

Treatment for Gustilo Type-IIIB open tibial fractures: the significance of early soft-tissue coverage

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Background: The deep infection rate in patients with Gustilo Type- IIIB open tibial fractures was high (32%) in Kitasato University Hospital between 1986 and 1993. The mean period of soft-tissue coverage in the non-deep infection group was 15.7 days, whereas it was 51 days in the deep infection group. Because of these results, we have been treating Gustilo Type- IIIB open tibial fractures were treated with early soft-tissue coverage since 1994.

Methods: We reviewed 26 fractures in 25 patients (20 males, 5 females). The patients averaged 38.8 years of age at trauma (range: 17–72 years). The soft tissue reconstruction was completed on the day of receiving trauma in 6 cases, and 1, 2, 3, 4, 5, 17, 21, and 28 days after trauma in 2, 3, 8, 1, 3, 1, 1, and 1 cases, respectively. The mean closure time was 4.5 days after trauma. Delayed union was defined as no achieving bone union on radiograph within 1 year after the trauma.

Results: Superficial infection was observed in 5 cases (19%), and deep infection in 2 cases (8%). In comparison with the previous study (1986–1993), deep infection rate was low rate significantly. 2 deep infection cases were extensive soft-tissue injury loss with periosteal stripping, bone exposure and massive contamination. Delayed union was observed in 12 cases (46%). In comparison with the previous study (1986–1993), it was a significantly low rate.

Conclusion: It was suggested that early soft tissue coverage with a vascularized flap might prevent deep infection and delayed union in patients with Gustilo Type- IIIB open tibial fractures.

Key words: Gustilo Type- IIIB open tibial fracture, early soft-tissue reconstruction, deep infection rate, delayed union rate

Introduction

Open tibial fractures usually indicate a high-energy injury to soft tissue and bone with resultant difficulties of infection and poor bone healing, which may threaten the limb and occasionally life.^{1,2} The problems with soft-tissue cover, infection and union are all too common and result in serious disability.³⁻⁷ The unique anatomy of the tibia with its associated soft tissues and their vulnerability to severe injury produces most of these problems.^{8,9}

Severe open fractures of the tibia are classified as Types IIIA and IIIB, according to the amount of soft-tissue stripping and devascularization of the bone at the site of the fracture and an additional category (IIIC) was established to distinguish fractures with associated major vascular injury.² This refined classification system is

useful for prediction of infection and delayed union.^{2,5} Investigators using this classification scheme concluded that early flap coverage of Type-IIIB fractures might lessen the high rate of infection and the long delay until union commonly seen with these injuries.^{5,10,11}

The potential benefit of vascularized muscle-flap coverage was supported by experimental investigations demonstrating that, after a severe fracture, the vasculature in the muscles contiguous to the wound are the primary source of blood supply to the fracture site of fracture because the intramedullary blood supply is disrupted.^{12,13} The healing of fractures that have an ischemic soft-tissue envelope does not begin until after neovascularization of the muscle layer.¹⁴ When early muscle-flap coverage was used there was a decreased rate of infection and an increased rate of union in patients who had a tibial fracture with extensive soft tissue loss.^{5,10}

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Deep infection was defined as purulent drainage or osteomyelitis presenting after definitive wound closure and diagnosed by the responsible surgeon based on clinical suspicion and subsequent deep culture. The deep infection rate of Type-III B fractures was high rate (32%) in the Kitasato University Hospital between 1986 and 1993. The mean period of the soft tissue coverage was 41 days and was 15.7 days in the non-deep infection group, whereas it was 51 days in deep infection group. From this result, we used the new treatment for Type-III B fractures in which fractures were treated with early soft-tissue coverage. The purpose of this retrospective study was to determine the rate of infection and delayed union after early soft-tissue coverage in patients who had a Type-III B fracture of the tibia.

Materials and Methods

We retrospectively reviewed 26 fractures in 25 patients with Type-III B fractures who were treated at Kitasato University Hospital, between 1994 and 2011. Patients were followed more than 1 year following discharge.

There are 20 men and 5 women, and the ages ranged from 17 to 72 years (average age, 39 years). Traffic accidents were the most frequent causes of injury (24 patients); the other cause included fall (1 patient).

All patients were managed with administration of antibiotics (cephalosporin and aminoglycoside), irrigation and debridement, and stabilization with an external fixation or an internal fixation within the first 6 hours after the injury. Antibiotics were continued for 5 days postoperatively in all cases. Specimens from the wound were taken for culture initially at subsequent debridements. Debridements were repeated as necessary within 72 hours until the wound was considered clean and all necrotic tissue had been removed. We treated the wound by definitive soft-tissue coverage with a

vascularized muscle flap with a split skin graft. The choice between a pedicle and a free muscle flap depends on the anatomy of the injury to the soft tissue. If immediate soft-tissue coverage was impractical, our aim was to obtain soft-tissue coverage within 72 hours of the trauma.

