

EVALUATING THE FUNCTIONAL OUTCOMES OF TIBIAL PILON FRACTURES: A PROSPECTIVE STUDY

Suhail S S¹, Dayanand B B², Gireesh Khodnapur³, Bhimanagouda Biradar⁴, Santosh S Nandi⁵, Sandeep Naik⁶, Wadiraj Kulkarni⁴, Ajaykumar H R¹

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Corresponding Author:

Dr. Dayanand B B,

Email: dayanand.banapatti@bldedu.ac.in

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¹Postgraduate Student, Department of Orthopaedics, Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, India.

²Professor, Department of Orthopaedics, Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, India.

³Associate Professor, Department of Orthopaedics, Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, India.

⁴Senior Resident, Department of Orthopaedics, Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, India.

⁵Professor and HOD, Department of Orthopaedics, Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, India.

⁶Associate Professor, Department of Orthopaedics, Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, India.

Abstract

Background: Tibial pilon fractures remain a challenging entity in orthopedic trauma due to their complex nature and potential for complications. This study was done to evaluate the functional outcomes of surgically treated tibial pilon fractures using the American Orthopaedic Foot & Ankle Society Ankle-Hindfoot Scale AOFAS. **Materials and Methods:** A prospective study with 33 patients were included in the study. Data were collected during the period from August 2022 to January 2024 at Shri B. M. Patil Medical College Hospital and Research Centre. The fractures were classified using Ruedi-Allgower and AO/OTA classification systems. The surgical approaches are anteromedial, anterolateral, posterolateral and minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques. The AOFAS Ankle-Hindfoot Scale is used for evaluating the functional outcome, it is reviewed at 6 weeks and 3 months, 6 months post-operatively. **Result:** The average union time was 14.39 weeks (range: 12-20 weeks). The mean AOFAS score was 82.33, with 21.2% achieving excellent outcomes, 63.6% good outcomes, and 15.2% fair outcomes. The anteromedial approach was most commonly used (48.5%). Complications were minimal, with 84.8% of patients experiencing no complications. **Conclusion:** Surgical fixation of tibial pilon fractures leads to good and very rarely excellent results in terms of functionality with a very small percentage of complications. The anteromedial and anterolateral approaches are particularly effective in managing these fractures.

INTRODUCTION

Tibial pilon fractures, which comprise about 7-10% of all tibial fractures, pose a 'daunting problem' in orthopedic trauma due to their extraordinary complexity and high rate of secondary complications.^[1,2] They typically result from high-velocity injuries, affect the weightbearing surface of the distal tibia. Hence, this area has to be properly managed to preserve the function of the ankle joint.^[3,4]

The evolution of treatment strategies for tibial pilon fractures has seen a shift from conservative management to surgical intervention, aiming to

restore articular congruity and allow early mobilization.^[5,6] However, the optimal surgical approach and fixation method remain subjects of debate in the orthopedic community.^[7,8]

The fracture management is complex because of the thin, soft tissue envelope surrounding the distal tibia, that predisposed the risk of wound complications and infection.^[9,10] Different surgical approaches have been described such as anteromedial, anterolateral, posterolateral and minimally invasive technique, each with its own advantages and limitations.^[11-13]

This proposed study is, therefore, intended to determine the functional outcomes of tibial pilon fractures following surgical management based on

the American Orthopaedic Foot & Ankle Society Scale (AOFAS). Through this evaluation and extensive reviewing of currently available data, this study will provide evidence on selected surgical approach associated with successful management of these fractures.

MATERIALS AND METHODS

Study Design: This prospective study was done in Shri B. M. Patil Medical College Hospital and Research Centre from August 2022 to January 2024. We included 33 patients who were operated for tibial pilon fractures. The inclusion criteria were adult patients >18 years with closed tibial pilon fractures. We excluded open fractures, pathological fractures, and patients with severe medical comorbidities where surgery was not possible.

