

# Staged Reconstruction Strategy for Gustilo Type IIIB and IIIC Open Fractures: A Case Series of 23 Patients

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## Learning Point of the Article:

A staged “fix followed by flap” strategy is a practical alternative for severe Gustilo Type IIIB/IIIC open fractures when early combined reconstruction is not feasible.

## Abstract

**Introduction:** Management of Gustilo Type IIIB and IIIC open fractures remains challenging, particularly with regard to the timing of definitive fixation and soft-tissue reconstruction. Although early combined orthoplastic management is widely recommended, it is not always feasible in patients with severe injuries, polytrauma, or complex fracture patterns.

**Materials and Methods:** We retrospectively reviewed 23 consecutive patients with Gustilo Type IIIB or IIIC open fractures treated at our institution between April 2022 and October 2024. Five patients underwent a single-stage “fix and flap” strategy, whereas 18 patients underwent a staged “fix followed by flap” strategy. Treatment selection was based on injury severity, fracture complexity, soft-tissue condition, and the overall physiological status of the patient. Clinical outcomes, including deep infection, non-union, malunion, and amputation, were assessed, together with treatment timing and operative duration.

**Results:** Patients treated with the staged strategy tended to have more severe overall injuries, with a higher mean injury severity score than those treated with the fix-and-flap strategy ( $13.8 \pm 7.3$  vs.  $10.8 \pm 4.0$ ,  $P = 0.25$ ). All patients requiring concurrent surgery for other anatomical sites were treated with the staged protocol. Deep infection occurred in two patients in each group. One patient in the staged group required additional surgery for an infected non-union. No cases of malunion or amputation were observed in either group. Importantly, no patients required additional flap procedures, indicating that adequate soft-tissue coverage was achieved in all cases.

The interval from injury to osteosynthesis was similar between groups, whereas the interval to soft-tissue reconstruction was significantly longer in the staged group ( $9.2 \pm 2.2$  vs.  $4.8 \pm 0.8$  days,  $P < 0.01$ ). Operative time for osteosynthesis was also significantly longer in the staged group.

**Conclusion:** A staged “fix followed by flap” strategy appears to be a practical and clinically useful option for managing complex Gustilo Type IIIB and IIIC open fractures when early combined reconstruction is not achievable. This approach may allow more accurate planning of soft-tissue coverage in severe injuries.

**Keywords:** Gustilo Type IIIB, Gustilo Type IIIC, open fracture, staged reconstruction, fix followed by flap, fix and flap.

## Introduction

The Gustilo-Anderson classification is widely used in the evaluation of open fractures and remains an important predictor

of complications such as deep infection, non-union, and amputation [1]. Among open fractures, Gustilo Type IIIB and IIIC injuries represent the most severe forms and are associated

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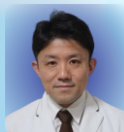
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## Author's Photo Gallery



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**Figure 1:** Pre-operative radiographs and clinical photographs of an open pilon fracture with Lisfranc dislocation.

with markedly increased complication rates compared with lower-grade injuries [2,3,4]. For this reason, these injuries require meticulous orthoplastic management to preserve limb function and reduce the risks of infection, non-union, and limb loss. Early soft-tissue coverage has been emphasized as a key principle in the management of severe open fractures [5,6]. Gopal et al. reported favorable results with the “fix and flap” strategy, in which definitive skeletal stabilization and flap coverage are performed together within 72 h after injury [7]. This concept has influenced contemporary guidelines, including those recommending definitive soft-tissue coverage within 72 h or, at the latest, within 7 days [8,9,10,11]. Despite the theoretical advantages of early combined reconstruction, this approach is not always feasible in daily clinical practice. Patients with polytrauma, hemodynamic instability, extensive bone defects, or highly complex fracture patterns may require damage control procedures, prioritization of other injuries, or prolonged time for definitive fixation. In such situations, staged

reconstruction may provide a practical alternative. In our institution, when immediate combined fixation and coverage is difficult, definitive fracture stabilization is performed first, followed by delayed soft-tissue reconstruction once the patient’s condition stabilizes and the final extent of the soft-tissue defect becomes clear. During this interval, negative pressure wound therapy (NPWT) is used as temporary wound management [8,9].

The purpose of this study was to describe our institutional experience with two treatment strategies for

Gustilo Type IIIB and IIIC open fractures: a single-stage “fix and flap” approach and a staged “fix followed by flap” approach. Rather than attempting to establish comparative effectiveness, we aimed to evaluate the clinical feasibility of staged reconstruction in severe and complex injuries.