Fracture-healing was monitored on serial radiographs made at 4 to 8-week intervals. Delayed union was defined as not achieving any bone union (defined radiographic evidence of bridging callus at the site of the fracture in 2 planes) on radiograph within 1 year after the trauma.

We report our experience comparing the deep infection rates and the delayed union rates in both our previous study (1986–1993) and this present study (1994–2011). The data were analyzed using the chi-square test and the unpaired *t* test to determine statistical significance. A *P* value of less than 0.05 was considered to indicate statistical significance.

Results

A total of 26 fractures had been treated using a muscle flap for soft-tissue coverage (7 free flaps and 18 local flaps). In the remaining case, a primary bone shortening had been performed and we closed the wound. The mean period of the soft-tissue coverage was 4 days and the closure time of the soft-tissue coverage between 1994 and 2011 was earlier than that between 1986 and 1993. This finding was statistically significant (Figure 1). The soft-tissue coverage was completed on the day of the trauma in 6 cases (26%), and 1, 2, 3, 4 and 5 days after trauma in 2, 3, 8, 1 and 3 cases respectively. Therefore soft-tissue coverage was established within 3 days in 75% of patients. Early soft-tissue coverage usually had been performed at least 3 to 5 days from day of the trauma. In 3 other cases (12%) the soft-tissue coverage was delayed more than 2 weeks, with a maximum of 28

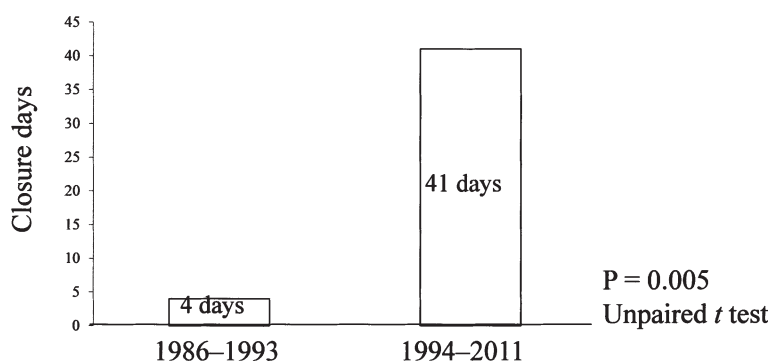


Figure 1. Comparison of the closure days of the wounds in both the previous and current studies

days, because of clinical circumstances not related to the leg injury (Table 1).

A total of 16 cases achieved stabilization of the fracture with external fixation, and 10 cases did so with internal fixation. The rate of superficial infections was 19% (5/26 fractures), whereas bony deep infections at the site of initial fracture site was 8% (2/26). These 2 cases of deep infections were each managed by external and internal fixation, respectively. The patients in this study who were managed by early soft-tissue coverage had a lower rate of deep infection (8%) than did those who had late coverage (32%) in the previous study, and the difference was statistically significant (Figure 2). Though the rate of delayed union was 80% in our previous study, it was 46% (12/26 fractures) in the present study, which was statistically significant (Figure 3).

Discussion

The high rate of complications seen in association with Gustilo Type-IIIB open fractures of the tibia has been well documented.^{1,2,4,5,8,10,15-17} The universally accepted principles of management of open fractures of the tibia include immediate wound debridement and irrigation, skeletal stabilization, repeated wound debridement, and early soft-tissue coverage.¹⁸⁻²⁰ Whereas Cierney¹¹ and Russel¹⁸ reported that it had been claimed that early soft-tissue coverage is not safe. However, analysis of our cases shows low rates of infection and delayed union, supporting the concept that delay is not necessary if healthy soft-tissue can be imported reliably to the wound site. Patients who had early muscle- flap coverage had fewer complications related to chronic drainage or to problems with the wound and lower rate of late deep infection. The explanations for this include better initial

Table 1. Numbers of fractures on the days the wounds were closed

Closure days	0	1	2	3	4	5	16	22	28
Fractures	6	2	3	8	1	3	1	1	1

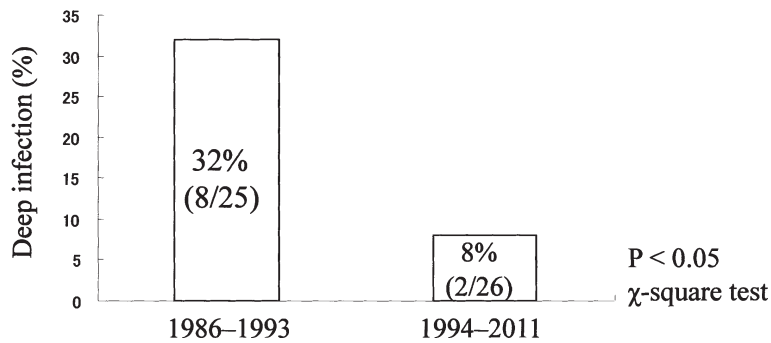


Figure 2. Comparison of deep infection rates in both the previous and current studies

