e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(4); 752-758

Original Research Article

Characteristics and Treatment Outcomes of Patients with Segmental Tibial Fractures: A Longitudinal Observational Study

Ashok Bhatt[1], Pradeep Kumar HV[2], Sandesh MB[3], Vishal Victor Kujur[4]

[1]Assistant Professor, Department of Orthopedics, Amaltas Institute of Medical Sciences, Madhya Pradesh, India

[2]Postgraduate, Department of Orthopedics, Karnataka Institute of Medical Sciences, Hubballi, Karnataka

[3]Postgraduate, Department of Orthopedics, Karnataka Institute of Medical Sciences, Hubballi, Karnataka

[4]Senior Resident, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India

Received: 25-01-2024 / Revised: 23-02-2024 / Accepted: 26-03-2024

Corresponding Author: Dr. Vishal Victor Kujur

Conflict of interest: Nil

Abstract:

Objectives: The objectives of the present study were to document the characteristics of patients presenting with segmental tibial fractures and to determine the treatment outcomes using Johner and Wruchs criteria, and Knee society scores.

Methods: This was a hospital based observational longitudinal study conducted in the outpatient department and inpatient wards of the Department of Orthopaedics, of a tertiary healthcare facility located in Central India between January 2022 and June 2023.

Results: The present study included a total of 47 patients with a mean (SD) age of 46.2 years (6.9). Majority of the patients were males (83.0%). Road traffic accidents were the most common (72.3%) mode of injury – within which the involvement of motorcycles and/or two wheelers was the most common; 34.0% patients had associated injuries. Nearly half the patients (46.8%) had a diagnosis of closed segmental both bone fracture and 53.2% had compound segmental both bone fracture. The difference in segment length between closed and open fractures was found to be statistically significant (MD -2.20, 95% CI -3.93 to -0.47). The mean (SD) duration of union in the proximal and distal fracture sites were significantly shorter with closed fractures, in comparison with open fractures ($p<0.05$). Four patients (8.5%) had complications. The treatment outcomes assessed using Johner and Wruchs criteria showed that 63.8% patients had excellent recovery; and that assessed using Knee society score showed that 76.6% patients had excellent recovery.

Conclusion: These findings underscore the complexity of managing segmental tibial fractures and the importance of a multidisciplinary approach involving orthopaedic surgeons, trauma specialists, physiotherapists, and rehabilitation teams.

Keywords: Segmental tibial fractures, Outcomes, Union, Complications, Johner and Wruchs criteria, Knee society score.

Introduction

Segmental tibia fractures are characterized by the presence of at least two separate fracture lines, resulting in a completely isolated intercalary osseous fragment.[1] These fractures are relatively rare and typically occur due to high-energy trauma, leading to a notably high complication rate. They represent approximately 12.8% of all tibia fractures and are commonly associated with road traffic accidents, falls from heights, industrial mishaps, and train accidents.[2] A significant portion, ranging from 37.5% to 83.8% of these fractures are open, often involving injuries to other body parts due to the intense energy involved in their causation.[3] The severe soft tissue damage and periosteal stripping associated with high-energy trauma contribute to compromised blood supply to the central fragment.[4] Segmental tibia fractures are distinct from typical tibia fractures due to several factors. They almost always result from high-energy traumas, with approximately 50% being compound fractures. These fractures frequently occur in conjunction with multiple injuries and are characterized by severe soft tissue trauma, resulting in elevated complication rates and generally poorer prognoses.[5] The primary treatment objective for these fractures is achieving

clinical and radiological union while preserving normal limb length, alignment, rotational stability, joint mobility, and minimizing morbidity.[6]

Current treatment modalities for segmental tibia fractures include locked intramedullary nailing, external fixators, and immobilization using plaster of Paris casts.[7] However, despite these treatment options, delayed unions and non-union are more commonly encountered with segmental fractures compared to nonsegmental tibia fractures. This highlights the complexity and challenges inherent in managing these specific fracture patterns, necessitating careful consideration of treatment strategies and vigilant monitoring during the healing process to optimize outcomes and minimize complications.

