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Original Research Article

COMPARATIVE EVALUATION OF FUNCTIONAL OUTCOMES IN GUSTILO–ANDERSON TYPE IIIA AND IIIB OPEN TIBIAL SHAFT FRACTURES BASED ON EARLY (<6 HOURS) VERSUS DELAYED (>6 HOURS) HOSPITAL PRESENTATION – A PROSPECTIVE OBSERVATIONAL STUDY

Dara Deva Darshini[1], K. Harikrishna Reddy[1], Biju Ravindran[1], Vishnu Vardhan Reddy[1], Indra Kumar Varma[1], Bhargav Ram[1], Dara Abhinay[1]

[1]Department of Orthopaedics, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.

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Corresponding Author:
Dr. Dara Deva Darshini,
Department of Orthopaedics, Narayana Medical College & Hospital, Nellore, Andhra Pradesh, India.
Email: devadarshinidara@gmail.com

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ABSTRACT

Background: Open tibial shaft fractures are among the most challenging orthopedic injuries due to their association with severe soft tissue damage, contamination, infection, delayed union, and functional disability. The concept of the "golden period" in trauma care emphasizes the importance of rapid medical intervention in reducing complications and improving patient outcomes. **Aim:** To evaluate and compare the functional outcomes of patients with Gustilo–Anderson type IIIA and IIIB compound tibial shaft fractures presenting to the hospital within 6 hours of injury versus after 6 hours.

Materials and Methods: This prospective observational study was conducted in the Department of Orthopaedics, Narayana Medical College, Nellore, from April 2024 to April 2026. Thirty patients with Gustilo–Anderson type IIIA and IIIB open tibial shaft fractures satisfying the inclusion criteria were enrolled. Patients were divided into two groups:

- Group A: patients presenting within 6 hours of injury (n=15)
- Group B: patients presenting after 6 hours of injury (n=15)

All patients underwent standardized trauma assessment, intravenous antibiotic administration, surgical debridement, fracture stabilization, and soft tissue management according to institutional protocol. Functional outcomes were assessed using the Lower Extremity Functional Scale (LEFS) at 6 weeks, 3 months, 6 months, and 12 months. Parameters analyzed included GANGA Hospital Open Injury Severity Score, number of surgical procedures required, duration of hospital stay, time to union, complications, and LEFS scores.

Results: The mean age was 28.72 years in Group A and 26.18 years in Group B. Among type IIIA fractures, patients presenting within 6 hours demonstrated significantly fewer surgical procedures (1.5 vs 2.66; p=0.032), shorter hospital stay (6.4 vs 16.11 days; p=0.0026), and earlier fracture union (10 vs 13.5 weeks; p=0.014) compared to delayed presenters. LEFS scores were consistently higher in early presenters at all follow-up intervals. Delayed presentation was associated with increased complications including osteomyelitis, delayed union, and non-union. In type IIIB fractures, although early presenters demonstrated better functional trends, the differences were not statistically significant, suggesting that injury severity had a greater influence on outcome.

Conclusion: Early hospital presentation within the 6-hour golden period is associated with improved clinical and functional outcomes in Gustilo–Anderson type IIIA tibial shaft fractures. Prompt administration of antibiotics, early debridement, and timely stabilization reduce morbidity and enhance recovery.

In type IIIB fractures, the severity of soft tissue injury remains the predominant determinant of outcome irrespective of presentation time.
Keywords: Open tibial fractures, Gustilo–Anderson classification, golden period, LEFS score, GANGA score, functional outcome, tibial shaft fractures.

