

# Soft Tissue Cover in Compound and Complicated Tibial Fractures Using Microvascular Flaps

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## Abstract

*This is a retrospective review of the use of microvascular flaps in the salvage of severely injured lower limb. From January 1992 to December 1994, we treated 10 patients using 10 microvascular flaps; 8 patients with Type III compound tibial fractures and 2 patients with infected implants following internal fixation of comminuted tibia1 fractures. The size of soft tissue defect ranged from 6 x 3 cm to 20 x 10 cm. One patient had a 6 cm bony defect. Soft tissue cover was achieved in 9 patients using microvascular muscle flaps with meshed split skin grafts and 1 patient using a scapula osteocutaneous flap. They were performed within 5 to 27 days following injury or removal of implants (mean 18 days). All the microvascular flaps were successful (100%). One re-exploration was performed. The mean period of hospitalization following microsurgical flap cover was 16.8 days. Eight out of 10 patients were followed up for a mean period of 48 months. All the 8 lower limbs were successfully salvaged. Three out of 8 patients (37.5%) had chronic osteomyelitis which required sequestrectomy and bone grafting. No amputation was necessary. Two patients required adjunctive cancellous bone grafting to accelerate bony union. Six out of 8 patients (75%) achieved bony union and full weight bearing capacity. The use of microvascular flap in achieving soft tissue cover plays an important role in the salvage of severely traumatized lower limb. Microvascular muscle flap is preferred when only soft tissue defect is present. Successful soft tissue cover facilitates secondary bone grafting procedures. Although the timing of surgery per se does not adversely affect the success rate of microvascular flaps, delayed soft tissue cover is associated with a high chronic infection rate (37.5%). An adequate surgical debridement is crucial in reducing the complication of deep infection.*

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**Key words:** Complications, Lower limb reconstruction, Muscle flap, Osteocutaneous flap

## Introduction

Compound tibial fractures are high-energy traumatic injuries, which are frequently associated with high incidence of complications like infection and failure of bony union leading to amputation. The extent of injury is proportional to the magnitude of trauma. In 1984 Gustilo and Anderson reclassified Type III compound tibial fractures into 3 subtypes, namely Type III A, B and C, with Type III B and C having significantly higher infection and amputation rates. Infection rates in the 3 subgroups were 4%, 52% and 42%, respectively and amputation rates were 0%, 16% and 42 %, respectively.<sup>1</sup>

In the light of these complications, early and aggressive management of the both the soft tissue and bony injury should be performed. A thorough surgical debridement of all devitalized tissue is essential to reduce the risk of infection.<sup>2</sup> Skeletal stabilization should then be achieved and followed by an early soft tissue cover. As

the distal one third of the leg is deficient in muscle and soft tissue, free tissue transfer becomes necessary. With the advances in microsurgical technique, successful soft tissue cover can be achieved reliably with microvascular flaps. The use of vascularized flaps helps to control infection and promote bony union. It also facilitates subsequent bone grafting of bony defects. We present a retrospective review of 10 patients treated with 10 microvascular flaps in severe lower limb trauma.

## Material and Method

From January 1992 to December 1994, we treated 10 patients with severe lower limb trauma; 8 patients with Type III compound tibial fractures and 2 patients with infected implants following internal fixation of comminuted tibial fractures. Ten microvascular free tissue transfers were performed. For the 8 patients with compound tibial fractures, 7 had surgical debridement with

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external fixation and 1 with plating. For the 2 patients with infected implants, both were surgically debrided with removal of implants and stabilization using external fixation.

Eight of the tibial fractures (80%) were due to road traffic accident and 2 (20%) due to industrial accident. All were males. Their ages ranged from 19 to 63 years (mean 32.6 years). Six of the fractures were located in the middle third, 3 in the lower third and 1 in the upper third of the tibia. The size of the soft tissue defect over the leg ranged from 6 x 3 cm to 20 x 10 cm. One patient had a tibial bony defect of 6 cm. Five patients (50%) sustained isolated compound tibial fractures while the other 5 (50%) had associated long bone fractures (ulnar fracture 1, calcaneal and ankle fracture 1, femur fracture 2 and contralateral tibial and fibula fractures 3). All the associated fractures were treated with internal fixation.

