



Case Report

## The Clinical Outcomes of Primary Wound Debridement and Closure in Patients with Open Gustilo-Anderson Grade II, IIIA & IIIB Fractures Presenting within 24 Hours of Injury

Dr. Anuj Kumar<sup>1</sup>, Dr. Anubhav Chhabra<sup>2</sup>, Dr. Anurag Chhabra<sup>3</sup>, Dr. Ashok Kumar<sup>4</sup>, Dr. Sumit Kamboj<sup>5</sup>, Dr. Ravi Sihag<sup>6</sup>, Dr. Pankaj Kamboj<sup>7</sup>, Dr. Siddhart Tayal<sup>8</sup>, Dr. Lalit Dhaka<sup>9</sup>, Dr. Rakesh Kumar<sup>10</sup>, Dr. Gajender Yadav<sup>11</sup>, Dr. Sonu<sup>12</sup>, Dr. Suryansh Agnihotri<sup>13</sup>, Dr. Sahil<sup>14</sup>, Dr. Rajeev Mehta<sup>15</sup>

<sup>1</sup>Postgraduate, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>2</sup>Assistant Professor, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>3</sup>Senior Professor and Head of Dept, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>4</sup>Professor, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>5</sup>Associate Professor, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>6</sup>Assistant Professor, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>7,8</sup>Senior Resident, Dept of Orthopedics, MAMC Agroha, Hisar, India

<sup>9,10,11,12,13,14,15</sup>Postgraduate, Dept of Orthopedics, MAMC Agroha, Hisar, India

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### Corresponding Author:

**Dr. Anurag Chhabra**

Senior Professor and Head of Dept,  
Dept of Orthopedics, MAMC  
Agroha, Hisar, India

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### ABSTRACT

**Background:** Open fractures are associated with high risks of infection, delayed healing and functional impairment. The role of primary wound debridement and closure in Gustilo–Anderson grade II, IIIA, and IIIB fractures remains controversial, particularly in resource-limited settings. This study aimed to evaluate clinical outcomes in terms of timings of primary wound debridement and closure with wound healing in patients presenting within 24 hours of injury at a tertiary care Centre in rural India.

**Methods:** This prospective observational study included 114 patients with open Gustilo–Anderson grade II, IIIA, and IIIB fractures presenting within 24 hours of injury. Patients underwent early antibiotic administration, meticulous wound debridement and primary wound closure when feasible. Outcomes were assessed using ASEPSIS score (first 15 days), Southampton score (15–90 days), and CDC/NHSN criteria for surgical site infection (SSI).

**Results:** Most patients were aged 21–40 years (55.3%) and males predominated (86.8%). Road traffic accidents were the most common cause (63.2%), with high-energy trauma observed in 72.8%. Gustilo–Anderson grade IIIB fractures constituted the majority (65.8%). Primary wound closure was performed within 6–12 hours in 58.8% of cases. Primary wound healing occurred in 47.4% of patients, while 88.6% achieved healing within 30 days. Surgical site infection was present in 18.5% of patients. Deep and organ-space/bone infections were significantly associated with delayed wound closure, gross contamination, and higher fracture grades ( $p < 0.05$ ). Early closure (<12 hours) demonstrated better wound healing outcomes and lower infection rates. MRSA was the most frequently isolated organism in infected cases.

**Conclusion:** Primary wound debridement and closure is a safe and effective strategy in carefully selected open Gustilo–Anderson grade II, IIIA, and selected IIIB fractures presenting within 24 hours. Early closure, meticulous debridement, and appropriate antibiotic therapy significantly improve wound healing and reduce infection rates. These findings support early primary closure as a viable option in appropriately selected patients.

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## INTRODUCTION

Open fractures are among the most severe musculoskeletal injuries encountered in trauma care, commonly resulting from high-energy mechanisms such as road traffic accidents, industrial injuries or falls from height.<sup>1</sup> Unlike closed fractures, they involve disruption of the skin and soft tissue, creating direct communication between the external environment and the fracture site. This significantly increases the risk of contamination, infection, delayed union, non-union, and limb loss.<sup>2</sup> Their management requires a multidisciplinary approach focused on early debridement, stabilization and timely wound closure.<sup>3</sup>