INTRODUCTION

Open fractures of the tibial shaft are among the most frequently encountered high-energy orthopedic injuries and continue to represent a major challenge in trauma care.[1] Due to the subcutaneous location of the tibia along most of its anteromedial surface, the bone is particularly vulnerable to direct trauma and soft tissue compromise.[2] These injuries are commonly associated with road traffic accidents, industrial trauma, falls from height, and high-velocity crush injuries, especially in young and economically productive individuals.[3]

The management of compound tibial shaft fractures remains complex because of the combined involvement of bone, soft tissues, vascular structures, and the risk of contamination.[4] The severity of soft tissue injury significantly influences fracture healing, infection rates, functional recovery, and long-term morbidity.[5] Open fractures are therefore associated with complications such as delayed union, non-union, chronic osteomyelitis, malunion, prolonged hospitalization, repeated surgical procedures, and permanent functional disability.[6]

The Gustilo–Anderson classification system is the most widely accepted method for categorizing open fractures based on the degree of soft tissue injury, contamination, periosteal stripping, and vascular compromise.[7] Type III injuries represent the most severe spectrum of open fractures and are subdivided into IIIA, IIIB, and IIIC injuries.[7] Gustilo–Anderson type IIIA fractures are characterized by extensive soft tissue laceration with adequate soft tissue coverage over bone, whereas type IIIB fractures involve extensive periosteal stripping, severe contamination, exposed bone, and require flap coverage procedures.[8] These injuries are associated with significantly higher rates of infection and poor functional outcomes.[9]

The concept of the “golden hour” or “golden period” in trauma care emphasizes the importance of rapid medical intervention following injury.[10] Early resuscitation, prompt administration of intravenous antibiotics, meticulous surgical debridement, adequate fracture stabilization, and timely soft tissue management are considered critical steps in reducing bacterial contamination, minimizing tissue necrosis, preserving vascularity, and improving healing potential.[11] Delay in presentation and treatment may lead to progressive soft tissue ischemia, increased bacterial colonization, worsening contamination, systemic complications, and inferior functional outcomes.[12]

Traditionally, the “6-hour rule” for debridement of open fractures has guided orthopedic trauma management.[13] Although recent literature has questioned the absolute validity of this rule, early antibiotic administration and timely debridement continue to play a crucial role in infection prevention and limb salvage.[14] Several studies have demonstrated that delayed treatment in severe open fractures is associated with increased rates of osteomyelitis, delayed union, repeated surgeries, and prolonged rehabilitation.[15]

Despite advances in fixation techniques, wound care protocols, antibiotics, and reconstructive surgery, the influence of timing of hospital presentation on functional outcomes in Gustilo–Anderson type IIIA and IIIB tibial shaft fractures remains inadequately explored, particularly in developing countries where delayed transportation, lack of peripheral trauma care facilities, and socioeconomic factors often contribute to late presentation.[16]

The present prospective observational study was therefore undertaken to evaluate and compare the functional outcomes of patients with Gustilo–Anderson type IIIA and IIIB compound tibial shaft fractures presenting within 6 hours of injury versus those presenting after 6 hours. The study also aimed to assess complications, number of procedures required, duration of hospital stay, time to radiological union, and overall functional recovery using the Lower Extremity Functional Scale (LEFS).

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics, Narayana Medical College, Nellore, from April 2024 to April 2026 after obtaining institutional ethical committee approval and informed consent from all patients.

A total of 30 patients presenting with compound tibial shaft fractures classified as Gustilo–Anderson type IIIA and IIIB were included in the study based on predefined inclusion and exclusion criteria.

Inclusion Criteria

1. Patients aged between 20 and 65 years.
2. Gustilo–Anderson type IIIA and IIIB compound tibial shaft fractures.
3. Fractures located distal to the tibial tuberosity and proximal to 4 cm above the ankle joint.
4. Patients presenting within or after 6 hours from the time of injury.

Exclusion Criteria

1. Pathological fractures.
2. Patients aged less than 20 years or more than 65 years.
3. Tibial fractures with intra-articular extension.
4. Gustilo–Anderson type I, II, and IIIC fractures.
5. Procedures performed more than 24 hours after presentation.

Patients were divided into two groups:

- Group A: Patients presenting within 6 hours of injury (n=15)
- Group B: Patients presenting after 6 hours of injury (n=15)

Initial management of all patients was performed according to Advanced Trauma Life Support (ATLS) principles. Intravenous antibiotics, tetanus prophylaxis, analgesia, wound dressing, and temporary immobilization were administered at presentation. Radiological assessment included anteroposterior and lateral radiographs of the tibia including adjacent joints.

