less than 0.05 was considered statistically significant.

Ethical Considerations; This study adhered to the principles of the Declaration of Helsinki. Informed consent was obtained from all participants before enrollment, outlining the study objectives, procedures, potential risks, and benefits. Patient

confidentiality was strictly maintained throughout the study, and data were de-identified during analysis.

Results

In our study, the mean age of the participants was 41.72 years, with a standard deviation of 13.15. In terms of gender distribution, 41 participants (73.2%) were male, while 15 participants (26.8%) were female.

Co-morbidities were observed in a subset of the population, with 5 participants (8.9%) having diabetes mellitus and 12 participants (21.4%) reporting hypertension (Table 1).

Table 1: Baseline characteristics of the study participants (N=56)

Variables	Frequency (%) / Mean+SD
Age (in years)	41.72+13.15
Gender	
Male	41 (73.2)
Female	15 (26.8)
Co-morbidity	
Diabetes mellitus	5 (8.9)
Hypertension	12 (21.4)

In our study, The predominant mode of injury was road traffic accidents, accounting for 69.7% of cases, followed by assault at 16.1% and falls from height at 14.2%. Regarding the side affected, the majority of fractures occurred on the right side (62.5%), while 37.5% were on the left side. Additionally, fracture types were delineated as open in 25.0% of cases and closed in 75.0% (Table 2).

Table 2: Injury characteristics of the study participants (N=56)

Variables	Frequency (%)
Injury mode	
Road traffic accident	39 (69.7)
Assault	9 (16.1)
Fall from height	8 (14.2)
Side affected	
Right	35 (62.5)
Left	21 (37.5)
Fracture type	
Open	14 (25.0)
Close	42 (75.0)

Among open fractures, Gustilo Anderson's classification was employed, revealing that 35.8% fell under Grade I, 21.4% each in Grades II and III A, and an additional 21.4% in Grade III B. In contrast, the classification of closed fractures utilized Tschern's criteria, highlighting that 40.5% were classified as Grade I and the majority, 59.5%, fell into Grade II (Figure 2).

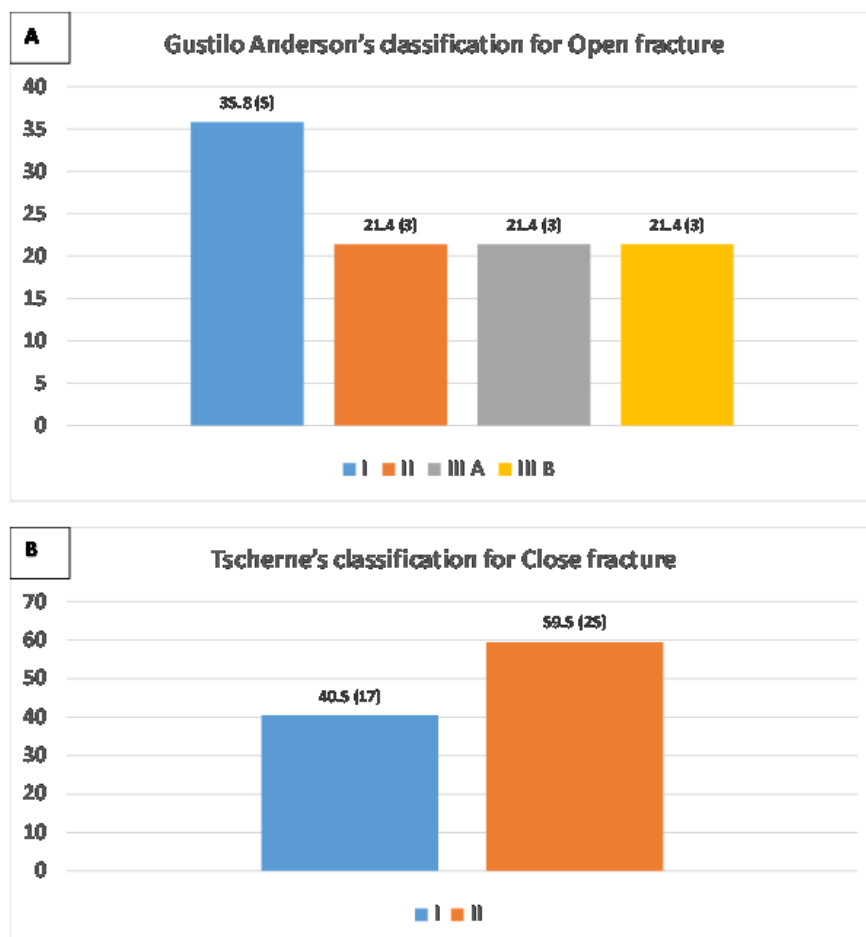


Figure 2: 2A: Distribution of Open fracture as per Gustilo Anderson's classification. 2B: Distribution of Close fracture as per Tschern's classification