Early surgical debridement—ideally within the so-called “golden period” of six to twelve hours—has traditionally been advocated.<sup>4</sup> However, recent evidence suggests that the critical determinant is not the exact timing but the adequacy of debridement and early antibiotic administration. For patients presenting within 24 hours of injury, timely and effective debridement remains central to preventing infection and facilitating wound closure.<sup>5</sup>

Historically, delayed wound closure was preferred to reduce infection risk. However, advances in surgical techniques, antibiotics and wound care have challenged this approach. Current evidence suggests that in selected cases, primary wound closure after adequate debridement may result in comparable or improved outcomes.<sup>6</sup>

Open fractures account for 2–3% of fractures in high-income countries but are more prevalent in low- and middle-income regions due to increased trauma burden. The tibia is the most commonly affected bone due to its subcutaneous location. These injuries are associated with significant morbidity including prolonged hospitalization, repeated surgeries and long-term disability.<sup>7</sup>

The Gustilo-Anderson classification is widely used to grade open fractures based on wound size, soft tissue damage, contamination, and vascular injury. Grade I and II injuries involve lesser soft tissue damage, whereas Grade III injuries represent high-energy trauma with extensive damage and are further subdivided into IIIa, IIIb, and IIIc. Higher grades are associated with increased complication rates.<sup>8</sup>

Wound debridement is the cornerstone of management, aiming to remove devitalized tissue and contaminants. While early debridement has been emphasized, adequacy of the procedure and prompt antibiotic administration are more critical than exact timing.<sup>9</sup>

The choice between timings of wound closure remains controversial. Primary closure may reduce infection rates, hospital stay and recovery time when performed after thorough debridement in clean, viable wounds. However, in grade IIIb fractures, where soft tissue coverage is inadequate or heavily contaminated, the risk remains higher, and closure strategies must be individualized.

Despite advances in trauma care, significant variability persists in the management of open fractures across institutions and surgeons. While the principles of early antibiotic therapy and prompt debridement are widely accepted, the decision to close the wound primarily or delay closure remains controversial, especially in Gustilo-Anderson grade II to IIIb fractures. This study aims to evaluate outcomes of primary wound debridement and closure in open fractures presenting within 24 hours, particularly in Gustilo-Anderson Grade II to IIIb injuries.

## MATERIALS AND METHODS

This study was conducted in the Department of Orthopaedics in Maharaja Agrasen Medical College, Agroha, Hisar from March 2024 to September 2025. The study was started after due approval of Institutional Ethical Committee (IEC). A total of 114 patients of either sex who presented with open grade II, IIIA & IIIB fractures within 24 hrs of injury and consented for the study were included in the study. Patients with open grade I & IIIC fractures, ISS >25, peripheral vascular disease, malignancy, skin and soft tissue loss & severe head, abdominal or chest injuries excluded from the study. In all patients a detailed history regarding the mode, duration and nature of injury was taken. Radiological investigation was done and the fracture was classified according to Gustilo-Anderson classification. Clinical outcomes following wound closure were assessed using the ASEPSIS Score for first 15 days and the Southampton Score from 15 to 90 days. Patients who already had sutured wounds were also included. Sutures were removed as appropriate, and subsequent wound management done. Statistical analysis was performed using SPSS version 20, with  $p < 0.05$  considered statistically significant.

Preliminary wound examination was performed to assess size, location, extent of soft tissue damage, contamination level and a culture-sensitivity swab was obtained. A first dose of broad-spectrum intravenous antibiotic was administered within 30 minutes of presentation. Necessary radiographic views were taken to confirm fracture type and extent.

The wound was then taken up for definitive debridement and closure. The skin and fascia were extended longitudinally for better exposure. Margins were trimmed, and avascular fasciae were excised. Muscle tissue was evaluated for viability and debrided where necessary. Small bony fragments without soft tissue attachments were removed. Gross contaminants and devitalized soft tissue likely to undergo necrosis were excised. The wound was thoroughly irrigated with normal saline based on wound size and contamination.

A negative suction drain was inserted when deep space collection was anticipated. Special attention was given to ensure a tension-free closure.

To immobilize the fracture, a POP splint, skeletal traction, or external fixator was applied according to anatomical site. If wound discharge was observed, a repeat culture-sensitivity swab was obtained.

All patients were followed for 90 days (minimum of 30 days) or until complete wound healing, whichever occurred earlier.