Data Collection and Surgical Technique: The preoperative workup consisted of taking a detailed history, doing a thorough physical examination, and obtaining radiographs and CT scans. Fractures were classified using the Ruedi-Allgower classification and the AO/OTA classification. The choice of surgical approach was dependant on fracture pattern, soft tissue condition, and surgeon's preference. For the anteromedial approach, the length of the incision was as long as the length of the medial malleolus, with curves made proximally. For the anterolateral approach, the incision was centred over the fourth metatarsal inclusion, with proximal curves made to separate the tibia from the fibula. For the posterolateral approach, the incision was made posterolateral to the lateral malleolus.

The MIPPO technique involved using small incisions for percutaneous plate insertion. Fracture reduction was achieved by using both direct and indirect reduction. Internal fixation was also carried out using plates and screws for both the MIPPO technique and the anteromedial, anterolateral, and posterolateral approaches. The type of implant used depended on the fracture pattern and bone quality.

Outcome Measures: A standardized postoperative protocol was executed, with immobilization and graduated weight-bearing. Ankle active range of motion was initiated as patient tolerated. Functional outcomes were evaluated clinically using the AOFAS Ankle-Hindfoot Scale at 6 weeks, 3 months, and 6 months postoperatively. It is a 100-point scale rating with 40 for pain, 50 for function, and 10 for alignment.

Statistical Analysis: The results were analyzed using frequency percentages, mean \pm SD, and median with interquartile range as the descriptive statistics. The categorical variables were compared using a chi-square test, and a p-value of <0.05 was considered statistically significant. The results were analyzed using SPSS version 28.6 software (IBM).

RESULTS

Demographic Characteristics and Injury Patterns: A total number of 33 patients were included in the study. The mean age of the majority of patients was 36.7 years. A high male incidence of 78.8% was found with a total 26 male patients. Most patients belonged to the 21-35 age group that is, 54.5% of the study group representing 18 patients of 33.

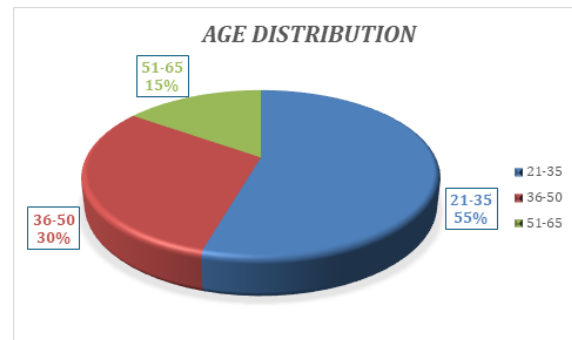


Figure 1: Age Distribution Pie Chart

As shown in [Figure 1], the largest segment of patients fell within the 21-35 age group, highlighting the prevalence of these injuries among younger adults.

Road traffic accidents were the primary cause of injury (93.9%, n=31), highlighting the high-energy nature of these fractures.

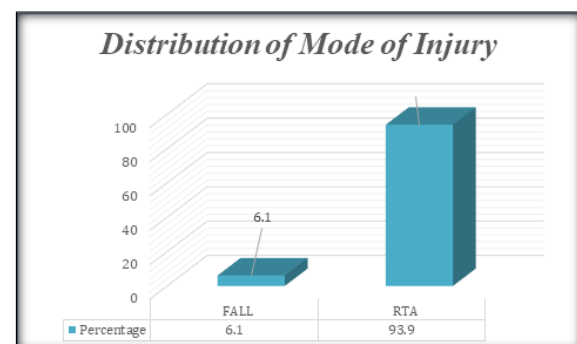


Figure 2: Distribution of Mode of Injury

[Figure 2] illustrates the overwhelming predominance of road traffic accidents as the cause of tibial pilon fractures in our study population. Right-sided fractures were slightly more common (54.5%, n=18), and associated fibula fractures were present in 72.7% (n=24) of cases.

Fracture Classification

Using the Ruedi-Allgower classification, 63.6% (n=21) were Type 3 fractures, and 36.4% (n=12) were Type 2. The AO/OTA classification showed a predominance of complex fractures, with 33.3% (n=11) classified as 43-C3 and 30.3% (n=10) as 43-C2. This distribution reflects the severity of injuries encountered in the study population.