## Materials and Methods

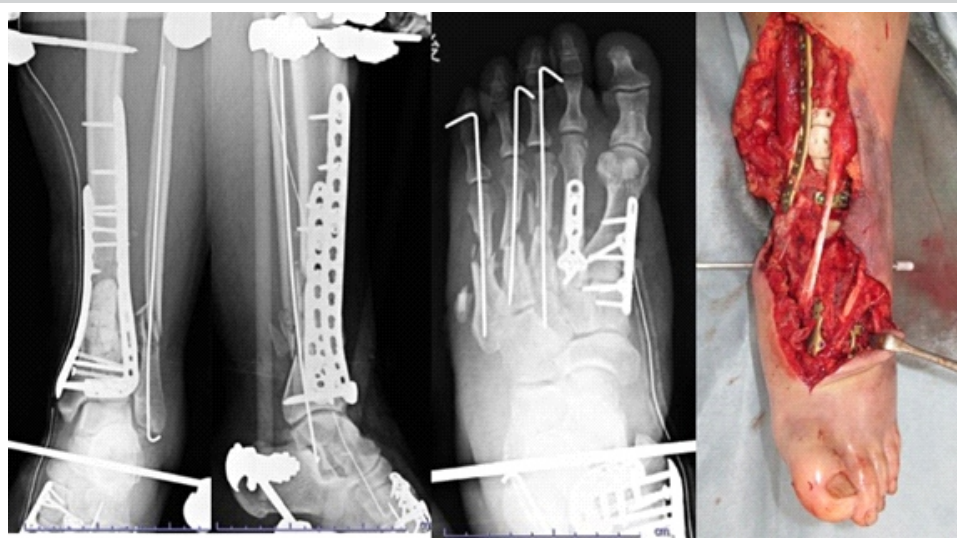
### Study design

This study was designed as a retrospective descriptive case series.

### Patients

We retrospectively reviewed all consecutive patients with Gustilo Type IIIB or IIIC open fractures treated at our institution between April 2022 and October 2024. Patients were either admitted directly through our emergency department or referred from regional hospitals after initial debridement and provisional stabilization.

Patients were included if they were 16 years of age or older and underwent treatment using either a single-stage “fix and flap” strategy or a staged “fix followed by flap” strategy. Patients treated with skin graft alone without flap reconstruction, patients transferred more than 1 week after injury, and patients with pre-existing infection at the time of transfer were excluded. Post-operative outcomes were evaluated in patients with a minimum follow-up of 12 months. No formal sample size calculation was performed because this study was a retrospective descriptive case series. All consecutive eligible patients treated during the study period were included.



**Figure 2:** Post-operative images after internal fixation and wound size measurement.



**Figure 3:** Image of free latissimus dorsi flap reconstruction performed on hospital day 6.

### Treatment strategy

The choice of treatment strategy was determined according to injury severity, fracture complexity, soft-tissue condition, and the overall physiological status of the patient.

In the fix-and-flap strategy, definitive osteosynthesis and soft-tissue reconstruction were performed on the same day. This strategy was selected when fracture fixation was technically straightforward, and the anticipated soft-tissue defect was not expected to change substantially after fixation.

In the fix-followed-by-flap strategy, definitive fracture fixation was performed first, and soft-tissue reconstruction was performed at a later stage. This approach was preferentially used in patients with polytrauma, extensive bone defects, comminuted or complex fractures, or when the extent of soft-tissue coverage could be better determined after osteosynthesis. NPWT was used in both strategies before definitive soft-tissue coverage.

### Data collection

The following variables were collected: Age, sex, body mass index (BMI), Gustilo classification, fracture site (upper or lower extremity), skin defect area, presence of fractures at other anatomical sites requiring surgery, American Society of Anesthesiologists Physical Status (ASA-PS) classification, injury severity score (ISS), type of fixation (plate fixation, intramedullary nailing, or combination), and type of soft-tissue reconstruction (free flap or pedicled flap).

### Outcomes

Primary outcomes included deep infection, non-union, malunion, amputation, and the need for additional flap procedures.

Secondary outcomes included time from injury to

osteosynthesis, time from injury to soft-tissue reconstruction, operative time for osteosynthesis, operative time for soft-tissue reconstruction, and interval from osteosynthesis to soft-tissue reconstruction in the staged group.