Preoperatively swabs were taken from the wound for culture and sensitivity. In the 8 patients with acute injury, 2 patients (25%) had no bacterial growth and 6 patients (75%) were colonized; 4 patients had *Pseudomonas aeruginosa* and 2 had multiple organisms including methicillin-resistant *Staphylococcus aureus* (MRSA), *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Providencia* species. Intravenous antibiotics were given according to sensitivity report. For the 2 patients with infected implants, the organisms isolated were *Staphylococcus aureus*.

Nine patients had microvascular muscle flaps with meshed split skin grafts and 1 patient had osteocutaneous scapular flap. The donor muscles were chosen according to the size of the defect. Two latissimus dorsi muscles were used for large defects, 6 rectus abdominis muscle for medium defects and 1 gracilis muscle for small defects. One osteocutaneous flap was used because there were both bone and soft tissue defects. The scapula osteocutaneous flap used included a 10 cm segment of the lateral border of the scapula and an elliptical parascapular skin flap. The donor sites were all closed primarily.

Anterior tibial vessels were used as recipient vessels in 5 patients, posterior tibial vessels in 3 patients, dorsalis pedis and medial geniculate vessels in 1 patient each. Eight of the arterial anastomoses were end to end and two end to side. All the venous anastomoses were end to end. No interpositional vein grafts were used.

All the microvascular flaps were performed within 5 to 27 days following the acute injury or removal of infected implants. By the classification of Godina, all the flaps were performed in the subacute stage. The operating time ranged from 3 hours 40 minutes to 6 hours 40 minutes (mean 5 hours). The period of hospitalization after soft tissue cover with microvascular flaps ranged from 6 to 26 days (mean 16.8 days).

## Results

All the 10 microvascular flaps were successful (100%). One patient required re-exploration in the early postoperative period (within 24 hours). A haematoma was found under the flap but vascular anastomosis was intact. Other early and minor complications include superficial wound infection of the skin grafts in 2 patients, haematoma at the latissimus dorsi muscle donor site in 1 and secondary bleeding from the pin tract in 1. The haematoma at the donor site was evacuated with complete resolution. The superficial wound infection and secondary bleeding resolved with conservative management.

Eight out of 10 patients were available for follow up and further assessment. Two patients from the compound tibial fracture group were lost to follow up as they had moved away. The period of follow up ranged from 35 to 70 months (mean 48 months). Soft tissue cover and salvage were successful in all the 8 patients. Cancellous bone grafting was performed in 2 patients as an adjunct to accelerate bony union. Bony union was achieved in 6 out of 8 patients (75%). All 6 patients started to full weight bear from 6 months to 1 year after the injury.

However, late complication of chronic osteomyelitis of the tibia was encountered in 3 out of 8 patients (37.5%). They presented with chronic discharging sinuses. Two patients had chronic osteomyelitis with sequestrum formation and non-union at the comminuted fracture site. Both patients were treated with sequestrectomy and antibiotics followed by bone grafting. The third patient had a localized area of infection at the pin tract site. It required curettage and antibiotics but bony union was achieved at the fracture site without infection (Table I). No amputation for infected non-union was required.

All the donor sites healed with no significant complications. There was no abdominal laxity or hernia noted at the rectus abdominis muscle donor site. The scapula donor site had a broad scar but not hypertrophic or unstable. The range of motion at the knee and ankle were assessed. All the patients were found to have good range of motion at the knee (good  $\geq 90$  degrees flexion). For the ankle, 1 patient had good range of motion ( $>40$  degrees), 2 patients had moderate range of motion (between 20 and 40 degrees) and 5 patients had poor range of motion ( $<20$  degrees). Ankle stiffness was more marked than knee stiffness.

