Free tissue transfer for Type III tibial fractures

Microsurgery in 19 cases

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We report 19 tibial fractures Types III B and C treated by free flaps. The fracture healed in 16 cases after 12 (3–54) months. In 3 cases a secondary amputation was carried out. Tibial malalignment or substantial shortening ensued in 1 case each. We conclude that coverage with free flaps, radical removal of dead bone, stable external fixation and transfer of vascularized bone may salvage the majority of Type III B and C tibial fracture with function superior to that after amputation.

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An immediate below-knee amputation after high energy leg trauma with major soft tissue loss and fracture of the tibia may restore a patient to full function within an enhanced psychosocial support environment (Lange 1989). However, new techniques in the surgical management, such as assessment of areas of tissue for debridement, methods for stabilization of the fracture, transfer of vascularized bone and free flaps for soft tissue coverage should impel the orthopedic surgeon towards limb salvage in the majority of cases.

We summarize our results of microvascular free tissue transfer in patients with tibial fractures of Types III B and III C (Gustilo et al. 1984).

Patients and methods

Between 1984 and 1990, 16 Type III B and 3 Type III C tibial fractures were treated. There were 18 men and 1 woman with a mean age of 30 (16–51) years at the time of the index operation. Traffic accidents had caused 13 injuries, 2 were caused by a gun shot and 4 by a crush accident during work or sports (Table 1). The Type III C fractures had been treated primarily in our hospital by replantation. The primary treatment of the Type III B fractures had been carried out elsewhere, and none of them had been treated with vessel repair (Table 2). 2 patients presented with an infected open tibial nonunion (Cases 1 and 9). The mean delay between the injury and the flap transfer for the remaining 17 patients was 71 (0–275) days. Prior to the free flap transfer the patients had undergone on average 4 (0–15) operations, which included wound revision, split skin grafting, local pedicle flap, osteosynthesis, and cancellous bone transplantation. The type of fracture fixation and the size/length of the covered tissue defect are shown in Table 3 and Tables 1 and 4, respectively.

The procedure for raising the lateral arm flap, the iliac crest flap, the scapular flap, the forearm flap and the fibula were as described by Taylor et al. (1979), Song et al. (1982), Yoshimura et al. (1983), Katsaros et al. (1984), Swartz et al. (1986) (Table 5). The graft vessels were sutured to the posterior tibial vessels in 2 transfers, to the peroneal vessels in 1 case and to the anterior tibial vessels in the remaining 19 transfers. Follow-up was continued until fracture healing or amputation.

Results

Flap survival. 2 of the 22 flaps failed. In Case 6 (Table 1) the necrotic osteocutaneous scapular flap was replaced by a lateral arm flap which provided excellent soft tissue coverage. The fracture healed after serial cancellous bone graftings and osteotomy of the fibula 54 months after the index operation. In Case 12, we removed the necrotic lateral arm flap, shortened the tibia and raised a local pedicle flap. The fracture healed with 10 degrees varus deformity, 10 degrees retrocurvation and a reduced range of motion in the ankle joint. The poor condition of the soft tissue contraindicates any corrective tibial osteotomy, and an ankle arthrodesis is planned.

Amputations. Secondary amputations were carried out in 3/19 cases. Case 2 initially had a crush amputation of the left leg and upper arm. The leg was

Table 1. Observations in 19 tibial fractures Types III B and III C

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	III B	15	288	4x8	3	3	1	Yes	No	0	4	0	No	No	No
2	III C	0	0	15x30	20	5	7	Yes	2	7	A	–	–	–	–
3	III C	3	7	10x15	5	4	1	Yes	No	2	4	1	No	No	Fused
4	III B	4	9	7x14	12	10	1	Yes	No	5	4	0	No	No	No
5	III B	4	1.6	10x15	5	2	4	Yes	No	4	29	1	No	No	No
6	III B	4	3	8x13	13	12	4	No	6	6	54	2	No	No	No
7	III B	2	1.0	6x8	6	1	5	Yes	No	0	4	0	No	No	Ext 0°
8	III B	1	0.3	10x20	10	8	4	Yes	No	0	5	0	No	No	No
9	III B	6	48	4x12	5	3	6	Yes	No	0	6	0	No	No	Ext 0°
10	III C	2	1.2	7x12	7	3	5	Yes	No	3	23	4.5	No	No	No
11	III B	2	0.8	4x6	3	0	6	Yes	No	0	3	0	No	No	No
12	III B	3	0.4	7x12	4	1	6	No	No	6	18	2	Varus 10°	No	Ext 0°
13	III B	3	1.0	11x25	11	7	5	Sepsis	–	–	A	–	–	–	–
14	III B	3	9	4x8	6	0	6	Yes	No	1	3	0	No	No	Ext 0°
15	III B	8	0.9	8x23	12	2	5	Yes	No	3	11	0	Valgus 7°	No	No
16	III B	3	0.8	12x25	15	12	5	Yes	3	1	12	0	No	No	Drop foot
17	III B	5	1.4	5x11	11	2	6	Yes	No	–	A	–	–	–	–
18	III B	4	1.0	8x12	15	5	4	Yes	No	0	6	0	No	No	Drop foot
19	III B	4	1.6	7x12	10	6	6	Yes	No	1	9	0	No	No	No

