Delayed reconstruction of soft tissue defects in mangled lower extremities: A report of three cases

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ABSTRACT

Background: The best timing for the soft tissue reconstruction procedure in the mangled lower extremity is still controversial. Despite the advantages of acute treatment, delayed soft tissue reconstruction are often inevitable for various reasons. This case report aims to present three cases of delayed reconstruction to treat lower extremities soft-tissue defects in mangled lower extremity following high-energy trauma.

Case Series: This study included three cases that underwent delayed reconstruction for the mangled lower extremity. The definitive reconstructions were done in 15, 30, and 60 days after injury and all cases underwent serial debridement before the definitive procedure. The reconstruction methods used were skin graft and free flap. There was no graft/flap loss observed in this study.

Conclusion: We believe that soft tissue reconstruction of mangled lower extremities following high-energy trauma may also be safely done in a delayed setting if the wound debridement is adequately done, and the basic reconstructive principles are fulfilled.

Keywords: delayed reconstruction, soft tissue, defect, mangled extremities, crush injury

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INTRODUCTION

Complex high-energy trauma to the lower extremity often leads to devastating morbidity for the patients. It mostly results in mangled extremity caused by a crush injury, requiring complex reconstruction to restore anatomic and functional deficits. Management of soft-tissue defects in mangled lower extremities remains a challenge for reconstructive surgeons. Many procedures have been reported to manage the soft-tissue defect, including the timing consideration for the reconstruction.1 The best timing for the soft tissue reconstructive procedure following high-energy trauma is still controversial. Due to the open wound’s exposures, the aim of early soft tissue reconstruction is to minimize the possibility of nosocomial contamination. Many investigations have been reported that early reconstruction (within 72 hours) can reduce post-operative infection, flap failure, non-union fracture rates as well as the chance of osteomyelitis.2 Based on those studies, the implementation of emergency soft tissue reconstruction is thought to allow a considerable decrease in the rate of complications.3

Despite the advantages of acute treatment, delayed soft tissue reconstruction are often inevitable for some reasons. Communication issues between plastic and orthopedic surgeons, different opinions about the timing of wound closure, and a requisite of re-debridement to provide an optimal wound bed, complex microsurgery technique, as well as equipment that hard to follow in an emergency setting often deter the implementation of emergency reconstruction. The other reason is the presence of polytrauma in most patients who suffered from high-energy trauma, where saving a patient’s life is the top priority.4–5 In this article, we presented three cases of delayed reconstruction to treat lower extremities soft-tissue defects in mangled lower extremity following high-energy trauma.

CASE 1

Male, 45 years old was injured in a motorcycle crash and referred to our hospital 6 hours after injury. The patient was presented with polytrauma and crush injury of the right leg (Figure 1-2), open dislocation of ankle joint, closed fracture right humerus middle third, and pelvic ring injury with rapid response hypovolemic shock. The orthopaedic surgeon performed immediate debridement, then fixed the
fracture fragment by an external fixator, and the patient was left with soft tissue defects on the right leg (Figure 3).

Reconstructive surgery of the right leg skin defect was done in 15 days after injury with Split-Thickness Skin Graft (STSG) (Figure 4). 30 days post-trauma, the patient was discharged, and post-operative wound care was performed in an outpatient clinic. The graft achieved 97% in the first month after surgery, and the rest raw surface area was healed by secondary intention (Figure 5).

Figure 1. The clinical picture of the patient’s right leg during admission.

Figure 2. X-ray of the patient’s right leg during admission.

Figure 3. The pre-operative clinical picture of the right leg soft tissue defect. A) Anterior View, B) Medial View, C) Lateral View, D) Posterior View.

Figure 4. The postoperative clinical picture of the patient’s right leg. A) Anterior View, B) Medial View, C) Lateral View, D) Posterior View.

Figure 5. The clinical picture of 1-month post-reconstruction. A) Anterior View, B) Medial View, C) Lateral View, D) Posterior View.

Figure 6. Photo of the patient’s right leg during admission.
CLINICAL CASE 2

A 22-year-old female was diagnosed with crush injury of the right leg with right tibia plateau fracture type 2 Schatzker classification and right middle third tibia fracture IIIB type (Gustillo-Andersen classification) after a motorcycle crash injury (Figure 6–7). The patient was warded with a stable state. The patient then underwent two extensive debridements; the first operation was debridement of the right leg together with a fracture fixation by a lag screw and external fixator by orthopaedic surgeon during admission (Figure 8). Six days later, second debridement was performed by a plastic surgeon, and the patient was left with soft-tissue and 8 cm long tibial bone defect on the right leg (Figure 9–10).

