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ORIGINAL STUDY

Treatment of large diaphyseal bone defect of the tibia by the "fibula pro tibia" technique : application in developing countries

René Castro Gayito, Giambattista Priuli, Sidi Yaya Traore, Olivier Barbier, Pierre-Louis Docquier

From Cliniques universitaires Saint-Luc, Service de Chirurgie orthopédique et Traumatologique, Brussels, Belgium and Hôpital Saint Jean de Dieu, Tanguiéta, Benin

Large segmental bone defects of the tibia may be due to infections, high-energy fractures, congenital diseases or tumors and represent a challenge for both the physician and the patient. In developing countries, the use of expansive techniques is not possible so that amputation is sometimes proposed. However, an alternative technique for limb salvage, applicable in developing countries consists of tibialization of the ipsilateral fibula. This technique is also called "Fibula pro Tibia", fibular transfer to the tibia or fibular centralization. We report this transfer in 4 patients with an average defect length of 11.8 cm. Union between the transferred fibula and the tibia was obtained in all patients, for both proximal and distal junctions, after an average time of 8.5 months (range, 4 to 18 months). Three patients returned to a normal walking function while one was still limping, but was able to walk independently without need of crutches.

Keywords : Tibialization of fibula ; fibular transfert to the tibia ; large defect of the tibia.

INTRODUCTION

Large segmental bone defects of the tibia are challenging therapeutic problems for both the physician and the patient. The most common causes of bone defects are infections, high-energy fractures, congenital diseases (i.e tibial agenesis or tibial pseudarthrosis) and tumors. Different techniques of limb salvage have been described for treating these defects including large segmental allografts, vascularized or avascular autografts and bone transport (*15*). In developing countries, the use of expansive techniques is not possible so that amputation is sometimes proposed. This decision is not always acceptable for the patients and their family especially for children. We report an alternative technique of limb salvage treatment that consists of tibialization of the ipsilateral fibula that is applicable in developing country. This technique is also called "Fibula pro Tibia", fibular transfer to the tibia or fibular centralization.

Historically, "Fibula pro tibia" was used successfully for the first time by Huntington in 1903 (*7*) in a case of diaphyseal tibial defect due to osteomyelitis. He described the technique in two stages. First stage

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■ René Castro Gayito, MD.
■ Giambattista Priuli, MD.
Hôpital Saint Jean de Dieu, Tanguiéta, Benin.
■ Sidi Yaya Traore, MD.
■ Olivier Barbier, MD.
■ Pierre-Louis Docquier, MD, PhD.
Cliniques universitaires Saint-Luc, Service de Chirurgie orthopédique et Traumatologique, Brussels, Belgium.
Correspondence : Pierre-Louis Docquier, Cliniques universitaires Saint-Luc, Service de Chirurgie orthopédique et Traumatologique, Avenue Hippocrate 10, 1200 Brussels, Belgium. E-mail : Pierre-Louis.Docquier@clin.ucl.ac.be

Table 1. — Clinical data of the patients

Sex	Age (yrs)	Side	Initial lesion	Previous surgery	Bone defect (cm)	Time before union (months)	Hospitalization time (months)	Functionnal results	Complications
F	4	Right	Congenital tibial agenesy (distal 2 thirds)	No	5	7	11	Walking with limping	Varus foot deformity needing corrective osteotomy
M	7	Left	Tibial osteomyelitis	Sequestrectomy	12	4	3	Normal walking	No
F	8	Left	Tibial osteomyelitis	Sequestrectomy	20	5	6	Normal walking	Genu valgum
M	20	Left	Open tibial fracture with bone loss	Osteosynthesis by external fixator	10	18	3	Normal walking	No

consisted of proximal fibular osteotomy. The divided end of the fibula was firmly planted in a cup-shaped depression in the tibia. Huntington was not satisfied by the weight-bearing condition of the limb because of tendency of foot to evert in stance phase. He described the second stage in which he transferred the lower end of the fibula to the lower fragment of the tibia. Several other authors have used this technique with success in variable indications (*1,2,8,10,13-15*).