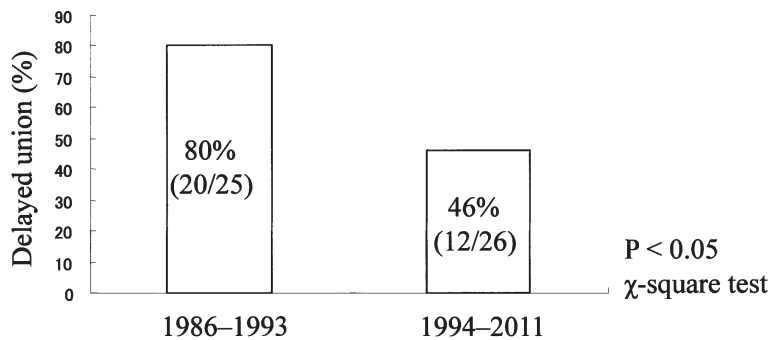


Figure 3. Comparison of delayed union rates in both the previous and current studies

debridement; and the increased blood supply provided by the flap, as in Mathes et al.,²¹ reduced bacterial counts in animals and humans and early re-epithelialization leads to a reduction of colonization of the wound and to a decreased risk of local contamination of deeper tissues. It should be emphasized that in this study "early soft-tissue coverage" means within 72 hours.

The prevention of infection depends on several factors. Two deep infection cases were the most severely injured limbs that had extensive soft-tissue injury loss with periosteal stripping, bone exposure and massive contamination. We believe that our low rate of infection is associated with the adequacy of the debridement, skeletal stabilization and the subsequent obliteration of the dead space by a healthy, well-vascularized and conforming muscle flap.^{12,14} These procedures also promote early soft-tissue coverage. In addition, as previously noted earlier, patients who had some of the more severe injuries might have received the muscle flap later than 2 weeks after the injury, because of difficulty in evaluation or debridement of the original injury.²² Fischer et al.²² reported that early soft-tissue coverage not only had a reduced risk of infection but also achieved union significantly earlier. Early soft-tissue coverage was encouraged by the higher standards of modern medicine, better control of postoperative infections, and a better understanding of bone healing, moreover, of the paramount importance of an adequate blood supply.

We believe that the ability to debride the wound thoroughly depends on the surgeon's confidence that the resulting defect can be reliably filled with healthy tissue within a relatively short period. This depends on the experience of the whole team and the close working relationship between the orthopedic and microvascular surgeons. Early soft-tissue coverage is essential, and it should be performed within 48 hours, usually timed to coincide with the "second look." Godina²³ reported that the low infection rate obtained in the first 72 hours with soft-tissue coverage suggests that proper debridement of most wounds can be done immediately after the injury. Occasionally, it is not possible to achieve this, but every attempt should be made to close the wound within 5 days.^{21,24} Further delay beyond this period leads to increased rates of infection and nonunion, with reduced success of free tissue transfers.²³

Overall, these results in this study show that in Type-IIIb open fractures of the tibia, modern techniques of management combining the skills of experienced orthopaedic and plastic surgeons can consistently restore excellent limb function in a very high proportion of patients. Inappropriate wound extensions performed by

inexperienced surgeons during the initial debridement may limit the options available when coverage is required. It is important to understand what is possible when assessing such an injury, and it is critical to consider where the skills required are available.

We considered the versatility of the acute bone-shortening concept. Distant flaps may involve the use of microsurgical techniques that require special technical skills, and unaffected parts of the body should serve as possible harvesting areas. The acute shortening technique has been proposed as an alternative to this complicated method of coverage. After applying the acute shortening procedure, the need for free flap coverage became less frequent, because most of the defects could be closed primarily or by using small local flaps and skin grafts.²⁵⁻²⁷ The temporary shortening of the severely injured limb after extensive radical debridement allows preservation of the potential for structural and functional restoration by guided graduated distraction using the Ilizarov technique.²⁸ The mechanical quality of the distracted bone is superior to that of cancellous bone grafts.²⁹ Some authors recommend that lengthening should be limited to 20% to 25% of the bone length.³⁰⁻³⁴

In conclusion, we have witnessed the establishment of a relatively standard protocol for the treatment of severe open fractures of the tibia. This protocol entails urgent debridement, stabilization and early soft-tissue coverage. Early soft-tissue coverage with a vascularized flap may help prevent deep infection and delayed union in patients with Gustilo Type- IIIb open tibial fractures.

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