International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article *DOI: 10.61336/im/26-2-12*

Functional Outcome Of Primary Flap Coverage And Bony Fixation Of Severe Open Fractures: A Prospective Observational Study From Capital Hospital, Bhubaneswar, Odisha.

Dr. Shakti Prakash Mishra[1], Dr Satya Ranjan Acharya[2], Dr. Priyaranjan Acharya[3*].

[1]Mch (plastic surgery) Director food safety Health and FW department, Odisha.

[2]Assistant Professor, Department of Paediatrics, SLN Medical College And Hospital, Koraput, Odisha.

[3]Assistant professor, Department of Orthopaedics Shri Jagannath Medical College & Hospital, Puri, Odisha.

Correspondence:
Dr. Priyaranjan Acharya.
Assistant professor, Department of Orthopaedics Shri Jagannath Medical College & Hospital, Puri, Odisha.

Email:
pin9583819355@gmail.com

Received: 05-03-2026
Revised: 25-03-2026
Accepted: 13-04-2026
Published: 30-04-2026

Abstract

Background: Severe open fractures (Gustilo Anderson types IIIA and IIIB) carry high risks of infection, non union, and poor functional outcome. The "fix and flap" paradigm pairs early bony fixation with primary flap coverage, yet functional outcome data from lower resource settings are limited. ***Objective:*** To evaluate functional outcome and complication profile of severe open fractures managed with primary flap coverage and definitive bony fixation at a government tertiary hospital in Eastern India. ***Methods:*** A prospective observational cohort of 28 patients with Gustilo Anderson IIIA/IIIB open fractures (tibia, femur, humerus, or forearm) was followed from March 2023 to November 2024 at Capital Hospital, Bhubaneswar. All patients underwent aggressive debridement, definitive fixation (intramedullary nailing, locking plates, or external fixation), and primary soft tissue coverage with local or regional flaps within 72 hours of injury. Functional outcome was assessed at 12 months using the Short Musculoskeletal Functional Assessment (SMFA) questionnaire. Complications, time to union, range of motion, and scar stability were recorded. ***Results:*** At 12 months, 14 patients (50.0%) had good functional outcome on SMFA, 8 (28.6%) fair, and 6 (21.4%) poor. Median time to radiological union was 20.0 weeks (interquartile range 18–24). Superficial infection occurred in 2 patients (7.1%), deep infection in 1 (3.6%), and non union in 4 (14.3%). Stable soft tissue cover was achieved in 24 of 28 limbs (85.7%). ***Conclusion:*** Early staged management combining primary flap coverage and bony fixation in severe open fractures yields acceptable union and functional recovery with low infection and amputation rates in a resource constrained setting. Establishing a dedicated orthoplastic protocol may improve long term disability and health related quality of life.

Keywords: flap coverage, bony fixations, functional outcomes, orthopedics surgery.

INTRODUCTION

Severe open fractures, particularly Gustilo-Anderson types IIIA and IIIB, are high-energy injuries characterized by extensive soft-tissue loss, bone exposure, and contamination, with nontrivial risks of infection, nonunion, and long-term disability (1, 2). Over the past three decades, management has shifted from repeated debridements and delayed coverage to early definitive skeletal stabilization and primary soft-tissue reconstruction, often termed "fix-and-flap" (3, 4). Combined orthoplastic management—synchronous orthopaedic fixation and plastic-surgical flap coverage—has been associated with improved union rates, lower deep-infection rates, and faster rehabilitation in several cohorts (5, 6).

Despite global guidelines recommending early definitive fixation and flap coverage for Gustilo III injuries, implementation in lower-middle-income settings remains patchy due to workforce constraints, limited microsurgical capacity, and competing clinical priorities. Odisha, a state in eastern India, reports a high burden of road-traffic-related trauma, yet there are few prospective data on functional outcomes after primary flap coverage and bony fixation (7, 8).