MATERIAL AND METHODS

The technique of "Fibula pro Tibia" was applied in four patients in the hospital of Tanguiéta in Benin. The patients' clinical data are summarized in Table I. For the septic cases (cases 2 and 3), dead necrotic bone was first debrided (sequestrectomy) and the infection was treated with antibiotics. When surrounding soft tissues were adequately supple and vascularized, proximal transfer of fibula to the proximal tibia was performed (first stage) (Fig. 1). The procedure was performed under general anaesthesia and with the use of a tourniquet. A double surgical approach was used for tibia and for fibula respectively. By the medial approach to the tibia, proximal origin of tibialis anterior and extensor muscles were elevated from the lateral aspect of tibia. Extremity of the tibia was drilled, curetted and decorticated. By the lateral approach to the fibula, the common peroneal nerve was first identified and protected. The fibula was proximally osteotomized keeping and preserving the muscular attachements and the fibular artery. The fibula was displaced to the proximal tibia and attached to the tibia with a metal cerclage wire to maintain a close contact between the 2 bones. The lower leg was stabilized by a full leg cast or by an external fixator. The second stage consisted of transferring the distal part of fibula to the tibia. It was delayed 6 weeks to 4 months after the first stage, until the proximal tibio-fibular junction was healed. The two procedures were separated to decrease the heaviness of the surgery and not to compromise the vascularization of the transferred fibula. As proximally, this procedure was performed under general anesthesia and by double medial and lateral approaches.

Patients were followed up regularly and assessed clinically and radiologically for bone union. Bony union was concluded when the authors observed the osseous bridging (uninterrupted external bony borders) between the fibula and tibia with no evidence of gap on the antero-posterior and lateral views of the X-rays. No immediate complications occurred.

RESULTS

This technique was performed in 4 patients (Table I). The average age was 9.7 years (range, 3 to 20 years). The average length of defect was 11.8 cm (range, 5 to 20 cm). All patients underwent the surgical procedure in two steps. The average time before union was 8.5 months (range, 4 to 18 months).