A Case
B Fracture type
C Number of operations prior to the tissue transfer
D Delay injury – tissue transfer (month)
E Size of soft tissue defect (cm x cm) after resection of devitalized tissue
F Length of exposed tibia (cm) after removal of devitalized tissue
G Length of tibial defect (cm) after resection of avascular bone
H Type of free flap
  1 Compound iliac crest
  2 Simple iliac crest
  3 Fibular
  4 Compound scapular
  5 Simple scapular
  6 Lateral arm
  7 Radial forearm
I Flap survival
J Secondary free flap (See H)
K Number of secondary procedures related to skin coverage and fracture healing
L Fracture healed within (months; A amputation)
M Tibial shortening (cm)
N Malalignment
O Reduced knee motion
P Reduced ankle motion

Table 2. Infrapopliteal artery injuries in 19 tibial fractures Types III B (n 16) and III C (n 3)

Injured artery	III B	III C
None	7	0
Anterior tibial alone	2	0
Posterior tibial alone	1	0
Peroneal alone	1	0
Anterior and posterior tibial	1	0
Anterior tibial and peroneal	4	0
All (revascularization)	0	3

Table 3. Fracture fixation in 19 Type III tibial fractures

	Primary	At flap transfer
AO plate	3	0
Hoffman apparatus	12	4
Intramedullary nailing	1	0
Calcaneal traction	2	0
Orthofix® apparatus	0	15
Sum	19	19

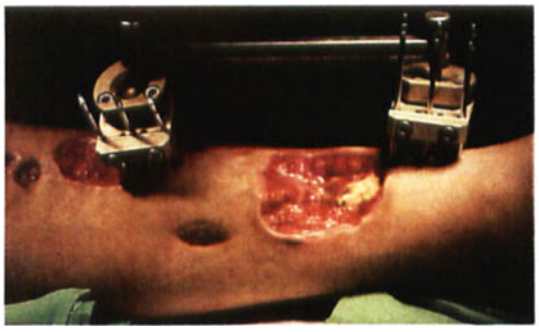
Table 4. Mean (range) size/length of covered defects after resection of the devitalized tissue

Skin defect	92 cm^2	(25–330 cm^2)
Length of exposed tibia including the defect	8.7 cm	(3–20 cm)
Length of tibial defect	4.5 cm	(0–12 cm)

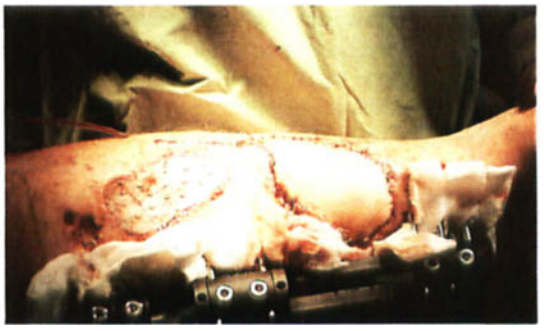
Table 5. Type of flaps in 19 Type III tibial fractures

Flap type	Skin	Bone	Compound Skin + bone	Total
Scapular	5	0	4	9
Lateral arm	7	0	0	7
Iliac crest	0	1	3	4
Radial forearm	1	0	0	1
Fibula	0	1	0	1
Sum	13	2	7	22

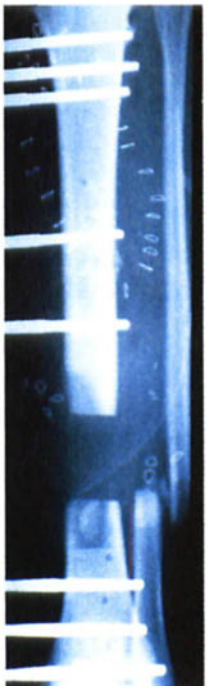
3 patients received 2 flaps



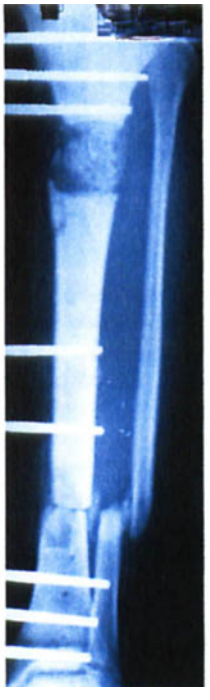
7 weeks after external fixation.



Coverage by a lateral arm flap after removal of dead bone, reposition and fixation by Orthofix device for bone transfer according to Ilizarow.



Radiograph of the same.



The transfer is completed after 3 weeks.

The fracture and donor sites were solidly united after 7 months.

