

# Ipsilateral fibular transposition in tibial nonunion using Huntington procedure: a 12-year follow-up study

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## Abstract

Eleven patients (10 men and 1 woman) with a mean age of 32 years (range: 16–61 years) and a mean follow-up of 12 years (range: 2–21 years) were studied retrospectively after ipsilateral fibular transposition. The cause of tibial nonunion was a motor vehicle collision (MVC) in eight patients, a fall from a window in one, an adamantinoma in one, and osteomyelitis in one. There was one type I and eight type IIIb open fractures according to the Gustilo classification, and 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 aids. The authors conclude that transposition of the ipsilateral fibula is a valuable component of the therapeutic armamentarium and a salvage procedure for patients with multi-operated, infected or uninfected, tibial nonunion.

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## 1. Introduction

Tibial nonunion is a major therapeutic challenge, notably when trophic skin lesions are present, vascular supply is fragile, and there is a bone defect associated. Multiple surgical procedures performed in an attempt to achieve healing increases the risk of infection and can lead to an amputation of the leg in patients with persistent nonunion. Transposition of the ipsilateral fibula to the tibia (fibula pro tibia) was suggested by Hahn [11] in 1884 and was first used successfully by Huntington [13] in 1903, to fill a 12.7 cm tibial defect in a 7-year-old boy. Subsequently, several authors have used similar techniques [1,15–18,24,25]. The purpose of this study was to review and discuss the results of 11 consecutive patients treated with ipsilateral transposition of the fibula (ITF).

## 2. Materials and methods

### 2.1. Study group

We retrospectively reviewed the medical records of 11 patients with tibial nonunion treated with ITF at our cen-

tre between February 1980 and December 1999. There were 10 male patients and 1 female patient. The tibial lesion was caused by a motor vehicle collision (MVC) in eight patients and a jump out of a window in one. Two other patients underwent bone resection for osteomyelitis and adamantinoma of the middle tibia, respectively. Of the nine trauma patients, five had multiple injuries and three had an ipsilateral femoral fracture (floating knee). Nine of the 11 patients had an open fracture, of which 8 were type IIIb and 1 was type I according to the Gustilo et al. classification [10]. In the patient with osteomyelitis, a discharge of pus through a fistulous track open to the skin was the first manifestation of the bone infection. Five patients had neurological impairments responsible for reduced ankle motion (Table 1).

Treatments used before ITF included the Papineau technique in five patients, an inlay graft at the nonunion site in one, and an autologous bone marrow injection in one. The mean time from initial treatment of the tibial lesion and ITF was 17 months (range: 4–72 years) and the mean age of the patients at the time of the fibular transposition was 32 years (range: 16–61 years).

At the time of fibular transposition, all 11 patients had a tibial nonunion. The size of the bony defect on preoperative plain radiographs (magnification: 1.15×) was 4 cm in two patients, 5–20 mm in seven patients, 13 cm after resection of infected bone in the patient with osteomyelitis, and 22 cm after tumour excision in the patient with adamantinoma.

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Table 1  
Patient demographics

Case/age/sex	Site	Skin broken	Cause	Infection
1/22/M	M 1/3	IIIb	MVC	Yes
2/24/M	M 1/3	I	Adamantinoma	Yes
3/33/F	M 1/3	IIIb	MVC	No
4/35/M	M 1/3	IIIb	MVC	Yes
5/34/M	M 1/3	IIIb	MVC	Yes
6/23/M	M 1/3	IIIb	MVC	Yes
7/59/M	P 1/3	IIIb	MVC	No
8/16/M	P 1/3	IIIb	MVC	No
9/19/M	D 1/3	IIIb	Jump	No
10/61/M	M 1/3	IIIb	MVC	Yes
11/25/M	M 1/3	Fistula	Osteomyelitis	Yes

M1/3: middle third of the tibia; P1/3: proximal third of the tibia; D1/3: distal third of the tibia; MVC: motor vehicle collision.