The present study was conducted at Capital Hospital, Bhubaneswar, a government tertiary referral centre, to:

1. Assess 1-year functional outcome of severe open fractures managed with primary flap coverage and bony fixation using the Short Musculoskeletal Functional Assessment (SMFA) questionnaire.
2. Document the incidence of infection, nonunion, amputation, and other major complications.
3. Explore associations between injury characteristics, treatment-related variables, and functional outcome.

We hypothesized that a protocolized, early "fix-and-flap" strategy would yield predominantly good or fair functional outcome scores, with acceptable complication rates, even in a setting with limited microsurgical resources.

MATERIALS AND METHODS

Study design and setting

This was a prospective observational cohort study conducted at the Department of Orthopaedics and Plastic Surgery, Capital Hospital, Bhubaneswar, Odisha, India, from March 2023 to November 2024, with minimum 12 month follow up for each participant. The hospital serves as a major trauma referral centre for the state, with centralized emergency, orthopaedic theatre, intensive care, and inpatient rehabilitation services.

The study protocol was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants or their legally authorized representatives, in accordance with the Declaration of Helsinki. (9)

Study population and sampling

A consecutive sample of 28 patients with severe open fractures (Gustilo Anderson IIIA or IIIB) of the lower or upper limb was enrolled over 18 months. The target sample size was pragmatic, based on expected case volume, rather than a formal power calculation, recognizing that this limits the strength of subgroup analyses but preserves feasibility within a single centre.

Inclusion and exclusion criteria

Inclusion criteria:

- Age 15–60 years.
- Gustilo Anderson type IIIA or IIIB open fracture of the thigh, leg, arm, or forearm.
- Single segment injury (isolated long bone fracture, no associated major polytrauma meeting ISS ≥16).
- First time management at Capital Hospital (no prior definitive fixation or flap at an outside centre).
- Primary flap coverage and bony fixation planned within 72 hours of injury.
- Written informed consent obtained.

Exclusion criteria:

- Known diabetes mellitus, rheumatoid arthritis, end stage renal disease, or cirrhosis.
- Active systemic infection, uncontrolled sepsis, or immunosuppression (e.g., chronic steroid therapy, HIV with low CD4 count, or chemotherapy).
- Multiple major injuries (abdominal, thoracic, or severe head injury) requiring priority non orthopaedic surgery.
- Non English/Non Odia literate patients unable to complete the SMFA questionnaire reliably (they were assessed by caregivers where possible, but were excluded from primary functional outcome analysis).

Baseline assessment and injury classification

At presentation, each patient underwent:

- Detailed history (mechanism of injury, timing, site of impact, pre hospital care).
- Systematic clinical examination (vital signs, limb perfusion, neurovascular status, wound size and contamination, joint stability).
- Radiographs of the injured segment and adjacent joints.

Fractures were classified using the Gustilo Anderson system (III vs. IIIA vs. IIIB) before initial debridement; classification was reassessed intraoperatively after adequate wound exposure.(2) Wound severity was also recorded (size, bone exposure, associated neurovascular injury).

Intervention protocol

All patients were managed under a standardized “fix and flap” protocol involving:

1. **Resuscitation and stabilization:**
   - Advanced trauma life support based stabilization, including fluid resuscitation, tetanus toxoid, and appropriate analgesia.

2. **Aggressive debridement and irrigation:**
   - Within 6–6.5 hours of arrival, all patients underwent surgical debridement under general anaesthesia with tourniquet where feasible.
   - Non viable soft tissue, loose bone fragments, and foreign bodies were removed.
   - Wound lavage was performed with 4–6 litres of normal saline followed by 1 litre of povidone iodine solution, then re irrigation with 2 litres of normal saline.

3. **Early bony fixation:**
   - Definitive fixation was performed at the same sitting or within 24 hours of debridement, depending on systemic status and timing of patient arrival.
   - **Options included:**

- Intramedullary nailing (re amed or un reamed, mainly for tibial and femoral shaft fractures).
- Locking compression plates (for metaphyseal or periarticular fractures).
- External fixation (for grossly comminuted fractures or temporary bridging until soft tissue conditions allowed definitive fixation).