The majority of patients, constituting 44.6%, underwent fixator application for less than 15 weeks, with no cases in the open fracture group and 59.5% in the closed fracture group falling within

this category. The distribution of fixator duration further reveals that 33.9% had a duration between 15 to 17 weeks, 16.1% between 18 to 20 weeks, and 5.4% beyond 20 weeks. Range of motion

(ROM) in flexion demonstrated a mean of 116.63 degrees (SD = 14.43) for the entire cohort, with the open fracture group exhibiting a slightly higher mean of 119.68 degrees (SD = 7.82) compared to the closed fracture group, which had a mean of 115.46 degrees (SD = 15.89). Extension lag, observed in 26.8% of cases, exhibited a mean

prevalence with no standard deviation reported. Furthermore, the mean duration of hospital stay was 12.56 days (SD = 8.21) for the entire cohort. When stratified by fracture type, the open fracture group had a mean duration of 14.32 days (SD = 8.16), whereas the closed fracture group had a mean duration of 11.23 days (SD = 6.73) (Table 3).

Table 3: Outcome characteristics of the study participants (N=56)

Variables	Frequency (%) / Mean+SD		
	Total	Open	Close
Fixator duration			
<15 weeks	25 (44.6)	0 (0.0)	25 (59.5)
15-17 weeks	19 (33.9)	9 (64.3)	10 (23.8)
18-20 weeks	9 (16.1)	2 (14.3)	7 (16.7)
>20 weeks	3 (5.4)	3 (21.4)	0 (0.0)
ROM flexion	116.63+14.43	119.68+7.82	115.46+15.89
Extension lag	15 (26.8)	3 (21.4)	12 (28.6)
Duration of stay	12.56+8.21	14.32+8.16	11.23+6.73

In our study, pin tract infections were reported in 10 cases, representing 17.9% of the cohort. Knee stiffness was documented in 7 cases, accounting for 12.5% of patients, while limb shortening was observed in 5 cases, constituting 8.9% of the study population (Figure 3).

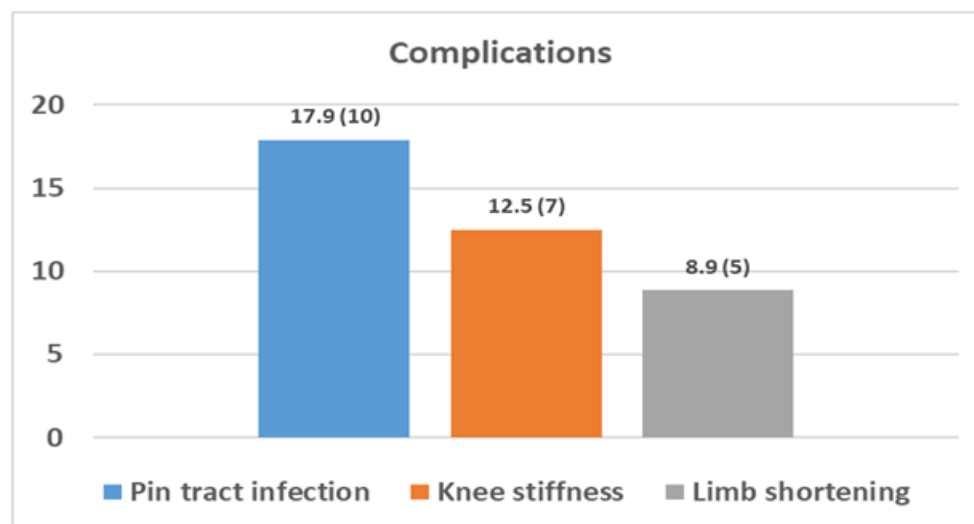


Figure 3: Distribution of complications among study participants (N=56)

Discussion

The present study delves into the functional and radiological outcomes of proximal tibial fractures with compromised skin conditions treated using the Ilizarov external fixator. Our findings offer valuable insights into the demographic and clinical characteristics of the study cohort, contributing to a more comprehensive understanding of the outcomes associated with this specific treatment approach. The demographic profile of the participants revealed a mean age of 41.72 years, consistent with the adult population commonly affected by proximal tibial fractures. The gender distribution indicated a higher prevalence among males (73.2%), highlighting potential gender-related factors influencing fracture occurrence, and was in consistent with the observations reported by

Gupta et al., and Sharma et al., [11,12]. Additionally, the presence of comorbidities, such as diabetes mellitus and hypertension, in a subset of patients underscores the importance of considering systemic health factors in the management of these fractures.

The mode of injury analysis demonstrated a notable prevalence of road traffic accidents (69.7%), emphasizing the impact of high-energy trauma in this cohort. The side distribution revealed a slightly higher occurrence on the right side (62.5%), suggesting potential patterns influenced by external factors or biomechanics and similar pattern was observed in the studies by Aggarwal et al., and Savolainen et al., [13,14].