Figure 1. Case 19. MC-injury with loss of soft tissue and bone and lesion of the tibialis posterior artery. A lateral arm flap and bone transfer according to Ilizarow was used. The donor and recipient sites were transplanted by autografts at completion of the transfer, since no callus was formed.

replanted using the amputated forearm as a combined vessel and skin graft. A remaining large tibial bone defect was later filled by a vascular iliac bone graft. The upper end of the graft did not heal in spite of serial cancellous bone graftings, and we performed a below-knee amputation 22 months after the iliac bone transfer and 53 months after the replantation. Case 13 developed septicemia 2 days after a successful transfer of a scapular flap, and we had to make an emergency below-knee amputation. Case 17 had an ipsilateral open femoral shaft fracture primarily treated with an interlocking intramedullary nail at the referring hospital. The patient developed an intramedullary femoral empyema 12 days after a successful transfer of a lateral arm flap to the leg. The femoral nail was replaced by an external fixator and the medullary cavity was continuously irrigated. The patient developed septicemia and a high femoral amputation was carried out on vital indication.

Secondary procedures. The mean number of secondary procedures was 2 (0–7). This included cancellous bone grafting, osteotomy of the fibula, the Ilizarow bone transfer (Figure 1), replacement and/or adjustment of the external fixator, wound revision and

split skin transplantation. Only 6/19 cases healed without any secondary procedure.

Clinical results. 16/19 fractures healed on average 12 (3–54) months after the index operation. Full range of knee motion was seen in all 16 patients with healed fractures. In 1 patient (Case 15) with an ipsilateral femoral fracture and an anterior cruciate ligament injury, a moderate anterior knee instability persisted. The ankle movement was normal in 8 patients, reduced in 7, and 1 was treated by ankle arthrodesis. 2 patients had a drop foot caused by damage of the muscles of the anterior compartment, and 3 patients had a moderate toe clawing. In 2 patients, reduced sensibility in the sole of the foot persisted. The mean tibial shortening was 0.7 (0–4.5) cm. 2 obese patients treated with large local pedicled flaps prior to the free tissue transfer developed a localized lymphedema. No significant donor site complication was seen.

Discussion

The prognostic value of the subclassification scheme for Type III open tibial fractures introduced by Gustilo et al. (1984) has been demonstrated by Caudle and Stern (1987). None of the Type III A fractures in their series was associated with deep infection or required secondary amputation, and only 27 percent developed nonunion. Type III B fractures were infected in 29 percent, developed nonunion in 43 percent and led to secondary amputation in 17 percent. The Type III C fractures were eventually treated by amputation in 78 percent. Lange et al. (1985) found in a study of 23 fractures associated with vascular injuries an amputation rate of two thirds. In a review of the management of massive leg trauma, Lange (1989) discussed the limits of our ability to salvage and reconstruct functional limbs in a reasonable period of time, at acceptable overall cost, and without risking life for limb. According to Lange the present conceptual and subjective guidelines for amputation should be replaced by sound protocols of management. With reference to our results we disagree with those who claim that the functional results after such challenging treatment are often worse than an amputation (Hansen 1987, Lange 1989).

The majority of our patients were primarily treated at other hospitals. The reduction and fixation of the fractures were frequently insufficient, the debridement of devitalized tissue had not been radical enough, and the delay between injury and referral for flap transfer turned out to be too long. This may have contributed to the slow healing of some of the fractures in our series.

The primary treatment should include fixation of the fracture with a stable one-plane unilateral external fixation device that provides access to the limb for the later flap transfer (Meléndez and Colon 1989). Obvious dead bone should be removed and the complex wound should be converted into surgically clean areas before the flap is transferred. It can, however, be difficult to know how radical the debridement should be in cases with potentially viable tissue. In some of our cases necrotic bone was obviously retained under the flap resulting in sequestration and sinus formation, which in Case 3 ended up in amputation, and in some others led to prolonged fracture healing time.

The compound skin/bone flaps are more difficult to carry out than simple flaps, especially in obese patients, and our results with those flaps are somewhat disappointing. Therefore, we now postpone the treatment of the bony defect until the simple free skin flap is healed and all soft tissue is covered. A prerequisite is, however, removal of all dead bone and an acceptable reduction of the fracture with stable external fixation. The selection of soft tissue flaps in our series reflects the rapid development of new free flaps in the period investigated. It is claimed that free muscle flaps in addition to coverage also promote fracture healing. In a series of 7 Type III B fractures, Seyfer and Lower (1989) used the latissimus dorsi muscle flap covered by split skin grafts. 2 patients in their series developed nonunion and 1 had secondary amputation because of an infected nonunion. In our series we have not used free muscle flaps, but our results indicate that acceptable results can be achieved by skin and/or bone flaps. For smaller soft tissue defects up to 7 × 15 cm we now use the lateral arm flap. This flap is relatively thin, but it can be made thicker by incorporating the fascia and a layer of underlying muscle. Larger defects up to 15 × 30 cm are now covered by the scapular flap which can also be raised with the underlying fascia and a short muscle cuff.

After full soft tissue coverage, smaller bone defects can be transplanted with cancellous or corticocancellous grafts, whereas gross bone defects must be substituted with vascularized bone. The Ilizarow method (1989) for bone transportation is suitable for medium-size distal defects (Figure 1). Longer defects need a free fibula graft (Weiland et al. 1983) from the contralateral leg.

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