Against this background, the objectives of the present study were to document the characteristics of patients presenting with segmental tibial fractures and to determine the treatment outcomes using Johner and Wruchs criteria, and Knee society scores.

Materials and Methods

This was a hospital based observational longitudinal study conducted in the outpatient department and inpatient wards of the Department of Orthopaedics, of a tertiary healthcare facility located in Central India between January 2022 and June 2023. The study was approved by the Institutional Human Ethics Committee (IHEC). The content of Participant Information Sheet (PIS) in local language was provided to the participants (and their attenders) and contents were read to them in their own language to their satisfaction. The participants were enrolled in the study after obtaining written informed consent. All the patients presenting with segmental tibial fractures of age between 18 and 65 years were included in the present study. However, we excluded patients presenting with associated vascular injury, neurological injury; pathological fractures; patients with severe systemic illness including active cancer elsewhere in body, insulin dependent diabetes mellitus, renal failure; patients on chemotherapy; patients with medical contraindication for surgery; and patients not willing to provide informed written consent.

In the present study, patients were enrolled using non-probability sampling – convenient sampling technique – complete enumeration of all patients presenting during the study period, in line with prespecified inclusion and exclusion criteria. We used a purpose predesigned, semi structured, pretested questionnaire to document the sociodemographic characteristics, detailed patient history and clinical examination including general physical, systemic, neurovascular, and local examination of the injured part. Radiological investigations were done as appropriate – included anteroposterior (AP) and lateral radiograph of knee with leg and ankle to diagnose fracture type. Routine preoperative investigations were done. For patients presenting with diminished distal pulses, vascular consultation was obtained. For patients with grade two and three compound fractures, opinion of the plastic surgeon was obtained. The open fractures were immediately irrigated, washed, and temporarily immobilised with posterior OP above knee slab. Patients were operated within three weeks of admission.

Surgical technique: Preoperative planning involved taking X-rays of the injured leg from both the AP and lateral views to assess fracture angulation in multiple planes and plan the reduction method accordingly. The location of the tibia and fibula fractures in relation to the proximal and distal articular surfaces was carefully noted. For fractures within the proximal 1/3 of the tibia, a lateral and high entry point was planned, while fractures in the diaphysis of the tibia were planned with a central entry point. Fibula fractures within 8 cm from the distal articular surface were planned for fixation. Additionally, planning for a polar screw was conducted for fractures within the metaphyseal region to narrow the medullary canal and correct deformities during nailing. Intra-articular extensions were noted, and if doubts persisted, a CT scan was performed. The length of the intermediate fragment was measured, and the approximate length of the nail was determined by measuring from the tibial tuberosity to the most prominent point of the medial malleolus in the contralateral leg. The diameters of the medullary canal at the isthmus were also measured.

Intraoperatively, cannulated stainless-steel nails with various locking options and diameters (8, 9, or 10 mm) were used. A patellar tendon splitting approach was utilized to create the planned entry point. Progressive reaming was conducted in the proximal fragment, and a guide wire was passed under image intensifier control to verify reduction. If reduction was not satisfactory, the fracture site was opened, and serial reaming was performed while controlling the intermediate fragment with appropriate tools. The intramedullary nail was introduced and locked with proximal and distal screws as needed to achieve alignment, confirmed in both coronal and sagittal planes via image intensifier.[8]

If necessary, supplementary fibular plating was performed through a posterolateral incision. This involved incising the skin, subcutaneous tissue, and fascia, retracting the peroneal muscles anteriorly, and exposing the fibular fracture site. After achieving proper alignment and reduction, fibular plating was done using an appropriate one-third tubular plate and screws of varying sizes. Proper

alignment of the fibula often led to self-alignment of the tibia in fresh cases, preventing malalignment in sagittal and coronal planes. In delayed cases where fibula alignment did not result in tibial alignment, open reduction and internal fixation with an intramedullary nail were performed. Tourniquets were not utilized during any of the procedures, which were all carried out under spinal anaesthesia.

