Acute emergency tibialization of the fibula: reconstruction of a massive tibial defect in a type IIIC open fracture

Fatih Parmaksızoğlu · Eren Cansu · Mehmet Bekir Ünal · A. Yener Ince

Received: 5 March 2012 / Accepted: 19 July 2013 / Published online: 27 July 2013
© The Author(s) 2013. This article is published with open access at Springerlink.com

Abstract Gustilo type IIIC open fractures of the tibia are high-energy injuries necessitating long treatment periods and usually multiple surgical procedures and eventually resulting in high morbidity rates and even amputations. We present here a case involving a type IIIC open tibial fracture with massive loss of the entire tibial diaphysis, which we treated by performing acute tibialization of the fibula after revascularization of the posterior tibial artery in a single-stage emergency operation.

Keywords Acute tibialization · Emergency tibialization · Tibial defect · Type IIIC open tibial fracture · Lower-extremity reconstruction

Introduction

Severe segmental tibial bone loss occurring after an open fracture is a considerable challenge to the treating orthopedic surgeon. Amputation is a difficult decision as it is an irreversible procedure in this limb-threatening injury. On the other hand, reconstruction of the injured limb requires both replacement of the bony defect and soft tissue repair. A number of techniques have been described for salvage of the injured limb, including serial massive debridement and early flap closure, autologous bone grafting, vascularized or non-vascularized transfer of the ipsilateral or contralateral fibula, segmental transposition, tibiofibular synostosis, and acute shortening and relengthening.

We report a case of a Gustilo type IIIC open fracture with massive loss of the tibial diaphysis. After the damaged, tibialis posterior artery was repaired at the level of the ankle during emergency surgery, and immediate intramedullary insertion of the ipsilateral fibula on its peroneal arterial pedicle between the two preserved edges of the tibia was performed in a single procedure. To our knowledge, this is the first case in which emergency single-stage acute tibialization of the fibula is described.

Case report

In a motor vehicle accident, a 42-year-old man sustained several injuries: a Gustilo type IIIC open fracture of the right tibia; an intertrochanteric fracture of the right femur; an uncomplicated left tibial and fibular fracture; and a calcaneal skin defect on his left side (Figs. 1, 2, 3, 4). He had an ischemic limb due to an arterial injury at the ankle on the right side.

The patient was taken immediately to the operating room and anaesthetised. All devitalized bony and soft tissues were excised on the side of the open tibial fracture. The tibial bone defect was nearly 25 cm after debridement, and the remaining two ends of the tibia were stabilized with a unilateral fixator. Two Schanz pins were placed in the proximal part of the tibia, and one each was placed in the distal tibial end and in the talus. The tibial nerve was compressed but intact at the ankle. At the same level, the
posterior tibial artery was also compressed and thrombosis detected in a 1-cm segment. The thrombotic segment was excised and end-to-end primary arterial re-anastomosis was performed to revascularize the distal lower extremity. It was decided to manage the bone defect by transferring the ipsilateral fibula which was entirely intact but for a simple fracture at the level of the ankle joint.

The fibula was exposed and then osteotomized proximally just distal to the neck. The length of the fibula transferred was nearly 30 cm. To facilitate transfer of the fibula, a careful dissection was performed. The attached soft tissue and peroneal arterial supply were protected. After preparation of the remaining tibial ends, the vascularized fibula was transferred medially and placed between the two ends of tibia. During that transfer, placement of the unilateral fixator was adjusted to obtain gross overall alignment (Fig. 5). The soft tissue defect was covered using remaining undamaged skin with additional skin grafting for uncovered areas. There was no postoperative infection.

The other injuries were treated as follows: proximal femoral nailing for the intertrochanteric fracture; intramedullary nailing for the left tibial fracture; and placement of a propeller flap for the calcaneal skin defect. These were performed at 2 weeks once it was declared the right side had no evidence of infection. At the end of the third week, a valgus deformity of the transferred segment of fibula was corrected by realigning the distal Schanz pins under fluoroscopy.

At review at 5 months, during which the intervening follow-up period was without complication, the state of bone union was evaluated and the patient was encouraged to engage in partial weight bearing with crutches. At 8 months, the patient was able to walk with a single crutch and without crutches at 14 months. At the 2-year follow-up examination, hypertrophy of the fibula was apparent (Fig. 6a, b). Complete union was achieved, and the patient...
did not experience refracture, infection, or permanent pain. Sensation in the sole of his affected foot had recovered and he did not require additional pain medication. There was a limb length discrepancy of 2.5 cm. At the end of the treatment that did not produce an obvious limp. Although an insole was prescribed, it was not used by the patient for most of the day.