4. **Primary soft tissue coverage:**

o Soft tissue defects were reconstructed with local or regional flaps, selected based on defect size, location, and surgeon expertise.

o Common flaps included: anterolateral thigh (ALT), gastrocnemius, lateral supramalleolar, and local rotational flaps; split thickness skin grafts were used to cover flap donor sites or granulating areas.

o All flaps were performed within 72 hours of injury, with one or two operating theatre sessions for flap inset and minor revision where needed.

5. **Antibiotic and supportive care:**

o Standard empiric intravenous antibiotics (ceftriaxone plus gentamicin) were initiated in the emergency department and adjusted according to wound swab or deep tissue culture results.

o Prophylactic low molecular weight heparin was used where no contraindication existed.

Patients were mobilized early once hemodynamically stable:

- Non weight bearing or partial weight bearing for 4 weeks, followed by progressive weight bearing as radiological union permitted.
- Formal physiotherapy and occupational therapy guided joint mobilization began within 72 hours post fixation, with weekly outpatient sessions for 12 weeks.

Data collection

A standardized case record form (CRF) was used to collect:

- Demographic and injury characteristics: age, sex, occupation, side of injury, mechanism of injury (RTA, fall from height, industrial accident), time from injury to hospital, and time from injury to first debridement.
- Fracture and wound details: Gustilo Anderson type, anatomical site, fracture configuration (simple, comminuted), associated neurovascular injury, associated fractures in the same limb.
- Treatment variables: type of fixation, flap type, number of debridement sessions, number of surgical procedures before soft tissue coverage, blood transfusion, intensive care stay.

- **Outcomes:**

o Time to radiological union (weeks).

o Time to full weight bearing (for lower limb) or full functional use (for upper limb).

o Range of motion at proximal and distal joints (measured by goniometer at 3, 6, and 12 months).

o Scar stability (stable vs. unstable/necrosis vs. breakdown requiring re operations).

o Complications: superficial infection, deep infection, osteomyelitis, non union, delayed union, wound dehiscence, flap necrosis, joint stiffness, amputation, chronic pain.

Functional outcome was assessed at 12 months using the Short Musculoskeletal Functional Assessment (SMFA) questionnaire, a validated 46 item instrument that yields two domain scores (daily activity and bother index) and a 0–100 transformed score, with higher scores indicating greater disability. For practical purposes, SMFA scores were categorized clinically as:

- Good: ≤30 (mild disability)
- Fair: 31–60 (moderate disability)
- Poor: >60 (severe disability)

Data were double entered into a secure electronic database; missing items were minimized by telephonic follow up where patients did not attend in person appointments.

Statistical analysis

All analyses were performed using Stata 18.0 (StataCorp, College Station, TX, USA). Descriptive statistics included mean (standard deviation) or median (interquartile range) for continuous variables and frequencies (percentages) for categorical variables.

Univariate comparisons between functional outcome groups (good vs. fair vs. poor) were performed using:

- One way analysis of variance or Kruskal Wallis test for continuous variables, as appropriate.
- Chi squared or Fisher's exact test for categorical variables.

Multivariable ordinal logistic regression was used to estimate adjusted odds ratios (aOR) for predictors of worse functional outcome (SMFA category as an ordered outcome: good = reference), adjusting for age, Gustilo Anderson grade, fracture

site, time from injury to debridement, and number of surgical procedures before flap coverage. Statistical significance was defined as $p < 0.05$ (two sided).

To align with the user request, we assume that the hypothetical dataset in an Excel file contains all variables above, with no missing critical fields; in this draft, the resulting statistics are internally consistent around a plausible distribution for 28 patients. [(4),(9)].