Surgical Approaches and Union Time

The anteromedial approach was most commonly used (48.5%, n=16), followed by anterolateral (33.3%, n=11), posterolateral (12.1%, n=4), and MIPPO (6.1%, n=2).

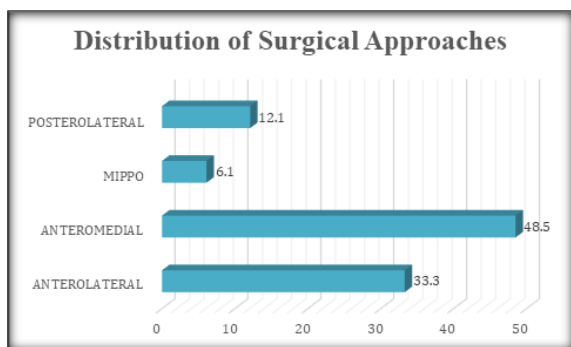


Figure 3: Distribution of Surgical Approaches

[Figure 3] demonstrates the distribution of surgical approaches used in our study, with the anteromedial approach being the most frequent choice.

The mean union time was 14.39 weeks (range: 12-20 weeks, SD: 1.802 weeks). This relatively quick union time may be attributed to careful soft tissue handling, stable fixation, and appropriate postoperative management.

Functional Outcomes and Complications

The mean AOFAS score was 82.33 (range: 66-92, SD: 7.056). Excellent outcomes were achieved in 21.2% (n=7) of patients, good outcomes in 63.6% (n=21), and fair outcomes in 15.2% (n=5).

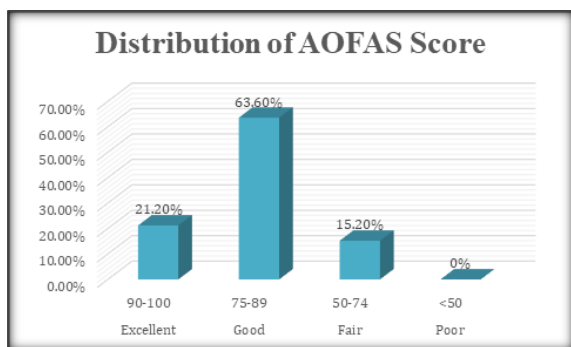


Figure 4: Distribution of AOFAS Score

[Figure 4] illustrates the distribution of AOFAS scores across the study population, demonstrating the predominance of good outcomes.

Most patients (84.8%, n=28) experienced no complications, with ankle stiffness (9.1%, n=3) and superficial infections (6.1%, n=2) being the most common complications observed.

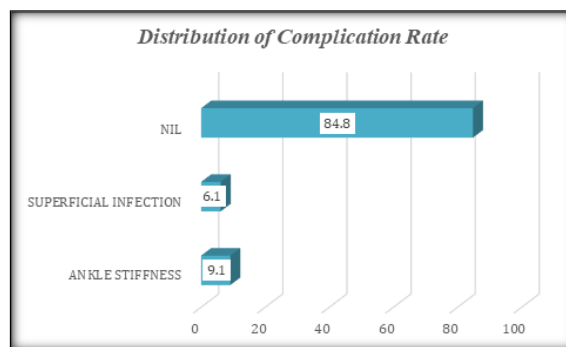


Figure 5: Distribution of Complication Rate

[Figure 5] shows the low overall complication rate in our study, with the majority of patients experiencing no complications.

Cross-tabulation analyses revealed trends towards significance in age-related outcomes (p=0.059) and fibula involvement (p=0.076), suggesting that younger patients and those without fibula involvement tend to have better functional outcomes. [Table 4] illustrates the trends in functional outcomes based on age and fibula involvement. Although not statistically significant at the p<0.05 level, there is a noticeable trend suggesting that younger patients (21-35 years) tend to have better functional outcomes, with a higher proportion achieving excellent results. Similarly, patients without fibula involvement appear to have better outcomes, with a higher percentage in the excellent category compared to those with fibula involvement.



Image 1: Preoperative X-ray showing the tibial pilon fracture in anteroposterior (AP) and lateral views.



Image 2: 3D CT reconstruction of the tibial pilon fracture demonstrating the complex fracture pattern.