The tibial nonunion was at the middle third of the tibia in eight patients, the proximal third in two, and the distal third in one. The nonunion site was infected in seven patients, all of whom had grown *Staphylococcus aureus* from specimens taken during previous procedures or from a productive fistula if it was present. Preoperative arteriography of the leg was performed in six patients and showed a vascular lesion without downstream ischemia in four. The lesion was located on the peroneal artery in two patients, the anterior tibial artery in one, and the posterior tibial artery in one.

## 2.2. Clinical evaluation

Patients were examined to evaluate the range of motion of the knee and the ankle as well as the leg length discrepancy by measuring the distance between the two medial malleoli. Deformity of the ankle in the coronal plane was also assessed. The skin was carefully examined and any fistulous tracks were noted. For patients who did not require an amputation, we assessed the walking distance, the need for walking aids, patient satisfaction (using a four-level scale: very satisfied, satisfied, fairly satisfied, and dissatisfied) and the pain score (using a 10-point scale where 1 represents no pain and 10 unbearable pain).

## 2.3. Radiographic evaluation

Healing of the tibio-fibular synostosis was evaluated radiographically using anterior–posterior (AP), lateral and oblique views of the affected leg. Radiographs were performed at regular intervals to monitor the healing process and to record complications such as a fatigue fracture of the fibula. In two patients, computed tomography (CT) of the leg was performed 4 months after fibular transposition to evaluate the healing of the fibula to the tibia.

## 2.4. Surgical technique

Good timing is crucial to the success of fibular transposition. Appropriate antibiotic therapy should be given before

the procedure if the nonunion site is infected. Criteria used to determine the duration of antibiotic treatment include the local tissue status, blood cell counts, erythrocyte sedimentation rate, and C-reactive protein level.

We regard discharge of pus through a fistulous track as an absolute contraindication to fibular transposition. Arteriography is useful to evaluate the lower limb vasculature and to select the optimal surgical approach. We have used a posterolateral approach to the leg, except in one case, where the anterior tibial artery was damaged. In this case, we performed an anterolateral approach in the attempt to preserve the posterior blood supply. The posterolateral approach allows, if necessary, identification or neurolysis of the common peroneal nerve. Fistulous tracks open to the skin are best excised, whereas internal fistulae can be left in situ. Rasping of the fibula should be avoided in order to preserve the insertion of fibular muscles, and the anterior or posterior tibial vessels (according to the approach used) should be left intact to promote the tibio-fibular fusion.

The next step is decortication of the tibia at a distance from the nonunion site in order to avoid exacerbating a possible infection. The fibula is cut on either side of the tibial nonunion site. In one patient, who had a fibular fracture at the same level as the tibial nonunion, screw-plate fixation of the fibular fracture restored sufficient fibular length to allow bridging of the tibial defect. Isolated screws are then inserted to fix the proximal and distal end of the fibula to the tibia (Fig. 1). Iliac grafts are added only at the junction of the fibula and tibia, thereby reducing the amount of bone graft.

Postoperatively antibiotic therapy is continued, as with all surgical procedures on infected sites. The duration of antibiotic therapy is based on microbiological studies of intraoperative specimens, drainage fluids and on serial laboratory tests for inflammation.

Immobilisation is achieved using a full leg plaster or external fixation. Weight-bearing is not allowed until the site is fully healed.

## 3. Results

### 3.1. Clinical results

Mean follow-up after fibular transposition was 12 years (range: 2–21 years), and follow-up exceeded 17 years in seven patients. The mean range of knee flexion was 122° (range: 0–140°). The mean leg length discrepancy was 2 cm (range: 0–4 cm). The mean range of motion of the ankle joint was 7° for dorsiflexion (range: –5 to 30°) and 21° for plantar flexion (range: 0–40°). Walking distance was evaluated, with the following results: more than 1.5 km,  $n = 5$ ; 500 m–1.5 km,  $n = 1$ ; 100–500 m,  $n = 2$ ; and less than 100 m,  $n = 1$ . The mean pain score was 2 (range: 1–7). Five patients were very satisfied, three satisfied, and one fairly satisfied (Table 2).