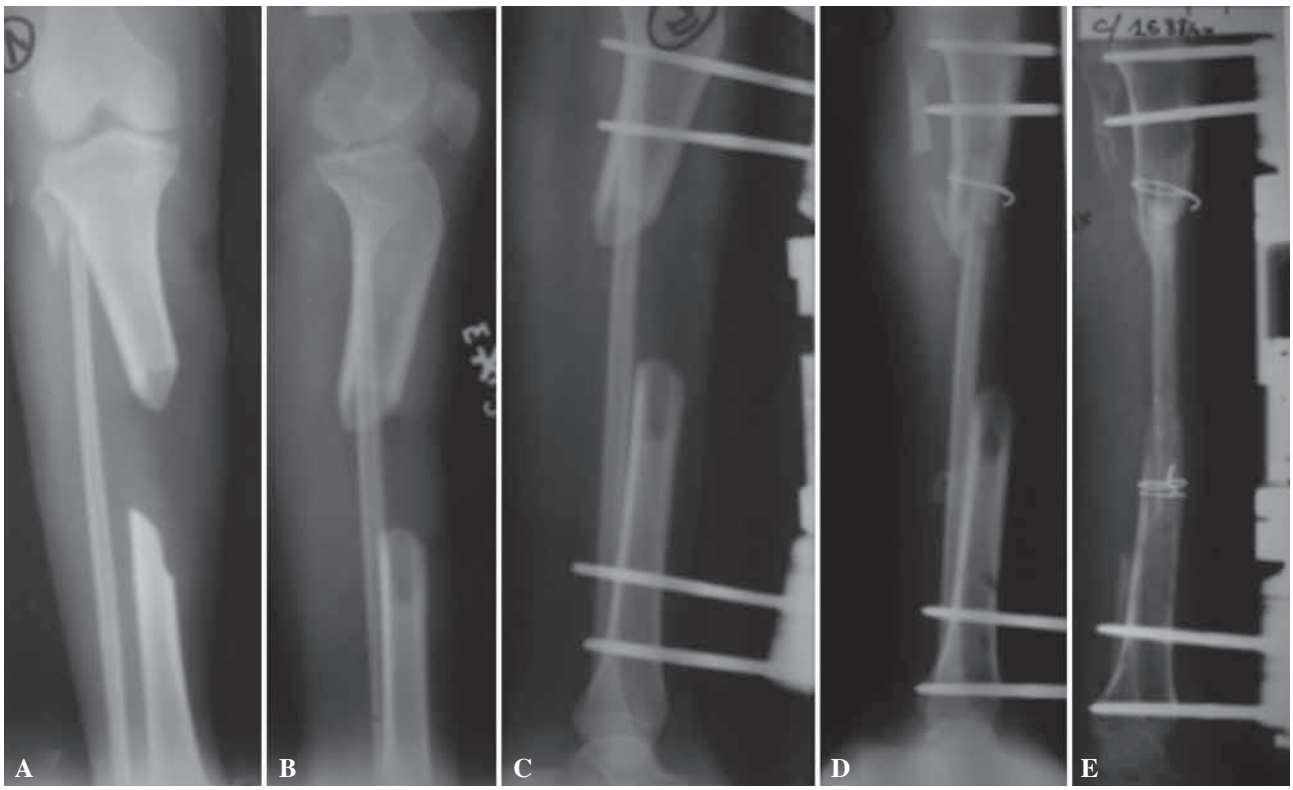

Fig. 1. — 20-year-old girl who sustained a traffic trauma with loss of 10 cm of tibial diaphysis. A and B : initial radiograph. C : temporary external fixation. D : Proximal transfer of the fibula to the proximal tibia. E : Distal transfer of the fibula to the distal tibia.

Union between the transferred fibula and the tibia was obtained in all patients, for both proximal and distal junctions. Three patients returned to a normal walking function while one was still limping, but was able to walk independently without need of crutches. Two late complications were observed. One patient presented a varus foot deformity needing surgical revision. A second patient developed a valgus deformity of the leg.

DISCUSSION

The treatment of large segmental bone loss is a challenging problem. Various techniques have been described but their use in developing countries is difficult. Primary amputation is still a common choice in these countries but when the vascularization of foot is intact and the sensation of the sole is preserved, limb-salvage procedures are options (*13*). Conventional bone grafting is useful for repairing defects smaller than 5 cm in cases where there is sufficient vascularization and no infection (*13*). Vascularized bone grafts from the fibula or iliac crest are potential solutions for larger defects. The iliac crest can be a donor source only for defects of a maximum length of 10–15 cm (*11*) and the anatomic features of iliac bone also present a congruency problem for the replacement of tubular bone. It is reasonable to consider the use of a vascularized fibular transfer (*17*) in case of a massive bone defect (ie, more than 10 cm), in case of a bone defect of smaller size which has failed to heal with nonvascularized bone grafting, in a previously infected bone non-union with a segmental defect, or a non-union with or without a defect associated with radionecrosis (*17*). Integrity of the donor fibula is essential in this procedure (*11*). In patients with polytrauma, injuries at the donor sites may preclude their use.