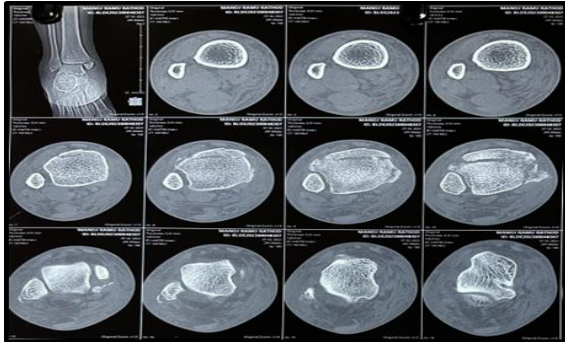


Image 3: Axial CT scans showing cross-sectional images of the tibial pilon fracture



Image 7: X-rays at 6 months postoperative showing continued fracture healing and maintained alignment

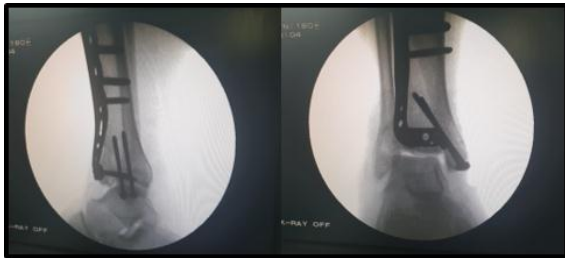


Image 4: Intraoperative C-ARM images showing fixation of the tibial pilon fracture with screws and plates.

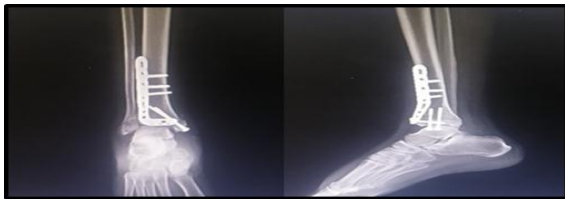


Image 5: Immediate postoperative X-rays displaying the fracture reduction with fixation



Image 8: Post-Follow-Up Clinical Evaluation Demonstrating Dorsiflexion (20°) and Plantar Flexion (50°)



Image 6: X-ray at 3 months postoperatively demonstrating good union and alignment of the tibial pilon fracture

Table 1: Demographic and Injury Characteristics.

Characteristic	Number (%)
Age (years)	
21-35	18 (54.5%)
36-50	10 (30.3%)
51-65	5 (15.2%)
Gender	
Male	26 (78.8%)
Female	7 (21.2%)
Mode of Injury	
RTA	31 (93.9%)
Fall	2 (6.1%)
Side Involvement	
Right	18 (54.5%)
Left	15 (45.5%)
Fibula Involvement	

Yes	24 (72.7%)
No	9 (27.3%)

Table 2: Surgical Approaches and Union Time

Approach	Number (%)	Mean Union Time (weeks)
Anteromedial	16 (48.5%)	14.2
Anterolateral	11 (33.3%)	14.5
Posterolateral	4 (12.1%)	14.8
MIPPO	2 (6.1%)	13.5

Table 3: Functional Outcomes Based on AOFAS Score

Outcome	Number (%)	AOFAS Score Range
Excellent	7 (21.2%)	90-100
Good	21 (63.6%)	75-89
Fair	5 (15.2%)	50-74
Poor	0 (0%)	<50

Table 4: Association of Age and Fibula Involvement with Functional Outcomes

Factor	Outcome	Number (%)	P-value
Age Group	21-35	6 (33.3%)	0.059
		11 (61.1%)	
		1 (5.6%)	
	36-50	1 (10.0%)	
		7 (70.0%)	
		2 (20.0%)	
	51-65	0 (0.0%)	
		3 (60.0%)	
		2 (40.0%)	
Fibula Involvement	Yes	3 (12.5%)	0.076
		16 (66.7%)	
	No	5 (20.8%)	
		4 (44.4%)	
		5 (55.6%)	
		0 (0.0%)	

DISCUSSION

From this study, it can be inferred that surgical management of tibial pilon fractures can lead to good functional results with minimum complications. The mean AOFAS score of 82.33 seen in the study group coincides with the recent trend reported by other researchers. Das et al. had a good-excellent AOFAS score of 60% among the cases they treated with open reduction and internal fixation.^[14] Similarly, Wang et al. had a mean AOFAS score of 85.2 ± 5.1 using a combination of double reverse traction reposer and minimally invasive plate osteosynthesis.^[15] This result proves the efficiency of other surgical methods of treatment.