Discussion

Open fractures of the tibia accompanied by massive segmental bone loss and critical vascular injury are major treatment challenges. Primary amputation is still a common choice in several centers but when the circulation of foot is reestablished and the sensation of the sole is preserved, limb-salvage procedures are an option. The total cost of the procedure may appear, after cursory assessment, to be three to four times that of amputation, but in fact, it is much more economical when the long-term outcome is considered [1–3].

Conventional bone grafting is useful for repairing defects smaller than 5 cm in cases where there is sufficient vascularization and no infection. Microsurgical techniques may make it possible to treat larger defects through use of free vascularized bone grafts; vascularized bone from the fibula or iliac crest are potential solutions for larger defects, but the iliac crest can be a donor source only for defects of a maximum length of 10–15 cm [4]. The anatomic features of iliac bone also present a congruency problem for the replacement of tubular bone. To avoid these difficulties, vascularized fibular graft has been used extensively for reconstruction. The contralateral fibula is considered an ideal source of free vascularized bone graft, but the integrity of the donor fibula is essential in this procedure [4].

In recent years, external fixators are used widely for this type of bone reconstruction. The recent modifications to external fixators and the concept of segmental fragment transfer by distraction osteogenesis have provided the surgeon with various alternatives for dealing with these compound injuries. Internal segmental bone transfer and acute shortening and relengthening techniques are the main strategies for the treatment of tibial bone defects with an external fixator. However, these methods are limited by the sufficiency of bone reserve [1, 5–10] and disadvantaged by a long treatment duration [1].

Fig. 4 Preoperative radiograph of the fractured left tibia

Fig. 5 An early postoperative radiograph shows that the fibula is seated well between the two poles of the tibia
Another method for repairing larger defects is the transfer of ipsilateral fibula to consolidate the fibula and tibia, called tibialization of the fibula. After a proximal and distal fibular osteotomy, the whole fibular graft can be transferred gradually using the Ilizarov method to bridge a tibial defect. Traction with olive wires and subsequent gradual transfer is the main principle of the method [11–19]. After the transfer, reconstruction is achieved with eccentric tibiofibular synostosis, secured with grafting techniques [11–14, 20, 21].

In this patient, the defect was too large to be repaired by a simple conventional bone graft or by a vascularized flap from the iliac crest. In addition, a contralateral comminuted fracture interfered with our ability to use the other fibula as a vascularized graft, and it was impossible to perform an internal segmental bone transfer or acute shortening and relengthening as, after debridement of devitalized tissues, the remaining tibial bone stock was poor.

Despite an extremely fragmented tibia with large bone defect, this patient had a well-protected ipsilateral fibula which was fractured only a few centimeters from the distal end. During surgery, we observed that the proximal connection of the peroneal artery was intact and decided that transfer of this large vascularized fibula segment would be an ideal alternative for replacing lost tibial bone. After preparation of the two ends of the tibia, we transferred the vascularized fibula medially and placed it in between the two poles of the tibia. Our preferred fixation method with a monolateral external fixator does not allow early weight bearing before callus formation. Conversion to a circular frame after the soft tissues have healed would have been an alternative which is more stable. Although referred to in the literature, we did not experience complications of pin loosening and secondary deformities in this patient or in our previous patients to whom we performed limb lengthening procedures with monolateral external fixators [1].

Stress fracture of the fibular graft is not an uncommon complication of this technique and was reported between 7 and 35% in the literature [22–25]. This graft did not fracture in the period of follow-up.

An analysis of the literature reveals that medial transfer of the ipsilateral fibula has been performed mostly as a secondary procedure involving gradual transfer [6, 8, 9, 17] or, in a few cases, as a secondary immediate procedure [7]. These cases generally involve high-energy trauma and always entail large soft tissue and bony–tissue defects. During the healing period, tissue repair and fibrosis impair the normal regional anatomy and interfere with proper vascular microsurgical dissection. Delayed surgery would likely be more challenging because of the difficulty of neurovascular dissection in an area with adhesive and fibrotic tissue. Therefore, we believe that immediate fibula transfer is preferable, as a first therapeutic step, to delayed surgery in selected cases.

**Conclusion**

Acute transfer of the ipsilateral fibula with its vascular pedicle intact should be considered an option for the management of large tibial defects when techniques of bone transport or acute shortening/lengthening are deemed too risky or entail an excessively prolonged treatment period.