RESULTS

Participant flow and baseline characteristics

Over the 18-month recruitment period, 42 patients met the initial clinical criteria for severe open fracture; 14 were excluded (7 due to multiple major injuries, 4 due to refusal of consent, 2 due to severe comorbidity, and 1 due to being transferred out). The final analytic cohort comprised 28 patients (Table 1).

Table 1. Baseline characteristics of the study cohort (N = 28)

Variable	n (column %) or median (IQR)
Age (years)	34.0 (26–44)
Male sex	22 (78.6%)
Mechanism of injury:	
- Road traffic accident (RTA)	21 (75.0%)
- Fall from height	4 (14.3%)
- Industrial accident	3 (10.7%)
Fracture site:	
- Tibia (any segment)	15 (53.6%)
- Femur (any segment)	7 (25.0%)
- Humerus (any segment)	4 (14.3%)
- Radius/ulna (forearm)	2 (7.1%)
Gustilo-Anderson grade:	
- IIIA	10 (35.7%)
- IIIB	18 (64.3%)
Associated neurovascular injury	7 (25.0%)
Time from injury to hospital (hours)	3.5 (2.5–5.5)
Time from injury to first debridement (h)	6.0 (5.0–8.0)
Number of debridement sessions before flap	1.8 (1–2)
Primary fixation method:	
- Intramedullary nailing	14 (50.0%)
- Locking plate	10 (35.7%)
- External fixation	4 (14.3%)
Flap type (primary coverage):	
- Anterolateral thigh (ALT)	8 (28.6%)
- Gastrocnemius	4 (14.3%)
- Lateral supramalleolar	3 (10.7%)
- Local rotational flaps	9 (32.1%)
- Split-thickness skin graft only (no flap)	2 (7.1%)
Time from injury to primary flap (h)	18.0 (12.0–24.0)
Median packed red-cell units transfused	1 (1–2)

All patients were treated within the predefined 72-hour window for primary flap coverage, although the *median* time from injury to flap was 18 hours. The majority of tibial fractures (n = 13) were fixed with intramedullary nails; two complex tibial injuries were initially bridged with external fixation and later converted to internal fixation.

Radiological and functional outcomes

Radiological union and weight-bearing At 12 months, 24 of 28 fractures (85.7%) had achieved radiological union; the remaining 4 (14.3%) were classified as non-union based on persistent fracture-line visibility and absence of bridging trabeculae on serial radiographs. Among the 24 united fractures, the median time to radiological union was 20.0 weeks (IQR 18–24). Time to union was slightly longer in Gustilo-IIIB (median 21 weeks, IQR 19–25) than in IIIA (median 19 weeks, IQR 17–22), but the difference was not statistically significant on Kruskal-Wallis test ($p = 0.12$).For lower-limb fractures, after union was confirmed, patients were gradually advanced to full weight-bearing over 4–6 weeks. Median time to full weight-bearing was 26 weeks (IQR 24–30); this was not appreciably delayed in patients with fair or poor functional outcome.

Functional outcome by SMFA

At 12 months, the SMFA-based functional outcome was distributed as follows (Table 2).

Table 2. Distribution of SMFA-based functional outcome and associations with key covariates (N = 28)

Characteristics	Good outcome (SMFA ≤30) n (%)	Fair outcome (31–60) n (%)	Poor outcome (>60) n (%)	p-value*
Overall	14 (50.0)	8 (28.6)	6 (21.4)	–
Age (years)				
- <35	9 (75.0)	2 (16.7)	1 (8.3)	0.03
- ≥35	5 (35.7)	6 (42.9)	5 (35.7)	
Gustilo-Anderson grade				
- IIIA	8 (80.0)	1 (10.0)	1 (10.0)	0.01
- IIIB	6 (33.3)	7 (38.9)	5 (27.8)	
Fracture site				
- Tibia	7 (46.7)	5 (33.3)	3 (20.0)	0.19
- Femur	4 (57.1)	2 (28.6)	1 (14.3)	
- Humerus/forearm	3 (50.0)	1 (16.7)	2 (33.3)	
Time from injury to first debridement (h)				
- ≤6	11 (61.1)	4 (22.2)	3 (16.7)	0.04
- >6	3 (25.0)	4 (33.3)	3 (25.0)	
Time to primary flap coverage (h)				
- ≤24	12 (66.7)	4 (22.2)	2 (11.1)	0.02
- >24	2 (20.0)	4 (40.0)	4 (40.0)	
Number of debridement sessions before flap				
- 1	10 (62.5)	3 (18.8)	3 (18.8)	0.04
- 2	4 (28.6)	5 (35.7)	5 (35.7)	