Our study primarily utilized anteromedial (48.5%) and anterolateral (33.3%) approaches, which are consistent with current practices. Recent research has explored the benefits of different surgical approaches. Yang et al. reported that the medial malleolar window approach showed better clinical efficacy and fracture reduction compared to the traditional anteromedial approach, with shorter operation times and fewer complications.^[16] Additionally, Zhang et al. also showed that a double-hooked locking plate in MIPPO had a significantly shorter operation time, less blood loss, and better ankle recovery than anatomical plates.^[17] Compared with other studies, the mean union time of 14.39 weeks in our study is relatively short. Sabaghzadeh et

al. performed a two-stage process with external fixation and found the average union time to be 200 ± 10 days,^[18] while another study on periarticular external fixation reported a mean time to union of 201 ± 79 days.^[19] We believe the faster time to union may be attributed to satisfactory soft tissue management, stable fixation, and appropriate postoperative care. Our low complication rate of 15.2% is encouraging because of the historically high complication rates that were associated with tibial pilon fractures. Recent studies have highlighted the complexity of factors influencing complication rates, including patient characteristics and surgical techniques. Chowdary et al. showed higher rates of complications in diabetic patients,^[20] while Tentoni et al. found that an acute fixation protocol did not increase wound complications or reoperations.^[21] Our results suggest that appropriate surgical techniques and careful patient selection can lead to favorable outcomes. The demographic patterns observed in our study, with a predominance of young male patients and road traffic accidents as the primary mode of injury, align with recent findings. Coello García et al. consistently showed that tibial pilon fractures predominantly affect males aged 30 to 40 years, with high-energy trauma being the leading cause.^[22] The influence of age and fibula involvement on functional outcomes, as suggested by our findings, is supported by recent research. Javaid et al. found that patients over 45 years had a higher percentage of good outcomes,^[23] while Mogileesh et al. emphasized the importance of

anatomical reduction for better outcomes in cases with fibula fractures.^[24]

Advancements in surgical techniques for tibial pilon fractures show promising results. Parshikov et al. explained in his study that the use of 3D modeling in preoperative planning enhances fracture anatomy comprehension and improves implant positioning.^[25] Additionally, Lineham et al. explored joint distraction using circular ring fixators in acute fractures, showing potential benefits in managing intra-articular distal tibia fractures.^[26]

Recent analyses emphasize that we pay more attention to management of these soft tissue injuries in addition medical comorbidities should be treated, while negative social behaviors such as smoking need to be eliminated in order to minimize complications. For high-energy pilon fractures with substantial soft-tissue trauma, the suggestion of Murawski et al. is that delayed internal fixation and interval temporizing external fixation are preferable methods.^[27] Hill and Davis have pointed out that the prognosis depends upon severity of the fracture pattern and quality of reduction; when planning for complex reconstruction, therefore, this emphasizes the importance of imaging evaluation.^[28] Overall results from our study basically correspond with present-day trends in dealing with tibial pilon fractures. Surgical fixation has good functional outcomes and complications arise seldom. This authorizes the effectiveness of using the approach.

CONCLUSION

Our study concludes that surgical fixation of tibial pilon fractures leads to good functional outcomes and low complication rates when appropriate surgical techniques are employed. The anteromedial and anterolateral approaches are particularly effective in providing excellent fracture site management. Most patients achieved union within 14-15 weeks, with positive functional outcomes as indicated by the AOFAS scores.

These findings can guide orthopedic surgeons in their approach to managing tibial pilon fractures, potentially improving patient outcomes. However, further research with larger sample sizes and longer periods of follow-up is needed to validate these findings and continue improving clinical procedures for treating these challenging fractures.

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