Our study further classified fractures based on Gustilo Anderson's classification for open fractures and Tscherne's classification for closed fractures. The prevalence of open fractures (25.0%) aligns studies by Aggarwal et al., and Savolainen et al., emphasizing the severity of trauma and the challenges posed by compromised skin conditions [13,14]. These classifications play a crucial role in guiding treatment decisions and predicting outcomes. Subramanyam et al., reported more close fracture as compare to open fracture [15].

Notably, the duration of fixator application exhibited variations across categories, with the majority of patients (44.6%) undergoing treatment for less than 15 weeks. The mean range of motion (ROM) in flexion was 116.63 degrees, with a slightly higher mean observed in the open fracture group and was in consistent with the study by Subramanyam et al., where the distribution of functional outcomes showed 16 patients rated as excellent, 8 as good, 5 as fair, and 1 as poor, respectively. Knee range of motion (ROM) averaged 114.7 degrees [15]. The study by Kartheek et al., reported predominantly favorable outcomes, with 14 patients achieving a good to excellent functional status and 1 patient rated as fair. Knee range of motion (ROM) averaged 124.6 degrees [16]. In a study by Sheshagiri et al., the functional outcomes varied, with 11 patients achieving an excellent result, 8 with a good outcome, and 1 rated as fair [17]. In a study conducted by Catagni et al., the study concluded that the Ilizarov external fixator yielded excellent to good results in the majority of cases involving complex tibial plateau fractures [18]. In a study conducted by Barbary et al., the functional outcomes were favorable, with a distribution of excellent, good, fair, and poor results reported as 18, 7, 1, and 2 patients, respectively. The median knee range of motion (ROM) was 0-112 degrees [19].

Extension lag was reported in 26.8% of cases, revealing a potential limitation in achieving optimal joint mobility. The mean duration of hospital stay (12.56 days) reflects the multifaceted nature of patient care, considering both fracture management and recovery. In a study by Subramanyam et al., the mean duration of 11.8 weeks for renuion, achieving a 100% success rate [15]. In a study conducted by Ramos et al., all cases demonstrated a satisfactory result, achieving a 100% success rate [20]. Knee range of motion (ROM) exceeding 10-100 degrees. In a study conducted by Mohamed et al., the Ilizarov external fixator demonstrated favorable outcomes with a mean fixator duration of 14.4 weeks. All patients achieved a satisfactory result, with a distribution of excellent, good, fair, and poor outcomes reported in 10, 10, 5, and 5 patients,

respectively [21]. In a study conducted by Catagni et al., the Ilizarov external fixator was employed for an average duration of 16.42 weeks. The functional outcomes were predominantly favorable, with 30 patients rated as excellent, 27 as good, 1 as fair, and 1 as poor [18]. In a study conducted by Barbary et al., the Ilizarov external fixator was applied for an average duration of 16.3 weeks [19]. The fixator demonstrates biomechanical stability equivalent to dual-column plating, as indicated by previous studies by Piper et al., and Yang et al., [22,23].

Complications, a vital aspect of any orthopedic intervention, were identified in our study. Pin tract infections, knee stiffness, and limb shortening were observed in 17.9%, 12.5%, and 8.9% of cases, respectively. These findings highlight the importance of diligent postoperative monitoring and the need for targeted strategies to minimize complications associated with Ilizarov external fixation. In a study by Subramanyam et al., pin tract infections were documented in 7 cases, and common peroneal neuropathy occurred in 2 cases [15]. The study by Kartheek et al., the incidence of complications included 2 cases of pin tract infection, 1 case of deep infection, 3 cases of arthritis, and 1 case of equinus deformity [16]. In a study by Sheshagiri et al., three cases of pin tract infections were reported [17]. In a study conducted by Ramos et al., noted a low incidence of complications, with 2 cases each of pin tract infection and compartment syndrome, and 1 case of deep venous thrombosis [20]. In a study conducted by Catagni et al., complications included 2 cases of deep venous thrombosis and 2 cases of common peroneal nerve palsy [18]. In a study conducted by Barbary et al., minor pin tract infections were noted [19].

Limitations

However, it is essential to acknowledge the inherent limitations, including the single-center design and potential selection bias.

Conclusion

In conclusion, our study contributes to the growing body of knowledge surrounding Ilizarov external fixation for proximal tibial fractures with compromised skin conditions. While our outcomes are generally consistent with recent literature, the observed variations warrant continued exploration. Collaborative efforts across institutions and the integration of emerging technologies could further enhance our understanding and improve the overall management of these challenging fractures. Future research endeavors should prioritize large-scale, multi-center studies to strengthen the evidence base and refine treatment protocols in orthopedic trauma care.

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