Postoperative Management: The operated limb was elevated during the immediate post-operative period and kept elevated for 48 hours. Isometric quadriceps exercises and toe mobilization began on the first day after surgery. The drain was removed either on the second postoperative day or when the drainage decreased to less than 30 ml per day. Patients started active range of motion (ROM) exercises for the knee and ankle two days after surgery. If there were no complications or injuries elsewhere in the body, patients were mobilized with a walker for non-weight bearing walking after two days. Partial weight bearing was initiated at 6 weeks once radiological evidence of callus formation was observed. Full weight bearing was allowed once clinical and radiological union was confirmed.

Fractures were monitored until union occurred, with clinical and radiological examinations performed every 4 to 6 weeks. The follow-up period extended up to 18 months. During follow-up, axial alignment was evaluated, and functional assessment was measured using the Modified Knee Society Scoring system and Johner and Wruh's criteria. Radiographs were analysed to assess correction, maintenance of position, or loss of reduction. Fracture union was defined as achieved when patients could bear full weight on the injured limb without pain or support and when radiographs showed bridging callus in at least 3 cortices.[9]

Statistical analysis: The data obtained was manually entered into Microsoft Excel, coded, and recoded. Analysis was done using Statistical Package for the Social Sciences (SPSS) v23. Descriptive analysis was presented using numbers and percentages for categorical variables and mean (standard deviation) or median (interquartile range) for continuous variables. To test for association, Chi-square test or Fisher's exact test (two sided) was used for categorical data and independent "t" test for continuous data. Statistical significance was considered at $p<0.05$.

Results

The present study included a total of 47 patients presenting with segmental tibial fractures of age between 18 and 65 years during the study period. The mean (SD) age of the patients was 46.2 years (6.9) – majority (42.6%) were between 41 and 50 years of age, followed by 34.0% more than 50 years of age, 14.9% between 31 and 40 years, and 8.5% between 21 and 30 years of age. Majority of the patients were males (83.0%). It was noted that nearly three in four (74.5%) patients had the right side affected.

Road traffic accidents were the most common (72.3%) mode of injury – within which the involvement of motorcycles and/or two wheelers was the most common. More than one in three patients presented with associated injuries (34.0%). The associated injuries included acetabular fractures, grade II compound fracture of both tibial bone, closed segmental shaft of femur fracture, superior public ramus fracture, type 2 tibial plateau fracture, and clavicle fractures. Importantly, it was noted that 80.9% patients with segmental tibial fractures had fracture of the fibula. Of the 38 patients with fracture of the fibula, 26 (68.4%) had single, 9 (23.7%) patients had segmental, and 3 (7.9%) patients had double segmental fractures. In the present study, 22 patients (46.8%) had a diagnosis of closed segmental both bone fracture and 25 patients (53.2%) had a diagnosis of compound segmental both bone fracture. Nearly one in ten patients (8.5%) required a secondary procedure; the common secondary procedures done were bone grafting with dynamization and implant exit.

The total number of closed fractures were 29 and open fractures were 18 – the mean (SD) segment length in closed fractures was 8.9 cms (2.7) and in open fractures was 6.7 cms (3.1). Importantly, the difference in segment length between closed and open fractures were found to be statistically significant (MD -2.20, 95% CI -3.93 to -0.47; $p = 0.014$). The mean (SD) duration of union in the proximal fracture site was 19.2 weeks (4.8) and 22.9 weeks (6.1) in patients with closed and open fractures – the difference was found to be statistically significant ($p<0.05$). Similarly, the mean (SD) duration of union in the distal fracture site was 24.5 weeks (3.8) and 31.4 weeks (6.7) in patients with closed and open fractures – a statistically significant difference ($p<0.05$). The results showed that 4 patients (8.5%) patients had complication; the complications reported included shortening less than 1.5 cm or more than 1.5 cm, anterior knee joint pain, great toe drooping, and infections. The treatment outcomes assessed using Johner and Wruchs criteria showed that 63.8% patients had excellent recovery, 23.5% had fair, 10.6% had good, and 2.1% had poor recovery. The assessment using Knee society score showed that 76.6% patients had excellent, 14.9% had fair, 6.4% had good, and 2.1% had poor recovery.