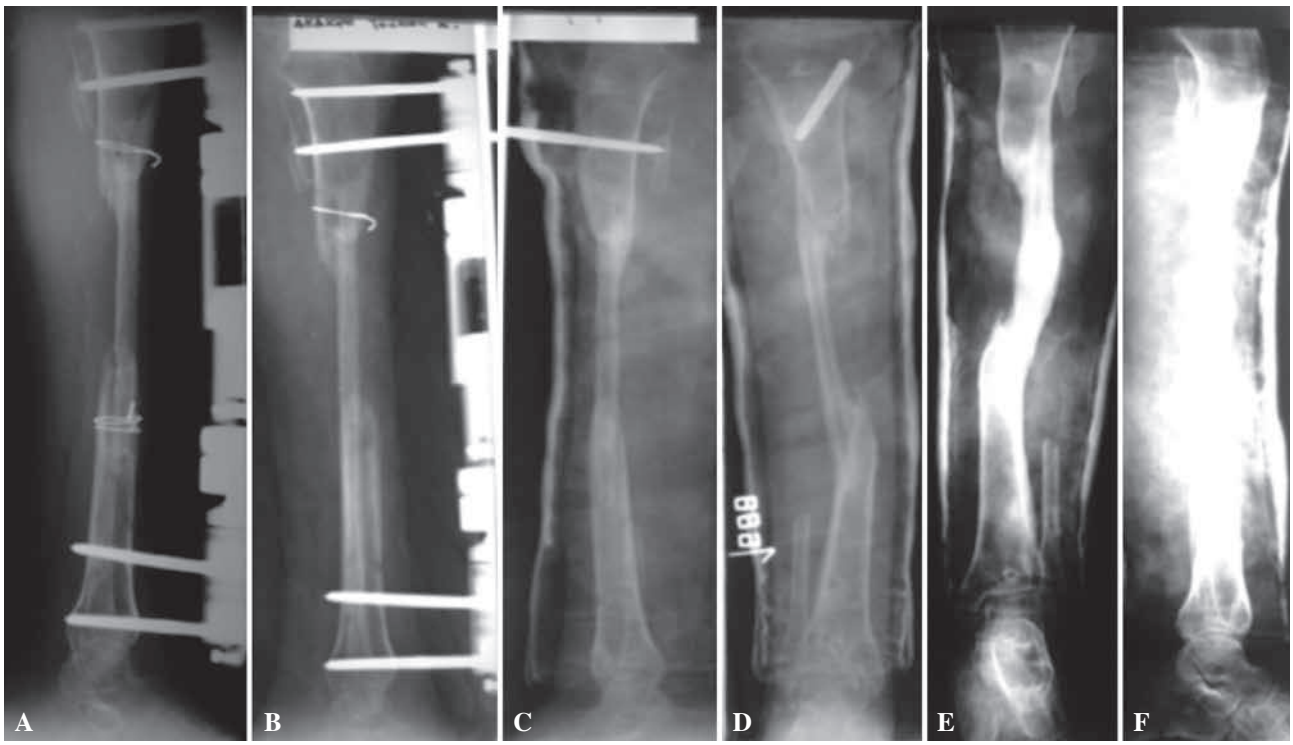

Fig. 2. — Same patient than Figure 1. Long-term evolution. A : 3 months. B : 9 months (distal wire was removed at 5th month). C and D : 10 months : external fixator was removed and replaced by a cast with a transfixing half pin to maintain the leg length. E and F : 20 months. A walking protective cast was worn until 24 months.

The possibility of donor-site morbidity and microvascular occlusion always should be considered. Contralateral vascularized or non vascularized fibula transfer involve considerable risk as they potentially threaten the unaffected limb. Complications such as deep infection, peroneal nerve injury, and ankle instability on the contralateral previously unaffected limb are disastrous.

Reconstruction with massive bone allograft is generally impossible in developing countries, as there is no adequate bone bank. Moreover, implantation of cadaveric tissue in large amounts in the post-trauma or chronically infected environment may be at a high risk of failure.Infection, rejection, fracture, and nonunion have been described with this technique (*12*).

In recent years, external fixators have been used widely for this type of bone reconstruction. Bone transport using monofocal or simultaneous bifocal distraction-compression osteogenesis with Ilizarov techniques were used for massive tibial bone loss. But if the amount of bone loss is great, the time to achieve the desired length of regenerated bone can be extremely long. Moreover, these methods are limited by the sufficiency of bone reserve (*13*). Another method to repair large defects with an external fixator is the gradual transfer of ipsilateral fibula called tibialization of the fibula. After a proximal and distal fibular osteotomy, the central portion of the bone can be transferred gradually using the Ilizarov principles to bridge a tibial defect. Traction with olive wires and subsequent gradual transfer is the main principle of the method (*3,4,16*). After the transfer, reconstruction is eventually completed by tibio-fibular synostosis secured with grafting techniques (*3,4,16*).