Reconstructive surgery was performed 30 days after injury with free musculocutaneous Anterolateral Thigh (ALT) flap and STSG (Figure 10–12). The skin paddle of the flap measured 20x14cm (Figure 11). The descending lateral femoral circumflex artery and vein to the peroneal
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artery and vein in and end-to-end fashion using 8/0 nylon. Eventually, the soft-tissue defect was covered with the skin paddle of the ALT flap and meshed STSG on the posterolateral part (Figure 12). The patient was acquitted from hospital 30 days after trauma. The flap was viable and the graft take was 98% two months after surgery (Figure 13). The next treatment plan is external fixator removal and bone graft by the orthopaedic surgeon.

**CASE 3**

Female, 40 years old diagnosed with crush injury of the left foot and right hip dislocation after injured in a motorcycle crash (Figure 14–15). The patient was hospitalized in a stable state. The first operation was reduction of right hip dislocation and debridement of left foot by orthopaedic surgeon in emergency operating room. The patient then consulted to the

![Figure 10](image1.png)

**Figure 10.** Pre-Operative clinical picture of the right leg soft tissue defect. A) Anterior View, B) Medial View, C) Lateral View, D) Posterior View.

![Figure 11](image2.png)

**Figure 11.** A) Flap Design, B) Skin Paddle, C) Flap Pedicle.

![Figure 12](image3.png)

**Figure 12.** Post-operative clinical picture of the right leg. A) Anterior View, B) Medial View, C) Lateral View, D) Posterior View.

![Figure 13](image4.png)

**Figure 13.** Clinical picture of 2 month post reconstruction. A) Anterior View, B) Medial View, C) Lateral View, D) Posterior View.

![Figure 14](image5.png)

**Figure 14.** Clinical picture of the patient’s left foot during admission. A) Medial View, B) Lateral View, C) Posterior View.

![Figure 15](image6.png)

**Figure 15.** Xray of the patient’s left foot during admission.
plastic surgery department to close the defect on left foot. Second debridement as well as Lisfranc amputation was performed on the twelfth day after injury (Figure 16 – 17). STSG was used to close the left foot defect 2 months after injury (Figure 18 – 19). She was discharged in 35 days after trauma. Post-operative care was uneventful and the graft achieved 99% took in the first month after surgery (Figure 20).

DISCUSSION

The mangled extremity is defined as a limb with injury concerns at least two out of four systems (soft tissue, nerves, vessels and bone), caused by crush then result in an unrecognizable limb. There are two treatment options for mangled extremities such as amputation or salvage reconstruction. The reconstructive strategies for salvage limb decision consist of skeletal stabilization, debridement, restoration of neurovascular system ensuring adequate limb perfusion, soft-tissue repair as well as wound coverage. A common principle in lower limb reconstruction depends on the anatomical division of leg (proximal, middle, and distal). The distal third reconstruction usually adapts the principles of the "reconstructive elevator" into practice to provide wound coverage due to minimum local tissue available for tissue rearrangement. This concept was applied in one of the cases in this case series (case 2), which ALT free flap was performed to cover extensive soft tissue loss on the right distal leg. In the other 2 cases, skin grafts were used to cover the wound. One patient also underwent Lisfranc amputation (case 3) in result of distal phalanges necrotic bones and the remaining raw surface was closed with STSG.

The other important issue in mangled extremity management is the timing for optimal wound closure that has been an area of constant debate over decades. Many studies advocated better results with early soft tissue reconstruction although the term 'early' is obscure. Cohort study in over 500 patients by Godina described that extensive debridement along with soft tissue coverage within...
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72 hours has the best outcome in decreasing flap failure rate, bone healing time, wound infection, duration of hospital stay as well as number of surgical procedures. Byrd et al. described no non-union or chronic infection case following definitive reconstruction in the first five days in management of open tibia fractures. Delaying soft tissue reconstruction (4-5 days) allows the boundary become clearer between vital and necrotic tissues. Yaremchuk et al. performed 22 reconstruction cases in traumatic lower limb osteocutaneous defect at an mean of 17 days after injury results in one flap loss and suggested performing definitive reconstruction within the first 7-14 days after injury.