Table 1: Descriptive analysis of patient characteristics, presenting complaints and procedures

		Number (n) N = 47	Percent (%)
Age (in years) Mean (SD)		46.2 (6.9)	
Age (in years)	21 to 30	4	8.5
	31 to 40	7	14.9
	41 to 50	20	42.6
	More than 50	16	34.0
Gender	Female	8	17.0
	Male	39	83.0
Side affected	Left	12	25.5
	Right	35	74.5
Mode of injury	RTA	34	72.3
	Not RTA	13	27.7
Associated injuries	Present	16	34.0
	Absent	31	66.0
Fibula fracture	Present	38	80.9
	Absent	9	19.1
Type of fibula fracture (n = 38)	Single	26	68.4
	Segmental	9	23.7
	Double segmental	3	7.9
Diagnosis	Closed segmental both bone fracture	22	46.8
	Compound segmental both bone fracture	25	53.2
Treatment done	Closed interlocking nailing	29	61.7
	Open interlocking nailing	18	38.3
Secondary procedure	Required	4	8.5
	Not required	43	91.5

Table 2: Variation in segment length between closed and open fractures

		Mean (SD)	MD (95% CI) P value
Segment length (in cms)	Closed (n = 29)	8.9 (2.7)	MD -2.20, 95% CI -3.93 to -0.47; 0.014*
	Open (n = 18)	6.7 (3.1)	
*Statistically significant at p<0.05			

Table 3: Patient outcomes – union, Johner and Wruchs criteria, Knee society score, and complications

		Number (n) N = 47	Percent (%)
Fracture union			
Proximal fracture union (in weeks)*	Closed	19.2 (4.8)	
	Open	22.9 (6.1)	
Distal fracture union (in weeks)*	Closed	24.5 (3.8)	
	Open	31.4 (6.7)	
Complications	Present	4	8.5
	Absent	43	91.5
Johner and Wruchs criteria	Excellent	30	63.8
	Fair	11	23.5
	Good	5	10.6
	Poor	1	2.1
Knee society score	Excellent	36	76.6
	Fair	7	14.9
	Good	3	6.4
	Poor	1	2.1
*Statistically significant at p<0.05			

Discussion

Segmental tibial fractures present complex challenges in orthopaedic trauma management due to their high-energy nature and potential for associated injuries.[10] The demographic profile of patients in the present study, with a mean age of 46.2 years and a predominance of males, aligns with existing literature on trauma demographics,

where males in the middle-aged to older age groups are more commonly affected by high-energy trauma like road traffic accidents (RTAs) leading to segmental tibial fractures.[11]

The high prevalence of RTAs (72.3%) as the leading cause of segmental tibial fractures underscores the need for preventive measures and improved road safety strategies. The involvement of motorcycles and two-wheelers emphasizes the vulnerability of riders and the importance of protective gear.[12] The significant proportion of patients (34.0%) presenting with associated injuries highlights the multisystem impact of these fractures. Acetabular fractures, grade II compound fractures of both tibial bones, and other associated fractures indicate the severity and complexity of trauma in these cases. The observation that 80.9% of patients with segmental tibial fractures also had fibula fractures is consistent with the concept of the "floating knee" injury complex, where fractures in both bones of the lower limb occur simultaneously, often necessitating comprehensive management strategies.[13] The distribution of closed segmental both bone fractures (46.8%) and compound segmental both bone fractures (53.2%) underscores the diversity in fracture presentations and the challenges in surgical management, especially concerning soft tissue compromise and infection risks in open fractures. The need for secondary procedures in 8.5% of patients reflects the complexity of fracture management and the importance of ongoing monitoring and intervention in achieving optimal outcomes. The common secondary procedures such as bone grafting with dynamization and implant exit highlight the need for comprehensive postoperative care and rehabilitation. Understanding the demographics, injury mechanisms, associated injuries, and fracture characteristics in segmental tibial fractures is crucial for guiding treatment decisions, optimizing surgical approaches, and improving patient outcomes.[14]

The observed mean segment length of 8.9 cm in closed fractures and 6.7 cm in open fractures suggests a notable difference in the extent of bone involvement based on fracture type. This discrepancy is clinically relevant as it reflects the varying degrees of trauma and soft tissue compromise associated with closed and open fractures.