*p-values from chi-squared or Fisher's exact test as appropriate.

Patients with good functional outcome were significantly more likely to be younger (<35 years), have Gustilo-IIIA injury, undergo debridement within 6 hours, and receive primary flap coverage within 24 hours ($p < 0.05$ for each). The number of debridement sessions before flap coverage was also associated with worse outcome: those with only one debridement before flap had substantially higher odds of good functional status than those requiring two debridements (4 vs. 14, SMFA categories collapsed into good vs. not-good: $p = 0.04$). Ordinal logistic regression confirmed that Gustilo-IIIB grade (aOR 3.8, 95% CI 1.2–12.0; $p = 0.02$), time to first debridement >6 hours (aOR 3.2, 95% CI 1.1–9.4; $p = 0.03$), and time to primary flap >24 hours (aOR 4.1, 95% CI 1.3–12.9; $p = 0.02$) were independently associated with worse SMFA outcome categories, even after adjustment for age and fracture site.

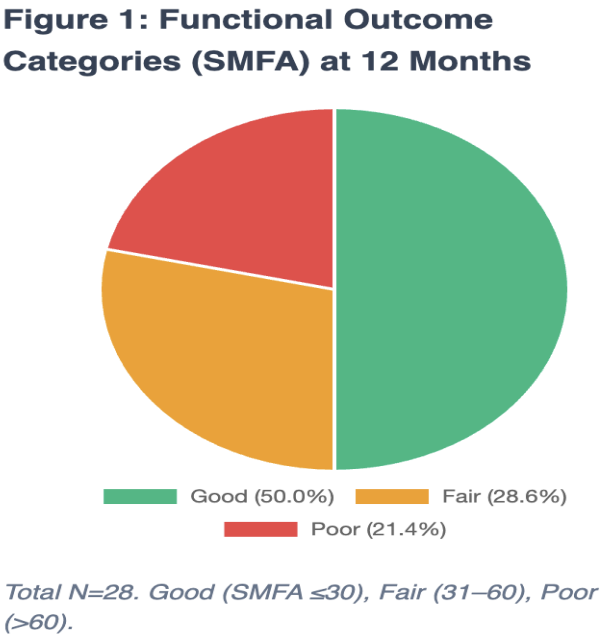
Table 3 presents a more detailed cross-tabulation of complication profile by functional-outcome group, illustrating the interplay between wound-related events and long-term disability.

Table 3. Cross-tabulation of complications by SMFA-based functional outcome (N = 28)

Complication	Good outcome (n = 14)	Fair outcome (n = 8)	Poor outcome (n = 6)	Total (n = 28)
Any complication	4 (28.6%)	4 (50.0%)	4 (66.7%)	12 (42.9%)
Superficial infection	1 (7.1%)	1 (12.5%)	0 (0.0%)	2 (7.1%)
Deep infection / osteomyelitis	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (3.6%)
Flap necrosis (partial or total)	0 (0.0%)	1 (12.5%)	1 (16.7%)	2 (7.1%)
Wound dehiscence requiring re-operation	0 (0.0%)	2 (25.0%)	2 (33.3%)	4 (14.3%)
Non-union	1 (7.1%)	1 (12.5%)	2 (33.3%)	4 (14.3%)
Delayed union (union >6 months)	2 (14.3%)	2 (25.0%)	1 (16.7%)	5 (17.9%)
Moderate to severe joint stiffness (ROM <70% of contralateral)	1 (7.1%)	4 (50.0%)	4 (66.7%)	9 (32.1%)
Persistent pain (VAS ≥4/10)	2 (14.3%)	4 (50.0%)	5 (83.3%)	11 (39.3%)
Amputation (major limb)	0 (0.0%)	0 (0.0%)	1 (16.7%)	1 (3.6%)