Based on the Godina study in 1986, three days remains the golden period for acute reconstruction, however, managerial issue and the presence of polytrauma to the vital organ often preclude definitive reconstruction in the emergency setting. Along with the advancement in the field of wound care, this critical period is shifted. Recent studies have shown the timing has progressed from 6 to 12.5 days from 2002 to 2011. This trend also reflects the importance of adequate wound debridement to provide optimum recipient wound bed. Serial debridement is needed to minimize the risk of osteomyelitis and catastrophic deep space, even if the definitive reconstruction must be delayed. Some literatures conclusively suggested that risk of free-flap failure is lowest when accomplished in first 3-5 days, but other reviews could not indicate this improvement clearly. The outcome of bone consolidation is more important than the time to perform free flap.

This case series consists of three clinical cases that underwent delayed reconstruction. All the cases were treated by prophylaxis antibiotic and immediate debridement in acute setting. The definitive reconstructions were done in 15, 30, and 60 days after injury. The reasons for the reconstruction timing are various including stabilization of patient’s condition based on polytrauma management principle, managerial issue, and unhealthy wound bed that needed to undergo serial debridement.

Acute wounds were managed by radical debridement and removing necrotic tissue, including avascular muscles. In order to eradicate the infection, the treatment of wounds in the chronic or sub-acute phase is followed by specific antibiotics based on culture examination and wound care carefully. Modern dressing is also used to improve wound conditions and protect the underneath exposed structures. The use of negative pressure dressings is recommended to delay flap coverage procedure for up to one week until wound cultures are negative after several debridements. Study by Yazar et al. described that soft tissue reconstruction was indicated when the wound culture was negative and the wound site looked clean and healthy, which significantly reduced infection and flap loss. In this case series, all patient wound cultures were ascertained negative before the definitive procedure and there’s no flap/graft loss were observed.

One patient in this case series (case 1) presented with hypovolemic shock. Patient with unstable hemodynamic is unable to withstand long operation for immediate complex reconstruction procedures. A principal rule in polytrauma case is “life before limb”; which means life-threatening conditions are become first priority. A study by Ivanov et al. has developed versatile algorithm for emergency situation of soft tissue reconstruction. The reconstruction strategy depends on the severity of the patient’s general condition. In stable condition, they recommended primary reconstruction within the first few hours after hospitalized. In borderline conditions, they explained that a local flap could be used during primary surgery while careful monitoring of vital functions was required. In an unstable condition, reconstruction can be done within 4-5 days, if the patient’s condition is optimal. According to their study, soft tissue reconstruction needs to be completed for up to 15 days after trauma.

Our study focused on the soft tissue aspect of the reconstruction in mangled lower extremity so management of bony problem was not discussed in detail. One patient in this case series (case 2) presented with 8 cm tibial bone defect and planned to undergo staged reconstruction. The timing of bone grafting is also debated; early bone grafting relies on ensuring that soft tissue coverage will provide adequate vascularity to support bone healing. Therefore, many studies described that it is important to achieve an optimal wound bed prior to bone reconstruction to avoid losing a limited stock of bone grafts. Two-stage reconstruction is recommended for composite soft tissue and bone defects larger than 6 cm. The first step is soft tissue reconstruction with muscle flaps, and vascularized bone transfer can be performed after hand (6 to 8 weeks after soft tissue reconstruction).

CONCLUSION

Management of soft-tissue defect in mangled lower extremities remains a challenge for reconstructive surgeons where the most optimum procedure timing is still controversial. The pre-existing theory advocating for immediate soft-tissue reconstruction within 72-hours has been liberalized due to the advancement of wound-care technology. Despite
many advantages of early soft tissue reconstruction, the opportunity to do it often missed due to various reasons. Thus, the timing of definitive reconstruction should be individualized based on the condition of the wound and the patient's general condition. We believe that soft tissue reconstruction of mangled lower extremities following high-energy trauma may also be safely done in a delayed setting if the wound debridement is adequately done, and the basic reconstructive principles are fulfilled.

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CONFLICT OF INTEREST
There is no competing interest regarding the manuscript.

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AUTHOR CONTRIBUTION
All of the authors are equally contributed to the study from the conceptual framework, data gathering, until reporting the content of study.

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