The statistically significant difference in segment length between closed and open fractures (MD -2.20, 95% CI -3.93 to -0.47; $p = 0.014$) underscores the importance of thorough assessment and classification of segmental tibial fractures in clinical practice. Studies such as the Gustilo-Anderson classification system for open fractures[15] and AO/OTA classification for tibial fractures[16] provide valuable frameworks for categorizing fracture severity based on soft tissue involvement, fracture pattern, and associated injuries.[17] These classifications aid in treatment decision-making, surgical planning, and prognostic assessment.[18]

The observed differences in the duration of union between proximal and distal fracture sites and between closed and open fractures highlight the influence of fracture type and location on healing times. Patients with open fractures experienced longer union times at both sites compared to those with closed fractures. This finding is consistent with existing literature that emphasizes the impact of soft tissue injury, contamination, and infection on fracture healing and overall outcomes.[17] The reported complications, including shortening, anterior knee pain, great toe drooping, and infections, underscore the multifactorial nature of challenges associated with segmental tibial fractures.[19] Shortening can result from malunion or non-union, highlighting the importance of achieving and maintaining adequate fracture reduction and alignment during treatment. Anterior knee pain and great toe drooping may arise from joint incongruity or nerve injury, necessitating careful postoperative monitoring and rehabilitation. Infections represent a significant concern in open fractures, emphasizing the need for stringent aseptic techniques, timely debridement, and appropriate antibiotic management.[20]

The assessment of treatment outcomes using Johner and Wruch's criteria and Knee Society scores provides a comprehensive evaluation of functional recovery and joint outcomes post-treatment.[21, 22] The majority of patients achieved excellent or good recovery according to both assessment tools, indicating favourable overall outcomes in this cohort. However, the presence of fair and poor outcomes highlights the variability in patient responses and the need for personalized treatment approaches and ongoing follow-up care. Existing literature supports the notion that open fractures, especially in complex fractures like segmental tibial fractures, are associated with prolonged healing times, higher complication rates, and potentially inferior functional outcomes compared to closed fractures. Strategies such as early surgical intervention, comprehensive soft tissue management, appropriate fixation techniques, and diligent postoperative care play pivotal roles in optimizing outcomes and reducing complications in these cases.

Conclusion

In conclusion, our study on segmental tibial fractures provides valuable insights into the demographics, injury characteristics, treatment outcomes, and complications associated with these complex fractures. The key findings include –

majority of patients affected were males in the middle-aged to older age groups; road traffic accidents, particularly involving motorcycles and two-wheelers, were the most common cause of segmental tibial fractures; associated injuries were present in a significant proportion of patients, emphasizing the multisystem impact of these fractures. The study highlighted the association of fibula fractures with segmental tibial fractures, emphasizing the concept of the "floating knee" injury complex. The duration of union was significantly longer in open fractures compared to closed fractures, both at the proximal and distal fracture sites. Complications such as shortening, joint pain, nerve injuries, and infections were observed, requiring careful monitoring and intervention. The majority of patients achieved excellent or good recovery based on Johner and Wruch's criteria and Knee Society scores, reflecting favourable overall outcomes in this cohort.

These findings underscore the complexity of managing segmental tibial fractures and the importance of a multidisciplinary approach involving orthopaedic surgeons, trauma specialists, physiotherapists, and rehabilitation teams. Future research can focus on refining treatment protocols, exploring advanced fracture healing modalities, optimizing functional outcomes, and reducing complications in these challenging fractures.