All patients underwent surgical wound debridement and fracture stabilization. Gustilo–Anderson classification and GANGA Hospital Open Injury Severity Score were assessed after thorough debridement. Type IIIA fractures were managed with either intramedullary interlocking nailing or external fixation depending on soft tissue status, while type IIIB fractures were managed using staged procedures including external fixation and soft tissue reconstruction where required.

Patients were followed up clinically and radiologically at 6 weeks, 3 months, 6 months, and 12 months. Outcome parameters assessed included:

- GANGA Hospital Open Injury Severity Score
- Number of surgical procedures required
- Duration of hospital stay
- Time to radiological union
- Complications such as infection, osteomyelitis, delayed union, malunion, and non-union
- Functional outcome using the Lower Extremity Functional Scale (LEFS)

Radiological union was defined as bridging callus formation across cortices with absence of pain at the fracture site on clinical examination.

Statistical analysis was performed using unpaired t-test for continuous variables and Fisher's exact test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 30 patients with Gustilo–Anderson type IIIA and IIIB open tibial shaft fractures were included in the study. Fifteen patients presented within 6 hours of injury (Group A) and fifteen patients presented after 6 hours of injury (Group B). Various demographic, clinical, radiological, and functional outcome parameters were analyzed and compared between the groups.

Table 1: Distribution of Gustilo–Anderson Fracture Types

Group	Type IIIA	Type IIIB	Total
Group A (<6 hrs)	6	9	15
Group B (>6 hrs)	8	7	15

Table 2: Demographic Characteristics

Parameter	Group A (<6 hrs)	Group B (>6 hrs)
Mean Age (years)	28.72	26.18
Male	11	9
Female	4	6
Right Leg Injury	10	8
Left Leg Injury	5	7

Table 3: Contamination Status

Contamination	Group A (<6 hrs)	Group B (>6 hrs)
Low contamination	5	9
High contamination	10	6

Table 4: Timing of Antibiotics and Debridement

Parameter	Group A (<6 hrs)	Group B (>6 hrs)
IV antibiotics within 6 hrs	15	0
Debridement within 6 hrs	13	0
IV antibiotics after 6 hrs	0	15
Debridement after 6 hrs	2	15

Table 5: Mean Total GANGA Scores

GA Type	Arrival Time	Mean Total GANGA Score	P value
IIIA	<6 hrs	8.70	
IIIA	>6 hrs	10.22	0.0805
IIIB	<6 hrs	9.00	
IIIB	>6 hrs	9.25	0.8694

Table 6: Mean Number of Surgical Procedures Needed

GA Type	Arrival Time	Mean Procedures	P value
IIIA	<6 hrs	1.5	
IIIA	>6 hrs	2.66	0.032
IIIB	<6 hrs	2.71	
IIIB	>6 hrs	3.0	0.629

Table 7: Mean Duration of Hospital Stay

GA Type	Arrival Time	Mean Hospital Stay (days)	P value
IIIA	<6 hrs	6.4	
IIIA	>6 hrs	16.11	0.0026
IIIB	<6 hrs	8.14	
IIIB	>6 hrs	11.0	0.3413

Table 8: Mean Time to Union

GA Type	Mean Time to Union <6 hrs (weeks)	Mean Time to Union >6 hrs (weeks)	P value
IIIA	10.00	13.50	0.014
IIIB	9.43	14.00	0.141