### Statistical analysis

Comparative analysis between the two groups was performed using Student's t-test for continuous variables and Fisher's exact test for categorical variables. A  $P < 0.05$  was considered statistically significant. All analyses were conducted using EZR statistical software.

### Ethics approval

This study was conducted in accordance with the Declaration of Helsinki. The Institutional Bioethics Committee of Yonemori Hospital approved the study (Approval No. YR2405, approved on August 5, 2025) and waived the requirement for informed consent because of the retrospective design. Given the retrospective nature of the study, ethical approval was obtained after data collection had commenced.

### Results

A total of 23 patients were included in this study: 5 were treated with the fix-and-flap strategy and 18 with the staged fix-followed-by-flap strategy. There were no statistically significant differences between the two groups in age, sex, BMI, Gustilo classification, fracture site, skin defect area, ASA-PS, or the presence of fractures at other anatomical sites requiring surgery. However, patients in the staged group tended to have more severe overall injuries. The mean ISS was higher in the staged group than in the fix-and-flap group ( $13.8 \pm 7.3$  vs.  $10.8 \pm 4.0$ ,  $P$

**Table 1: Comparison of demographic information of the patients and details of open fracture between two groups**

Variables	Fix and flap	Fix followed by flap	P-value
Case	5	18	
Age	51.0±16.9	53.0±16.2	0.91
Male/female	3/2	16/2	0.19
Body mass index (kg/m <sup>2</sup> )	22.1±3.2	26.5±5.6	0.13
Gustilo IIIB/IIIC	4/1	17/1	0.4
Upper limb/lower limb	2/3	2/16	0.19
Skin defect area (cm <sup>2</sup> )	121.2±55.0	156.7±135.5	0.85
Fractures of other parts	0	7	0.27
American society of anesthesiologists physical status	1.4±0.5	2.1±0.9	0.15
Injury severity score	10.8±4.0	13.8±7.3	0.25

= 0.25)(Table 1). Regarding fixation methods, plate fixation was used in 19 cases, intramedullary nailing in 2, and a combination of plate fixation and intramedullary nailing in 2. For soft-tissue reconstruction, free flaps were used in 15 cases, while pedicled flaps were used in eight cases. In addition, all cases requiring concurrent surgery for other anatomical sites were managed using the staged protocol. Deep infection occurred in two patients in each group ( $P = 0.19$ ). The causative organisms identified in these infected cases included methicillin-resistant *Staphylococcus aureus* and *Enterobacter cloacae*. One patient in the staged group developed an infected non-union and required additional surgical intervention. This patient was considered at particularly high risk because of severe contamination at the time of injury. No cases of malunion or amputation were observed in either group. Importantly, no patients required additional flap procedures after initial soft-tissue reconstruction, indicating that adequate coverage was achieved in all cases. No apparent differences in major complication rates were observed between the two groups (Table 2).

The mean interval from injury to osteosynthesis was  $4.8 \pm 0.8$  days in the fix-and-flap group and  $4.2 \pm 2.9$  days in the staged group ( $P = 0.29$ ). The mean interval from injury to soft-tissue reconstruction was significantly shorter in the fix-and-flap group than in the staged group ( $4.8 \pm 0.8$  vs.  $9.2 \pm 2.2$  days,  $P < 0.01$ ). The mean operative time for osteosynthesis was significantly shorter in the fix-and-flap group than in the staged group ( $81.8 \pm 19.1$  vs.  $227.2 \pm 88.7$  min,  $P < 0.01$ ). In contrast, the mean operative time for soft-tissue reconstruction was similar between the two groups ( $429.4 \pm 116.8$  vs.  $414.2 \pm 199.9$  min,  $P = 0.92$ ). In the staged group, the mean interval between osteosynthesis and soft-tissue reconstruction was  $5.0 \pm 2.1$  days. Additional procedures were performed as needed to

achieve union. These included bone grafting using the Masquelet technique in selected cases.

### Case Presentation

A 59-year-old male sustained a work-related injury resulting in an open pilon fracture and a Lisfranc dislocation on the left side (Fig. 1). Emergency stabilization using external fixation and NPWT was performed on admission. The initial soft-tissue defect measured approximately  $10 \times 5$  cm. On hospital day 2, second-look surgery and NPWT exchange were conducted. Internal fixation was performed on day 4, revealing an expanded soft-tissue defect of approximately  $25 \times 20$  cm (Fig. 2). A free latissimus dorsi flap was applied on day 6 (Fig. 3). Bone grafting using the Masquelet technique was done at 6 weeks. At 1-year follow-up, the patient had no complications and returned to work.