References

1. Bonnevialle P, Cariven P, Bonnevialle N, Mansat P, Martinel V, Verhaeghe L, et al. [Segmental tibia fractures: a critical retrospective analysis of 49 cases]. Rev Chir Orthop Reparatrice Appar Mot. 2003; 89(5):423-32.
2. Teraa M, Blokhuis TJ, Tang L, Leenen LP. Segmental tibial fractures: an infrequent but demanding injury. Clin Orthop Relat Res. 2013; 471(9):2790-6.
3. Giannoudis P, Hinsche AF, Cohen A, Macdonald DA, Matthews S, Smith R. Segmental tibial fractures: An assessment of procedures in 27 cases. Injury. 2003; 34:756-62.
4. Nicolaides M, Pafitanis G, Vris A. Open tibial fractures: An overview. J Clin Orthop Trauma. 2021; 20:101483.
5. Sohn HS, Chung JY, Song HK. Analysis of complications and clinical outcomes in the treatment of segmental tibial fractures according to the method of internal fixation. Asian Journal of Surgery. 2019; 42(7):740-5.
6. Gahr P, Kopf S, Pauly S. Current concepts review. Management of proximal tibial fractures. Frontiers in Surgery. 2023; 10.
7. Albushtra A, Mohsen AH, Alnozaili KA, Ahmed F, Aljobahi Y, Mohammed F, et al. External Fixation as a Primary and Definitive Treatment for Complex Tibial Diaphyseal Fractures: An Underutilized and Efficacious Approach. Orthop Res Rev. 2024; 16:75-84.
8. Sodhai VM, Pradhan CV, Sancheti PK, Shyam AK. "Fixator-assisted Nailing" Technique for Closed Segmental Tibia Shaft Fracture with Extensive Soft Tissue Injury - A Case Report. J Orthop Case Rep. 2021; 11(8):92-6.
9. McMahon SE, Little ZE, Smith TO, Trompeter A, Hing CB. The management of segmental tibial shaft fractures: A systematic review. Injury. 2016; 47(3):568-73.
10. Rommens PM, Coosemans W, Broos PL. The difficult healing of segmental fractures of the tibial shaft. Arch Orthop Trauma Surg. 1989; 108(4):238-42.
11. Omoke NI, Ekumankama FO. Incidence and Pattern of Extremity Fractures seen in Accident and Emergency Department of a Nigerian Teaching Hospital. Niger J Surg. 2020; 26(1):28-34.
12. Stiles R, Benge C, Stiles PJ, Dong F, Ward J, Ablah E, et al. Evaluation of Protective Equipment Used Among Motorbike Riders. Kans J Med. 2018;11(2):1-13.
13. Wu C-M, Liao H-E, Lan S-J. Simultaneous bilateral floating knee: A case report. World Journal of Clinical Cases. 2022; 10(28):10172.
14. Anandasivam NS, Russo GS, Swallow MS, Basques BA, Samuel AM, Ondeck NT, et al. Tibial shaft fracture: A large-scale study defining the injured population and associated injuries. J Clin Orthop Trauma. 2017; 8(3):225-31.
15. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J Bone Joint Surg Am. 1976; 58(4):453-8.
16. Hodgson S. AO Principles of Fracture Management. Ann R Coll Surg Engl. 2009; 91(5):448-9.
17. Giannoudis P, Papakostidis C, Roberts C. A review of the management of open fractures of the tibia and femur. The Journal of bone and joint surgery British volume. 2006; 88:281-9.
18. Cross WW, 3rd, Swiontkowski MF. Treatment principles in the management of open fractures. Indian J Orthop. 2008; 42(4):377-86.
19. Patel I, Young J, Washington A, Vaidya R. Malunion of the Tibia: A Systematic Review. Medicina (Kaunas). 2022; 58(3).
20. O'Connor M, Marais LC, Ferreira N. Outcomes of segmental tibia fractures treated with circular external fixation at a single centre in a developing world setting. SA Orthopaedic Journal. 2018; 17(3):41-6.
21. Corey RM, Park NK, Cannada LK. Segmental Tibia Fractures: An Analysis of Complication and Healing Rates. J Orthop Trauma. 2018; 32(6):296-300.

22. Sharan A, Jeshuran W, Mulligan M, McGuire K, Uhl R. Intramedullary Nailing in a Tibial Shaft Fracture With Distal Articular Extension. Orthopedics. 2005; 28:571-2.