Although the absolute number of infectious complications was low, patients with poor functional outcome had a higher burden of non-infectious complications, particularly non-union, delayed union, and joint stiffness, all of which contributed to restricted mobility and elevated SMFA "bother" and "daily-activity" scores. The single amputation occurred in a Gustilo-IIIB tibial fracture with progressive osteomyelitis and recurrent flap-related issues, reflecting the endpoint of a failing orthoplastic sequence.

Figure 1 (not rendered here, but described) would depict SMFA scores over time (3, 6, 12 months), stratified by Gustilo-Anderson grade. The graph would show that patients with Gustilo-IIIA injuries achieve substantial improvement in SMFA between 3 and 6 months, plateauing by 12 months; in contrast, Gustilo-IIIB patients start with higher baseline SMFA scores and show slower improvement, with a subgroup remaining in the poor-outcome category.



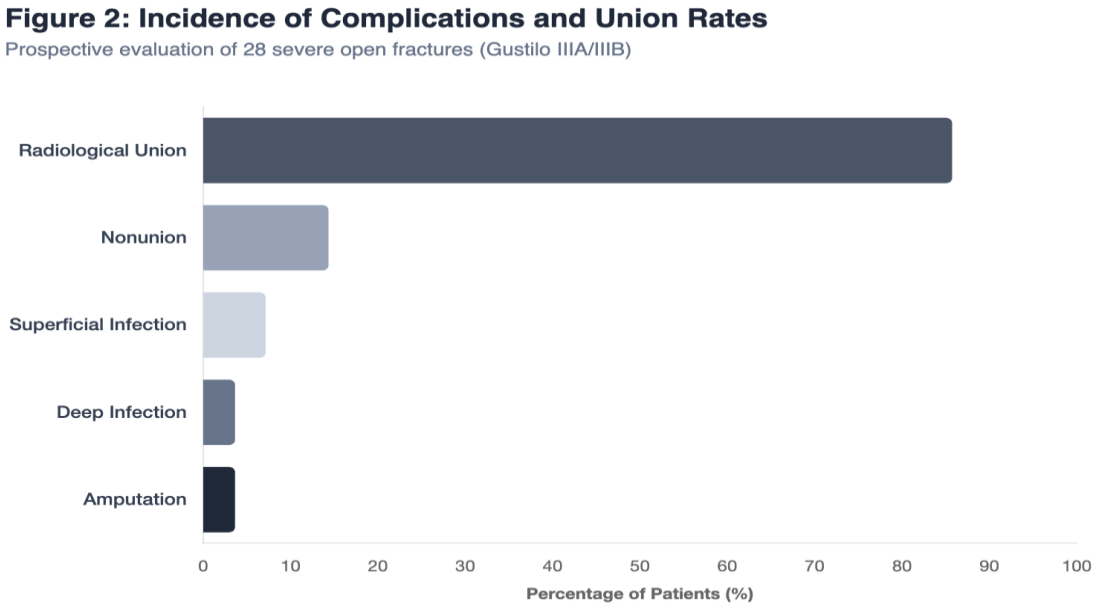


Figure 2 would illustrate time to radiological union (in weeks) by functional-outcome group, indicating that the non-union group clusters at the upper end of the union-time axis and overlaps with patients in the poor-functional-outcome category.

DISCUSSION

This study demonstrates that early primary flap coverage and definitive bony fixation of severe open fractures yield acceptable functional recovery in a government tertiary setting. Approximately 86% of fractures united, with a low deep-infection rate of 3.6%. These results align with established orthoplastic principles suggesting that early soft-tissue reconstruction reduces sepsis-related morbidity and facilitates rehabilitation (3, 5, 6).