Surgical Site Infection (SSI) was assessed and classified using:

- ASEPSIS Score
- Southampton Score
- Centres for Disease Control and Prevention / National Healthcare Safety Network [CDC/NHSN] Classification of Surgical Site Infections

Prophylactic antibiotic therapy was administered intravenously for the first three days, followed by oral antibiotics for an additional five days.

## RESULTS

Majority belonged to the 21–40 years age group (55.3%) with male preponderance (86.8%). Road traffic accidents (high energy trauma) were the most common mode of injury, reported in 72 participants (63.2%). Most commonly fractured open bone was tibia, seen in 46.5% patients. Smoking was the most frequently reported comorbidity (29.8%). The majority of fractures were classified as Gustilo–Anderson Grade IIIb, accounting for 75 participants (65.8%). Grade II fractures were seen in 34 participants (29.8%). Patients who underwent closure between 6 and 12 hours of injury were 58.8%, followed by those presenting within 6 hours (27.2%). Gross contamination was observed in 68 participants (59.6%). 47.4% of the wounds healed via primary healing. 41.2% wounds had marginal necrosis not requiring surgical intervention, 7.9% had necrosis requiring debridement, and the rest required wound coverage surgery. **Estimated average wound healing time ≈ 18.6 days.** As per the CDC/NHSN surveillance criteria Superficial SSI occurred in 2 participants (1.8%), deep SSI in 15 participants (13.2%), and organ-space/bone SSI in 4 participants (3.5%). MRSA was the most frequently isolated organism, identified in 11 participants (9.6%). Pseudomonas was seen in 7 participants (6.1%).

**Table 1. Association between incidence of SSI and time to closure**

Time to closure	Superficial		Deep		Organ-space/bone		None		p-value
	n	%	n	%	n	%	n	%	
<6 hours (31)	2	6.4	1	3.2	0	0	28	90.4	0.026
6-12 hours (67)	0	0	12	17.9	0	0	55	82.1	
12-18 hours (6)	0	0	2	33.3	0	0	4	66.7	
18-24 hours (10)	0	0	0	0	4	40	6	60	

**Table 2. Association between Gustilo–Anderson class of fracture and type of SSI**

Gustilo–Anderson Grade	Superficial		Deep		Organ-space/bone		None		p-value
	n	%	n	%	n	%	n	%	
II	2	100	0	0	0	0	32	34.4	0.002
IIIa	0	0	3	20	1	25	1	1.1	
IIIb	0	0	12	80	3	75	60	64.5	

## Case 4



**Figure 1: Open grade 3b fracture both bone right leg**



**Figure 3: Wound after primary closure**

**Figure 4: External fixator application with healed wound**

**Case 36**



**Figure 5: Open grade3b fracture right ankle with de-gloving injury**



**Figure 6: Xray right ankle –AP & lateral view  
Xray right foot-AP & oblique view**



**Figure 7: Wound after primary closure**



**Figure 8: Flap coverage for wound**

## DISCUSSION

The present study evaluated the clinical outcomes of primary wound debridement and closure in open Gustilo–Anderson grade II, IIIA, and IIIB fractures presenting within 24 hours. Outcomes were assessed using wound healing parameters, infection rates and standardized scoring systems while analyzing associations with timing, contamination and fracture severity.

The majority of participants in the present study belonged to the economically productive age group of 21–40 years, reflecting the increased exposure of this demographic group to high-risk activities. A marked male predominance was observed with males accounting for nearly 87% of cases.

Road traffic accidents emerged as the most common mechanism of injury in the present study, accounting for over 60% of cases. This pattern was consistent with findings by Yang et al., who reported road traffic accidents as the predominant cause of complex open fractures.<sup>10</sup> High-energy trauma accounted for nearly three-quarters of injuries in the present study, correlating strongly with the observed predominance of Gustilo–Anderson grade III fractures. Both-bone leg fractures constituted the most common injury site in the present study, followed by femoral and tibial fractures. This distribution aligned with observations by Baraouni et al. who reported the tibia as the most frequently involved bone in severe open fractures due to its subcutaneous location.<sup>11</sup>

Smoking emerged as the most prevalent habit in the present study. This finding was clinically significant given the well-established association between smoking and impaired wound healing. The predominance of Gustilo–Anderson grade IIIB fractures in the present study reflected the referral pattern of a tertiary care centre. Most wounds in the present study were closed within 6–12 hours of injury. This early intervention aligned with recommendations by Ondari et al., who demonstrated significantly lower infection rates when antibiotics were administered within 12 hours, reinforcing the critical role of early intervention.<sup>12</sup>

Disturbance of healing was the most frequent ASEPSIS outcome, while severe infections were relatively uncommon. Ondari et al. used the ASEPSIS score to assess wound outcomes and reported comparable infection rates with short and prolonged antibiotic regimens.<sup>12</sup> The present findings aligned with their observation that early antibiotic administration and timely surgery were more critical than antibiotic duration alone (Table.3).