## Discussion

With advances in the microsurgical techniques, the success in free tissue transfer has greatly improved over the years. On the average, the success rate is more than 90% in all microsurgical flaps.<sup>3-5</sup> Godina,<sup>3</sup> Khouri and

TABLE I: CHARACTERISTICS, TIMING OF SURGERY, COMPLICATIONS AND OUTCOME OF 10 PATIENTS WITH COMPOUND/COMPLICATED TIBIAL FRACTURES

| Patient    | Sex / Age | Type of fracture                                 | Skin defect                | Type of flap            | Timing of surgery    | Complication                         | Adjunctive operation                                                                 | Outcome                           | Organisms                                                      |
|------------|-----------|--------------------------------------------------|----------------------------|-------------------------|----------------------|--------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------|
| A 1<br>CAK | M / 19    | Type III B                                       | 6 x 3 cm<br>Bone: 6 cm gap | Scapula osteocutaneous  | D 21                 | Nil                                  | Cancellous bone graft                                                                | F.U. 57 M<br>FWB 9 M<br>Work 1 y  | <i>Pseudomonas aeruginosa</i>                                  |
| A 2<br>TKC | M / 20    | Type III B & ankle fracture                      | 20 x 10 cm                 | Rectus abdominis muscle | D 24                 | Nil                                  | Nil                                                                                  | F.U. 49 M<br>FWB 6 M<br>Work 16 M | <i>P. aeruginosa</i>                                           |
| A 3<br>CKC | M / 23    | Type III B & ankle fracture                      | 18 x 5 cm                  | Rectus abdominis muscle | D 26                 | Nil                                  | Nil                                                                                  | F.U. 37 M<br>FWB 9 M              | No growth                                                      |
| A 4<br>YJ  | M / 19    | Comminuted fracture & degloving Injury           | 20 x 10 cm                 | Rectus abdominis muscle | D 9                  | Nil                                  | Nil                                                                                  | F.U. 35 M<br>PWB 4 M              | No growth                                                      |
| A 5<br>NSS | M / 29    | Type III B                                       | 10 x 10 cm                 | Latissimus dorsi muscle | D 26                 | Chronic OM<br>Non-union at upper end | Sequestrectomy<br>Bone transport<br>Bone grafting + plate fixation<br>2nd bone graft | F.U. 52 M<br>Non-WB               | MRSA<br><i>Providencia sp</i><br><i>P. aeruginosa</i>          |
| A 6<br>TTC | M / 33    | Type III B                                       | 12 x 8 cm                  | Latissimus dorsi muscle | D 27                 | Chronic OM                           | Sequestrectomy + gentamicin beads<br>i/v antibiotics 6 wk                            | F.U. 42 M<br>Non-WB               | MRSA<br><i>P. aeruginosa</i><br><i>Acinetobacter baumannii</i> |
| A 7<br>AC  | M / 63    | Type III B                                       | 8 x 5 cm                   | Rectus abdominis muscle | D 5                  | No early complications               |                                                                                      | No F.U.                           | <i>P. aeruginosa</i>                                           |
| A 8<br>SHJ | M / 43    | Type III B                                       | 15 x 7 cm                  | Rectus abdominis muscle | D 6                  | No early complications               |                                                                                      | No F.U.                           | <i>P. aeruginosa</i>                                           |
| B 1<br>NKS | M / 44    | Closed comminuted fracture with infected implant | 10 x 3 cm                  | Gracilis muscle         | D 18 fr<br>R/O plate | Delayed union<br>Ankle neuroma       | Cancellous bone graft                                                                | F.U. 70 M<br>FWB 26 M             | <i>S. aureus</i>                                               |
| B 2<br>CPC | M / 32    | Closed Comminuted fracture with infected implant | 19 x 7 cm                  | Rectus abdominis muscle | D 8 fr<br>R/O plate  | Chronic OM at pin tract site         | Curretage                                                                            | F.U. 41 M<br>FWB 10 M             | <i>S. aureus</i>                                               |

OM: osteomyelitis, MRSA: methicillin-resistant *Staphylococcus aureus*

Shaw<sup>4</sup> and Serafin et al<sup>5</sup> reported that their recent flap success rate for microvascular flaps ranged from 96% to 97%. It was an improvement from their previous success rate of 72% to 91%, respectively. Therefore, severely injured lower limb can now be salvaged reliably using microvascular flaps.