### Discussion

The present study describes our institutional experience in managing severe open fractures using two treatment strategies: single-stage fix and flap, and staged fix followed by flap. The staged protocol was preferentially applied to patients with more severe injuries, including polytrauma, complex fracture patterns, and cases requiring prolonged operative time for definitive fixation. This tendency was supported by the higher ISS in the staged group, although not statistically significant. In addition, all patients requiring concurrent surgery for injuries at other anatomical sites were treated with the staged protocol, reflecting real-world clinical decision-making based on injury severity and patient condition.

Early combined reconstruction is widely advocated to reduce complications in severe open fractures. The fix-and-flap strategy performed within 72 h has been shown to decrease infection and amputation rates [7], and current guidelines recommend early soft-tissue coverage within 72 h or up to 7 days [10,11]. However, this approach is not always feasible in patients with polytrauma, unstable physiology, or complex fractures requiring prolonged fixation.

In such situations, a staged strategy may be more practical. Definitive skeletal stabilization can be prioritized first, allowing more accurate assessment of soft-tissue defects and improved planning of reconstruction. An additional advantage of the staged “fix followed by flap” approach is the ability to determine the required soft-tissue coverage after osteosynthesis. As demonstrated in the presented case, the extent of the defect may change after fixation due to realignment and stabilization. Simultaneous fixation and flap coverage may therefore result in inaccurate estimation of flap size and insufficient coverage. In

**Table 2: Comparison of treatment outcomes between two groups**

Outcomes	Fix and flap	Fix followed by flap	P-value
Deep infection	2	2	0.19
Non-union	0	1	1
Malunion	0	0	1
Amputation	0	0	1
Additional flap procedure	0	0	1
Mean time from injury to osteosynthesis (day)	$4.8 \pm 0.8$	$4.2 \pm 2.9$	0.29
Mean time from injury to soft-tissue reconstruction (day)	$4.8 \pm 0.8$	$9.2 \pm 2.2$	<0.01
Mean time for osteosynthesis (min)	$81.8 \pm 19.1$	$227.2 \pm 88.7$	<0.01
Mean time for soft-tissue reconstruction (min)	$429.4 \pm 116.8$	$414.2 \pm 199.9$	0.92



contrast, the staged approach enables reconstruction after the final defect is clearly defined, allowing more reliable coverage. In this series, no cases required additional flap procedures, suggesting that adequate coverage was achieved.

NPWT plays an important role in this staged approach by maintaining wound conditions during the interval before reconstruction and potentially contributing to infection control [8,9]. The staged strategy also offers practical advantages, including flexibility in surgical scheduling and improved coordination between orthopedic and plastic surgery teams. Previous studies have reported favorable outcomes with staged orthoplastic management without increased complication rates [12,13].

Nevertheless, delayed reconstruction may increase the risk of wound complications. Prolonged intervals between fixation and flap coverage have been associated with higher infection rates [13,14,15]. In this study, the interval in the staged group exceeded recommended timeframes in some cases, indicating an area for potential improvement. Although no clear increase in major complications was observed, minimizing delay remains important.

This study has several limitations, including its retrospective design, small sample size, and heterogeneity of injury patterns. Treatment selection was based on clinical judgment, and the staged group included more severely injured patients. Therefore, these findings should not be interpreted as demonstrating comparative effectiveness, but rather as supporting the clinical feasibility of staged reconstruction.

**Declaration of patient consent:** The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Conflict of interest:** Nil **Source of support:** None

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Accordingly, this study should be interpreted as a descriptive case series reflecting real-world clinical practice, rather than as a comparative effectiveness analysis.

Importantly, this study reflects real-world trauma care, where ideal timing is not always achievable. In such settings, a staged fix-followed-by-flap approach may represent a practical and adaptable option for managing complex open fractures.

## Conclusion

A staged "fix followed by flap" strategy appears to be a feasible and practical option for the management of complex Gustilo Type IIIB and IIIC open fractures. Although soft-tissue reconstruction is delayed, major complications such as deep infection, non-union, and amputation were not increased in this descriptive series. Importantly, no patients required additional flap procedures, suggesting that adequate and reliable soft-tissue coverage can be achieved with this approach.

## Clinical Message

When early combined orthoplastic reconstruction is not feasible, a staged "fix followed by flap" strategy provides a practical alternative for managing Gustilo Type IIIB and IIIC open fractures. Definitive fixation first allows more accurate assessment of the soft-tissue defect and facilitates appropriate flap selection.

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