Table 9: Comparison of Complications

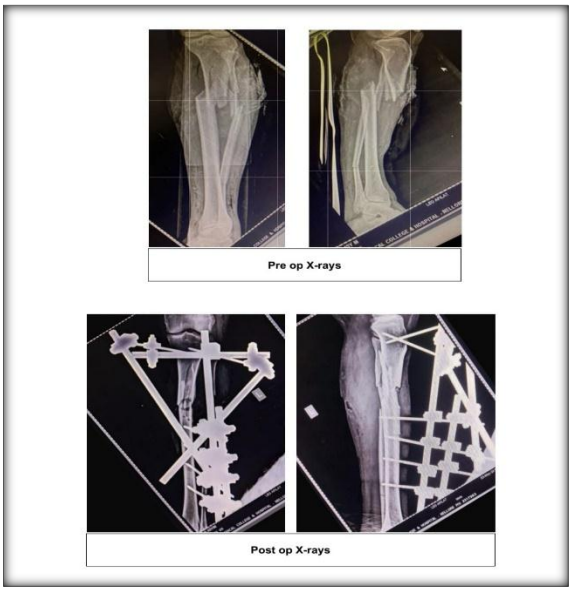
GA Type	Complication	<6 hrs	>6 hrs	P value
IIIA	Non-union	0	1	0.474
IIIA	Osteomyelitis	1	5	0.057
IIIA	Infection	0	0	1.000
IIIA	Malunion	0	0	1.000
IIIA	Delayed union	2	3	0.628
IIIB	Non-union	0	1	0.364
IIIB	Osteomyelitis	1	0	1.000
IIIB	Infection	0	0	1.000
IIIB	Malunion	0	0	1.000
IIIB	Delayed union	0	2	0.109

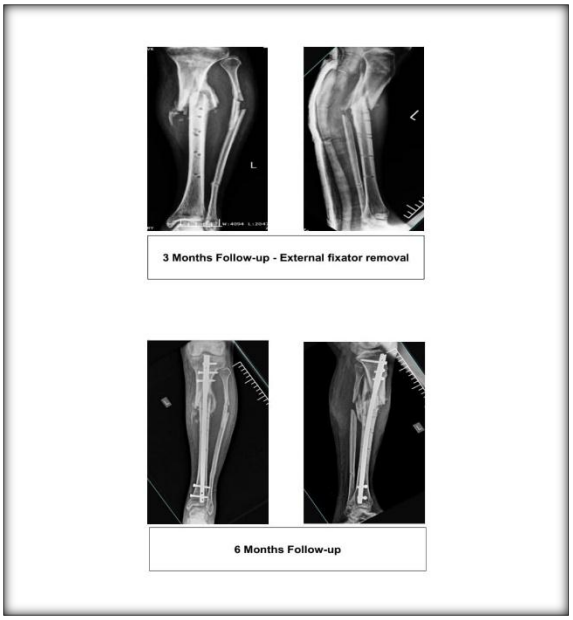
Table 10: Mean LEFS Scores

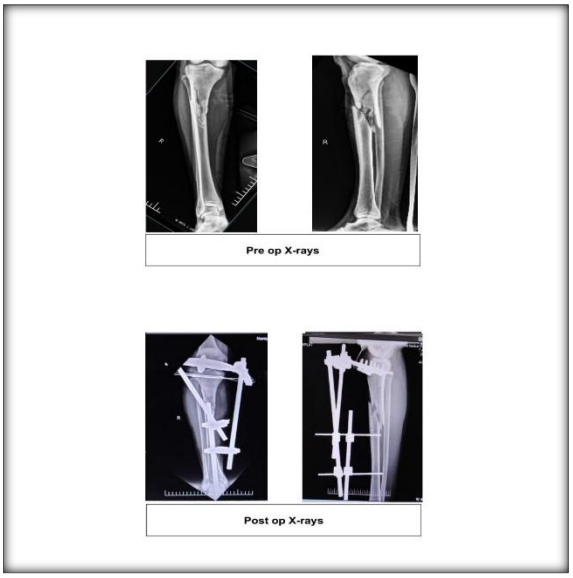
GA Type	Follow-up	Mean LEFS <6 hrs	Mean LEFS >6 hrs	P value
IIIA	6 weeks	31.20	27.67	0.067
IIIA	3 months	47.40	39.67	0.146
IIIA	6 months	62.60	56.22	0.128
IIIA	12 months	72.20	66.33	0.106
IIIB	6 weeks	32.43	26.75	0.128
IIIB	3 months	50.14	38.75	0.130
IIIB	6 months	63.71	52.00	0.184
IIIB	12 months	72.71	62.50	0.203