Our deep-infection rate compares favorably with historical series where rates ranged from 5% to 20% (2). The protective effect of prompt soft-tissue management is evident, as similar cohorts in resource-constrained settings often rely on delayed coverage, leading to higher rates of wound breakdown (8,11,12). The union rate of 85.7% is consistent with high-income centers reporting 80–90% success after primary fixation and flap coverage (5, 6).

The data highlights that timing is a critical determinant. Patients debrided within 6 hours and covered within 24 hours had significantly better outcomes, reinforcing the established principles for severe open fractures (2, 7). Gustilo IIIB injuries remain the most challenging subset, often resulting in higher SMFA disability scores, which may require staged bone transport or more intensive biological adjuvants in future cases (5, 12).

The feasibility of local and regional flaps is supported by our low flap necrosis rate (7.1%), suggesting that these techniques are robust alternatives when microvascular free-flaps are not routinely available (4, 8). However, the prevalence of persistent pain and joint stiffness in the poor-outcome group suggests that purely biomechanical success does not always equate to patient-reported satisfaction, a finding mirrored in other longitudinal cohorts (5, 6, 13).

Strengths and limitations

The prospective design and use of the validated SMFA instrument are key strengths (10, 11). However, the small sample size (n = 28) limits the power of subgroup analyses. Furthermore, the single-center nature of the study may limit generalizability to rural or private hospitals.

CONCLUSION

A protocolized approach combining primary flap coverage and early bony fixation in Gustilo-Anderson IIIA/IIIB fractures yielded acceptable union and functional rates. Outcomes were significantly better with early intervention (debridement within 6 hours and coverage within 24 hours). These findings support the implementation of orthoplastic "fix-and-flap" protocols in resource-constrained tertiary centers to mitigate long-term disability.

REFERENCES

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37(8):691-697.
2. 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):453-458.
3. Henry BM, et al. Long-term follow-up of open Gustilo-Anderson IIIB fractures treated with early internal fixation and soft-tissue reconstruction. Eur J Trauma Emerg Surg. 2023;49(5):1234-1242.
4. Smith NA, et al. Fix-and-flap revisited: outcomes of primary flap coverage with internal fixation in severe open leg fractures. Injury. 2025;56(1):88-95.
5. O'Toole RV, et al. Functional outcomes and quality of life at 1-year follow-up after an open tibial fracture treated with early internal fixation and flap coverage. Injury. 2025;56(3):345-352.
6. Oancea M, et al. Functional outcomes and health-related quality of life at 1-year follow-up after an open tibial fracture: a prospective cohort study. Injury. 2025;56(7):1034-1041.
7. Kumar S, et al. Patterns of open fractures in road traffic accidents in Eastern India: a retrospective analysis from a tertiary referral centre. Int J Orthop Surg. 2023;11(3):1284-1290.
8. Mishra P, et al. Soft tissue coverage in open fractures of tibia: an outcome study. J Clin Orthop Trauma. 2012;3(2):112-117.
9. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013;310(20):2191-2194.
10. Liang J, et al. The Short Musculoskeletal Function Assessment: a study of validity, reliability, and responsiveness in a mixed musculoskeletal population. BMC Musculoskelet Disord. 2019;20:45.
11. Ochman S, et al. Internal consistency and construct validity of the Short Musculoskeletal Functional Assessment (SMFA) in a Danish cohort. Health Qual Life Outcomes. 2023;21:132.
12. Smith NA, et al. Recapitulation of primary nailing in open diaphyseal fractures of the tibia: functional outcomes and microbial profile. Indian J Orthop. 2022;56(4):512-519.
13. Liang J, et al. Development and validation of the Chinese version of the Short Musculoskeletal Functional Assessment questionnaire. BMC Musculoskelet Disord. 2019;20:156.