The reasons for the current improved success rate of microvascular flaps could be attributed to improved microsurgical technique and better clinical judgement in assessing the zone of injury. Vessels with post-traumatic vascular disease are more prone to spasm. Flaps with longer pedicles are chosen to ensure that microvascular anastomosis is performed outside the zone of injury and vein grafts are avoided. The use of vein grafts was found to be associated with a higher incidence of anastomotic thrombosis.<sup>4,6</sup>

The timing of soft tissue cover has been much debated.<sup>3,7-9</sup> Both Gordina<sup>3</sup> and Byrd et al<sup>7</sup> advocated early soft tissue cover because they have shown that early cover is associated with lower infection rate and flap failure rate. Godina<sup>3</sup> reported that failure rate of free flaps was 0.75% in the early group (<72 hours) compared with 12% and 9.5 % in the delayed (72 hours to 3 months) and late groups (>3 months) respectively. The infection rate was 1.5% in the early group compared with 17.5% and 6% in the delayed and late groups. Byrd et al<sup>7</sup> reported that free flaps performed in the acute stage (1 to 5 days) have a failure rate of 10% compared with 40% failure rate in the subacute stage (1 to 6 weeks).

However, Khouri and Shaw<sup>4</sup> and Yaremchuk et al<sup>2</sup> felt that the timing per se is not the most important factor in the final outcome. They have shown that flap failure rate

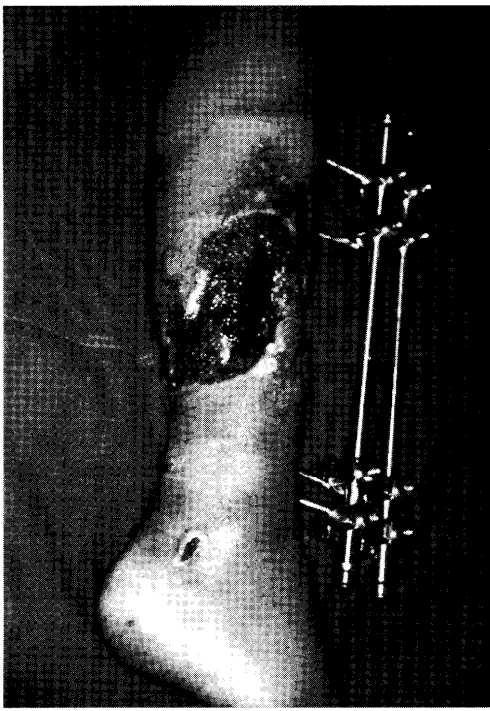


Fig. 1a. Type III tibial fracture with a 6 cm segmental bone loss. Debridement and external fixation done.



Fig. 1b. One-stage reconstruction with scapula osteocutaneous flap.



Figs. 1c & 1d. One year post-reconstruction showing bony union achieved after one adjunctive cancellous bone grafting. Patient returned to normal work.

was not higher when they were done in the subacute stage. Yaremchuk in 1987 reported a flap failure rate of 7% when they were performed at an average of 17 days from the time of injury. Khouri reported a flap failure rate of 2% in the group of patients with flaps performed from 1 week to 2 months.

In our series, the microsurgical flaps were performed within 5 to 27 days (mean 18 days) from the time of injury or removal of infected implants. By the classification of Godina<sup>3</sup> or Byrd et al,<sup>7</sup> most of our flaps were done in the delayed or subacute stage. Our late complication rate of chronic osteomyelitis is 37.5% (3 out of 8 patients). This

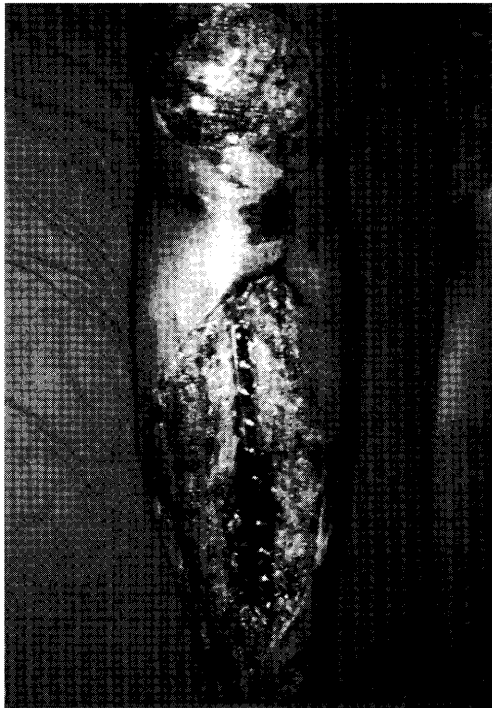


Fig. 2a. Comminuted right tibial fracture with degloving injury of the leg. Fracture was fixed with plates and screws. Loss of the anterior degloved skin resulted in exposure of the implants.