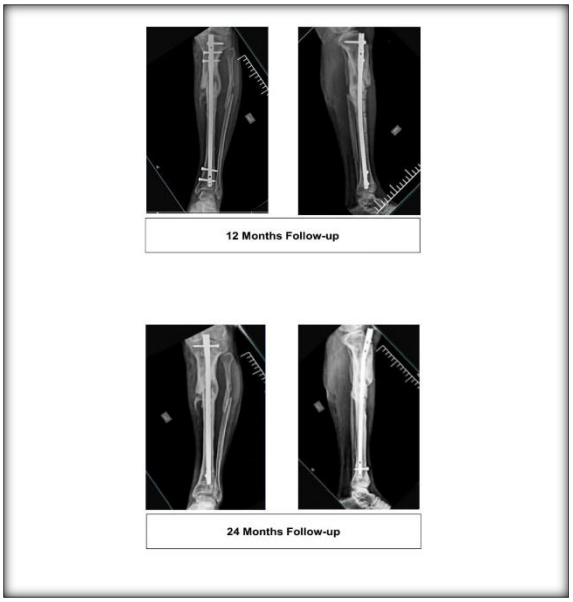
Patients presenting within the 6-hour golden period demonstrated improved outcomes in terms of reduced hospital stay, fewer surgical procedures, earlier fracture union, and higher LEFS scores, particularly among Gustilo–Anderson type IIIA fractures.

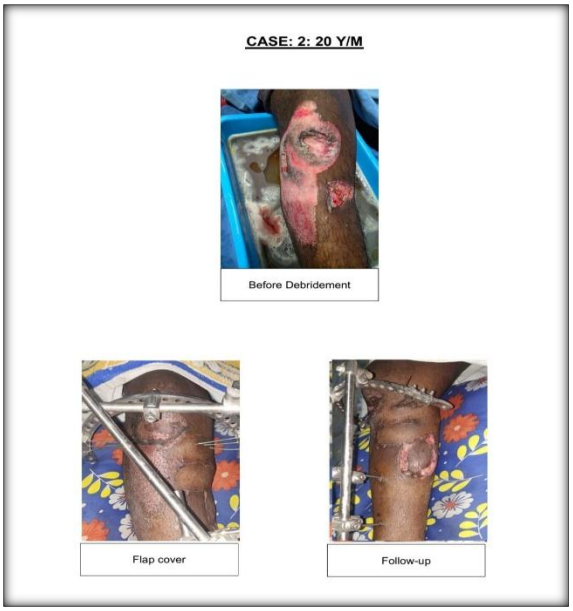
CASE ILLUSTRATIONS











DISCUSSION

Open fractures of the tibial shaft continue to represent a major challenge in orthopedic trauma due to the high incidence of contamination, soft tissue compromise, infection, delayed union, and long-term disability.[17] The present prospective observational study was conducted to evaluate the influence of

hospital presentation within the 6-hour golden period on the clinical and functional outcomes of Gustilo–Anderson type IIIA and IIIB tibial shaft fractures.

In the present study, the majority of patients belonged to the younger age group, with a mean age of 28.72 years in Group A and 26.18 years in Group B. This finding is consistent with previous studies which demonstrated that open tibial fractures predominantly affect young, active individuals involved in high-energy trauma, especially road traffic accidents.[18,19] Male predominance was observed in both groups, which may be attributed to increased outdoor activity, occupational exposure, and vehicular travel among males.[20]

Road traffic accidents constituted the major mechanism of injury in the study population, with a considerable proportion involving high contamination injuries such as two-wheeler accidents and farm-related injuries. The subcutaneous nature of the tibia predisposes these fractures to extensive contamination and soft tissue injury.[21] High contamination was more frequently observed among patients presenting within 6 hours, possibly reflecting the severity of trauma prompting earlier referral and transportation.

Early administration of intravenous antibiotics and prompt surgical debridement are considered essential components in the management of open fractures.[22] In the present study, all patients in Group A received intravenous antibiotics within 6 hours of injury, and most underwent debridement within the same period. This early intervention likely contributed to reduced bacterial colonization, preservation of viable soft tissues, and improved fracture healing.