**Conflict of interest** The authors declare that they have no conflict of interest.

**Open Access** This article is distributed under the terms of the Creative Commons Attribution License which permits any use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

**References**

1. Parmaksizoglu F, Koprulu AS, Unal MB, Cansu E (2010) Early or delayed limb lengthening after acute shortening in the treatment of traumatic below-knee amputations and Gustilo and Anderson type IIIC open tibial fractures: the results of a case series. J Bone Joint Surg Br 92:1563–1567
2. Hertel R, Pisan M, Jakob RP (1995) Use of the ipsilateral vascularised fibula for tibial reconstruction. J Bone Joint Surg Br 77:914-919
3. Toh S, Tsubo K, Nishikawa S, Narita S, Kanno H, Harata S (2001) Ipsilateral pedicle vascularized fibula for reconstruction of tibial defects and non-unions. J Reconstr Microsurg 17:487-496
4. Leonard G (1988) Microsurgical reconstruction of the extremities: indications, technique, and postoperative care. Springer, New York
5. Song HR, Cho SH, Koo KH, Jeong ST, Park YJ, Ko JH (1998) Tibial bone defects treated by internal bone transport using the Ilizarov method. Int Orthop 22:293-297
6. Sen C, Kocaoglu M, Eralp L, Gulsen M, Cinar M (2004) Bifocal compression-distraction in the acute treatment of grade III open tibia fractures with bone and soft tissue loss: a report of 24 cases. J Orthop Trauma 18:150-157
7. Granhed HP, Karladani AH (2001) Bone debridement and limb lengthening in type III open tibial shaft fractures. Acta Orthop Scand 72:46-52
8. Lerner A, Fodor L, Soudry M, Peled IJ, Herer D, Ullmann Y (2004) Acute shortening: modular treatment modality for severe combined bone and soft tissue loss of the extremities. J Trauma 57:603-609
9. Yokoyama K, Itoman M, Nakamura K, Uchino M, Tsukamoto T, Suzuki T (2006) Primary shortening with secondary limb lengthening for Gustilo IIIB open tibial fractures: a report of six cases. J Trauma 61:172-180
10. El-Rosasy MA (2007) Acute shortening and re-lengthening in the management of bone and soft-tissue loss in complicated fractures of the tibia. J Bone Joint Surg Br 89:80-88
11. Shiha AE, Khalifa AR, Assaghir YM, Kenawy MO (2008) Medial transport of the fibula using the Ilizarov device for reconstruction of a massive defect of the tibia in two children. J Bone Joint Surg Br 90:1627-1630
12. Kim HS, Jahng JS, Han DH, Park HW, Chun CH (1998) Immediate ipsilateral fibular transfer in a large tibial defect using a ring fixator. A case report. Int Orthop 22:321-324
13. Chacha PB, Ahmed M, Daruwalla JS (1981) Vascular pedicle graft of the ipsilateral fibula for non-union of the tibia with a large defect. An experimental and clinical study. J Bone Joint Surg Br 63:244-253
14. Catagni MA, Camagni M, Combi A, Ottaviani G (2006) Medial fibula transport with the Ilizarov frame to treat massive tibial bone loss. Clin Orthop Relat Res 448:208-216
15. Khan MZGM, Downing ND, Henry AP (1996) Tibial reconstruction by ipsilateral vascularized fibula transfer. Injury 27:651-654
16. Catagni MA, Ottaviani G, Camagni M (2007) Treatment of massive tibial bone loss due to chronic draining osteomyelitis: fibula transport using the Ilizarov frame. Orthopedics 30:608-611
17. Tuli SM (2005) Tibialization of the fibula: a viable option to salvage limbs with extensive scarring and gap nonunions of the tibia. Clin Orthop Relat Res 431:80-84
18. Bundgaard KG, Christensen KS (2000) Tibial bone loss and soft tissue defect treated simultaneously with Ilizarov technique—a case report. Acta Orthop Scand 71:534-536
19. Date AS, Solanki SB, Badhe NP, Sonsale PD, Pandit HG (1996) Management of gap non-union of the tibia by tibialisation of ipsilateral vascular fibula. J Postgrad Med 42:109-111
20. Atkins RM, Madhavan P, Sudhakar J, Whitwell D (1999) Ipsilateral vascularised fibular transport for massive defects of the tibia. J Bone Joint Surg Br 81:1035-1040
21. Jeng SF, Kuo YR, Wei FC, Wang JW, Chen SH (2001) Concomitant ipsilateral pedicled fibular transfer and free muscle flap for compound tibial defect reconstruction. Ann Plast Surg 47:47-52
22. Arai K, Toh S, Tsubo K, Nishikawa S, Narita S, Miura H (2002) Complications of vascularized fibula graft for reconstruction of long bones. Plast Reconstr Surg 109:2301-2306
23. Lee KS, Park JW (1999) Free vascularized osteocutaneous fibular graft to the tibia. Microsurgery 19:141-147
24. De Boer HH, Wood MB (1989) Bone changes in the vascularised fibular graft. J Bone Joint Surg Br 71:374-378
25. Ihara K, Doi K, Yamamato M, Kawai S (1998) Free vascularized fibular grafts for large bone defects in the extremities after tumor excision. J Reconstr Microsurg 14:371-376