Fig. 2b. One year after soft tissue reconstruction with rectus abdominis muscle flap. Bony union achieved with no complications.



Fig. 3a. Infected implant following internal fixation of comminuted tibial fracture.



Fig. 3b. Three years after removal of implant, external fixation and reconstruction with rectus abdominis muscle flap.

is fairly comparable with 30% infection rate reported by Peat et al<sup>10</sup> and 17.5% in the delayed groups reported by Godina.<sup>3</sup> The timing of wound closure in our series does not appear to influence the flap success rate but is associated with a high infection rate.

Yaremchuk et al showed that infection rate in their series was low even when flaps were performed in the subacute stage. They reported a 14% acute infection and no chronic infection. They attributed the low chronic infection rate in their series to aggressive surgical debri-

dement of the wound involving removal of both contaminated soft tissue and bony fragments by serial surgical debridement if necessary. In our series, 2 patients had infected non-union at the fracture site. Both had severe contamination of the wound with multiple organisms like MRSA, *Pseudomonas aeruginosa*, *Providencia* species and *Acinetobacter baumannii* before surgery. Both had delayed soft tissue cover performed at 26 and 27 days after the acute injury. Therefore, the high infection rate could be attributed to delay in soft tissue cover, severe contamination of the wound before surgery and inadequate surgical debridement.

Microvascular muscle flap with split skin graft is our method of choice for soft tissue cover. They were used in 9 out of 10 cases. There are 3 main reasons for choosing muscle flaps. Firstly, there is a wide range of muscle flaps available to suit the size of the defect. Secondly, muscle flaps are associated with lower infection rate due to its vascularity.<sup>10</sup> It has been reported that musculocutaneous flaps are able to control a bacterial inoculum better than skin flaps because of the improved vascularity.<sup>11,12</sup> Thirdly, muscle flaps are able to conform to the defect well and reduce dead space in the wound.<sup>10,13,14</sup> An osteocutaneous flap was chosen for one of them because that patient had a fairly large 6 cm bony defect as well as soft tissue loss. This case illustrates the concept of one stage soft tissue and bony reconstruction as shown by Serafin et al<sup>15</sup> and Sekiguchi et al.<sup>15</sup> Peat et al<sup>10</sup> reported that free vascularized bone flaps were associated with the least infection rate in all the adult patients that require bone grafting.

Five of the 8 patients on follow up had poor range of movement at the ankle (<20 degrees of motion). This could be attributed to a few reasons. Firstly, the involvement of the ankle in the injury. Two patients had degloving injury of the anterior aspect of the ankle and 1 of them was associated with anterior subluxation of the ankle. Secondly, severe fibrosis and scarring of the soft tissue due to both trauma and multiple surgery. Three patients had multiple surgical wound debridement before and after the flap due to complications of chronic osteomyelitis as well as prolonged immobilization.

## Conclusion

Soft tissue cover of compound tibial fracture can be reliably performed given the present microsurgical expertise. The success of the free flap is more dependent on careful planning of the surgery to ensure adequate pedicle length of the flap and meticulous microsurgical

anastomosis performed outside the zone of injury. The timing of soft tissue cover per se does not adversely influence the flap success rate. However, the delay in soft tissue cover is associated with a higher infection rate. The risk of chronic infection cannot be eradicated by merely providing a vascularized flap. An adequate surgical debridement is equally important. Besides reducing the risk of late infection, early soft tissue cover has the added advantage of shortening hospital stay. A microvascular muscle flap is preferred when only soft tissue cover is required because of its vascularity and versatility. An osteocutaneous flap is chosen when both bone and soft tissue reconstruction is required in a single stage.

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