The "Fibula pro Tibia" procedure is a cheap and simple alternative that gives good results. Advantages of "Fibula pro Tibia" by comparison with allograft, is a transfer of a living autograft with remodeling potential, resistance to infection and better long-term mechanical properties (*15*). In our

Fig. 3. — Final evolution after 8 years

cases, the bone remodelling process was observed with progressive enlargement of the transferred fibula as already reported (*9,15*). The technique is simple and accessible to any surgeon. It is cheap, as only a cerclage wiring is needed with a plaster cast or with an external fixator. Some authors have reported this technique more recently. Parmaksizoglu *et al* (*13*) reported this technique in a Gustilo type IIIC open fractures of the tibia with massive loss of the entire tibial diaphysis. He performed acute tibialization of the fibula after revascularization of the posterior tibial artery in a single-stage emergency operation. Puri *et al* reported 15 cases of fibular centralization after excision of tumours of the tibial diaphysis or distal metaphysis (*14*). Two patients were excluded ; one died from the complications of chemotherapy and a second needed a below-knee amputation for a recurrent giant-cell tumour. A total of 13 patients were reviewed after a mean follow-up of 29 months (range : 16 to 48). Only 16 of 26 host graft junctions united primarily. Ten junctions in ten patients needed one or more additional procedures before union was achieved. At final follow-up 12 of the 13 patients had fully united grafts and 11 walked without aids. The mean time to union at the junctions that united was 12 months (range : 3 to 36). Kassab *et al* (*8*) reported the technique in 11 patients with tibial nonunion, with a mean age of 32 years (range : 16 to 61) and a mean follow-up of 12 years (range : 2 to 21 years). The cause of tibial nonunion was a motor vehicle collision in eight patients, a fall from a window, an adamantinoma, and osteomyelitis, each in one patient. The nonunion was infected in seven patients. Healing of the tibial defect was obtained in eight patients, after a mean interval of 10.5 months. In the patient with the adamantinoma, resection of the tumour left a 22 cm-defect in the tibia. Two patients required amputation for acute local infection. Seven of the eight patients in whom tibial union was achieved were able to walk with no aid (*8*). Agus *et al* (*2*) reported four cases of infected tibial nonunion treated with debridement, sequestrectomy and two-stage ipsilateral fibular transfer. The mean age of the treated patients was 7.5 years (range : 2 to 11). Mean follow-up period was 9.5 years (range : 6 to 13) years. In all cases infection was resolved and tibio-fibular synostosis was achieved. The diameter of the transferred fibula increased significantly with regard to the unaffected fibula. None of the patients had limitation of joint motion or shortening more than 1 cm (*2*). According to Agiza (*1*), when the fibula is subjected to more than normal weight-bearing stresses, it undergoes hypertrophy and becomes the integral part of the static supporting architecture of the leg. We saw this phenomenon in all our cases. The diaphyseal diameter of each transferred fibula increased by at least twice its original size. One of the most important complications of ipsilateral fibula transfer for defective tibia pseudoarthrosis is the

development of angular deformity around the knee region. Daoud and Saighi-Bouaouina (*6*) treated varus, valgus or flexion angulation at the proximal tibia of more than 10° by osteotomy. Proximal angulation probably occurs because of weight bearing without external support before solid union at the transfer sites.

Transfer of the fibula to the tibia is not always easy, due to the presence of structures between the two bones that need to be retracted to allow the contact between tibia and fibula. But it is less demanding than a free fibular graft.

CONCLUSION

Transfer of the ipsilateral fibula with its vascular pedicle intact should be considered as an option for the management of large tibial defects, especially in developing countries.

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