The mean GANGA Hospital Open Injury Severity Score was higher among delayed presenters in type IIIA fractures, although the difference was not statistically significant. In type IIIB fractures, the scores were comparable irrespective of presentation time. This observation suggests that while delayed presentation may worsen tissue status in moderately severe injuries, the intrinsic severity of type IIIB injuries itself remains the predominant determinant of outcome.[23]

One of the important findings of the present study was the significantly higher number of surgical procedures required in delayed presenters with type IIIA fractures (p=0.032). Delayed presentation may result in worsening contamination, progressive tissue necrosis, and increased need for repeat debridement or secondary procedures.[24] However, in type IIIB fractures, multiple procedures were commonly required irrespective of presentation timing because these injuries inherently demand staged reconstruction and soft tissue coverage.

The duration of hospital stay was significantly prolonged in delayed presenters with type IIIA fractures (p=0.0026). Similar findings have been reported in previous studies where delayed treatment was associated with increased infection rates, repeated surgeries, and prolonged rehabilitation.[25] Although type IIIB fractures also demonstrated longer hospitalization in delayed presenters, the difference was not statistically significant due to the severe nature of injury and extensive reconstructive requirements in both groups.

Fracture union occurred significantly earlier in type IIIA fractures presenting within 6 hours compared to delayed presenters (10 weeks versus 13.5 weeks; p=0.014). Early debridement and stabilization likely preserved the biological environment necessary for fracture healing.[26] In type IIIB fractures, although earlier union was observed in patients presenting within 6 hours, statistical significance was not achieved, indicating that extensive periosteal stripping and soft tissue loss may overshadow the benefits of early presentation.

Complication analysis revealed higher incidences of osteomyelitis, delayed union, and non-union among delayed presenters, particularly in type IIIA fractures. Previous literature has demonstrated that delayed administration of antibiotics and delayed debridement are associated with increased infection risk in open fractures.[27,28] The findings of the present study support the importance of timely intervention in minimizing complications.

Functional outcomes assessed using the Lower Extremity Functional Scale (LEFS) showed consistently better scores among patients presenting within 6 hours at all follow-up intervals. The differences were more pronounced in type IIIA fractures during the early and intermediate follow-up periods. These findings suggest that early trauma care facilitates improved pain control, earlier mobilization, and better restoration of limb function.[29]

Interestingly, in type IIIB fractures, although early presenters demonstrated better functional trends, the differences were not statistically significant. This indicates that the severity of soft tissue injury, periosteal stripping, and requirement for reconstructive procedures may play a more dominant role in determining functional outcome than presentation timing alone.[30]

The present study reinforces the importance of the "golden period" in orthopedic trauma care. Early hospital presentation allows prompt antibiotic administration, timely debridement, fracture stabilization, and soft tissue management, which collectively contribute to improved outcomes. However, the benefits of early presentation appear to be more pronounced in Gustilo–Anderson type IIIA fractures, whereas in type IIIB injuries, the severity of tissue destruction itself remains the major prognostic factor.

The limitations of the present study include relatively small sample size, single-center design, and limited duration of follow-up. Larger multicentric studies with long-term follow-up are required to further validate the impact of early presentation on functional recovery in severe open tibial fractures.

CONCLUSION

Early hospital presentation within the 6-hour golden period was associated with better clinical and functional outcomes in Gustilo–Anderson type IIIA and IIIB open tibial shaft fractures. Patients presenting early demonstrated fewer complications, shorter hospital stay, reduced need for surgical procedures, earlier fracture union, and improved LEFS scores.

The benefits of early intervention were more significant in type IIIA fractures, whereas in type IIIB fractures, the severity of soft tissue injury remained the major determinant of outcome. Prompt antibiotic administration, timely debridement, and early stabilization play a crucial role in improving prognosis in severe open tibial fractures.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

Source of Funding

No external funding was received for this study.

Ethical Approval

The study was conducted after obtaining approval from the Institutional Ethics Committee of Narayana Medical College, Nellore.

Informed Consent

Informed written consent was obtained from all patients participating in the study.

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