**Table.3 Comparison of ASEPSIS score with other studies**

Author	Year	Findings
Ondari et al. <sup>12</sup>	2015	ASEPSIS scores correlated strongly with delayed antibiotics. (p-value <0.05)
Sp et al. <sup>13</sup>	2022	Marked improvement in wound scores following VAC therapy. (p-value <0.05)
Present study	2024–25	Disturbance of healing was most common; major complications in 14%.(p-value <0.05)

The majority of patients did not develop surgical site infection as per the CDC/NHSN surveillance criteria. Rajasekaran et al. reported deep infection rates of approximately 3% in selected grade III fractures undergoing primary closure, comparable to the present findings.<sup>14</sup> Bakshi et al. reported an infection rate of 6.4% following immediate closure, reinforcing the safety of this approach under strict criteria (Table.4).<sup>15</sup>

**Table.4 Comparison of surgical site infection with other studies**

Author	Year	Findings
Rajasekaran et al. <sup>14</sup>	2007	Deep infection occurred in 3% cases under strict selection.
Bakshi et al. <sup>15</sup>	2025	Infection increased significantly with higher GA grades (12.7%).
Present study	2024–25	Organ-space/ bone infection 3.5%; deep SSI 13.2%.

MRSA emerged as the most frequently isolated organism, consistent with findings by Souza et al. and Ondari et al., who identified *Pseudomonas* and *Staphylococcus* species as predominant pathogens in open fractures (Table.5).<sup>12,16</sup>

**Table.5 Comparison of bacterial infection with other studies**

Author	Year	Findings
Souza et al. <sup>16</sup>	2005	<i>Staphylococcus aureus</i> and <i>Pseudomonas</i> predominated (23%)
Ondari et al. <sup>12</sup>	2015	Similar organism profile with <i>S. aureus</i> and <i>Pseudomonas</i> (28.6%)
Present study	2024–25	MRSA most common; strongly associated with deep SSI.

The significant associations between fracture site, contamination, timing of closure, Gustilo grade, smoking status, and infection severity reinforced established risk factors documented by Bakshi et al. and Fujioka et al (Table.6).<sup>15,17</sup>

**Table.6 Comparison of factors associated with SSI with other studies**

Author	Year	Findings
Fujioka et al. <sup>17</sup>	2021	Delay in closure significantly increased osteomyelitis. (p-value <0.05).
Maimin et al. <sup>18</sup>	2023	Early debridement reduced complication rates (3% vs 11.7%)
Present study	2024–25	SSI significantly associated with delayed closure, contamination, GA grade, and smoking. (p-value <0.05).
Bakshi et al. <sup>15</sup>	2025	Severity of fracture was the strongest predictor of infection.

Based on the findings of the present study, primary wound debridement and closure, combined with prompt antibiotic administration preferably within 12 hours, is strongly recommended, as delayed closure was significantly associated with higher rates of deep and organ-space/ bone surgical site infections.

## LIMITATIONS

The observational design limits the ability to establish definitive causal relationships between primary wound closure and clinical outcomes. The absence of a control group undergoing delayed wound closure restricts direct comparison of treatment strategies.

The study was conducted at a single tertiary care center, which may limit the generalizability of results to other healthcare settings, particularly primary or resource-limited institutions. The predominance of Gustilo–Anderson Grade IIIB fractures may have influenced infection and complication rates, potentially skewing outcome interpretation.

## CONCLUSION

Primary wound debridement and closure is a safe and effective management strategy in selected patients with open fractures. When combined with early antibiotic administration and meticulous surgical technique, primary closure particularly within 12 hours resulted in satisfactory wound healing in the majority of patients, with acceptable surgical site infection rates. Conversely, delayed closure and gross contamination significantly increased the risk of deep and organ-space/bone infections

The study supports a shift from routine delayed closure toward a more individualized, evidence-based approach emphasizing early definitive management in appropriately selected cases.

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