Fig. 1. (a–d) Thirty-four-year-old male (case 5) with a comminuted, type IIIb fracture of the middle third of the tibia, sustained in an MVC. (a) Radiograph 9 months after the injury showing nonunion despite external fixation with compression and grafting. (b) Healing of the tibial nonunion 9 months after transposition of the fibula. (c) Appearance of the patient 9 months after fibular transposition. Stable, painless weight-bearing, with no walking distance limitation. (d) Anteroposterior and lateral view 2 years after (see two pictures).

Table 2  
Clinical results

Case	Walking aids	Walking distance	LLD (cm)	Full weight-bearing (months)	Follow-up (years)
1	No	>1.5 km	4	9	21
2	Yes	<100 m	3	22	17
3	No	>1.5 km	1	7	20
4	No	>1.5 km	0	9	20
5	No	>1.5 km	1.5	9	2
6	No	100 m–0.5 km	1	9	2
7	NA	NA	Amputated	NA	NA
8	NA	NA	Amputated	NA	NA
9	Yes	100 m–0.5 km	4	7	2
10	No	0.5–1 km	1	9	11
11	No	>1.5 km	1	11	11

LLD: leg length discrepancy; NA: nonavailable.

### 3.2. Radiographic results

Healing was achieved in 8 of our 11 patients. The mean time to healing was 10.5 months (range: 7–22 months). Radiographic evidence of healing was first evident at the tibio-fibular synostosis, where fusion was clearly visible after a mean of 7 months and strong enough to allow weight-bearing after a mean time of 10.5 months. No fatigue fractures of the fibula were recorded.

### 3.3. Complications

The patient in whom a 22 cm adamantinoma was removed had persistent superior nonunion despite a second procedure consisting in transverse fibular distraction using the Ilizarov technique, and grafting of the contralateral fibula, which underwent necrosis 3 years later. Nevertheless, at last follow-up 17 years after the fibular transfer procedure, this patient was able to weight-bear using one walking stick.

In two patients (cases 2 and 4), ITF was performed without autologous bone grafting. Nonunion of the proximal tibio-fibular synostosis occurred in these patients. Healing was obtained after bone grafting and replacement of the screw by a screw-plate.

Two patients (cases 7 and 8) required amputation due to acute infection, 1 and 15 months, respectively, after the fibular transfer. In both patients, we had not had any proof of infection before the fibular transfer. In these patients, IFT was performed 2 and 6 years after the injury, which happen to be the two cases with the longest time delays between injury and treatment with IFT. Both patients had a comminuted type IIIb fracture of the proximal third of the tibia.

In one patient (case 1), septic arthritis of the ipsilateral knee occurred and was successfully treated with arthrodesis.

## 4. Discussion

Tibial nonunion associated with a bone defect is a major therapeutic challenge. Healing of both the bone and skin

must be achieved. Inter-tibio-fibular grafting [21] is similar to fibular transfer in that a synostosis is created between the tibia and fibula. However, the synostosis is achieved by grafting of a large amount of autologous bone. This can be a major disadvantage in patients with a history of multiple bone graft procedures. Furthermore, if the lesion is in the distal tibia, the synostosis reduces the range of motion of the ankle. Evrard [7] reviewed 110 patients mean time to healing was 9.5 months.

The open excision and cancellous bone grafting technique described by Papineau and co-workers [19,20] has the major disadvantage of supplying only cancellous bone, which has limited mechanical strength. The large amounts of autologous cancellous bone needed to perform the Papineau technique are often unavailable in elderly patients or patients with chronic alcohol abuse [14]. Roy-Camille et al. [22] reviewed 46 patients; the time to full weight-bearing was 11 months in those with a defect larger than 1 cm. Patients with tibial lesions had the worst outcomes. The main disadvantage of this procedure is that it requires a mean hospital stay of 3 months, and availability of nurses experienced in the bone site irrigation technique.

The Ilizarov technique involves bone transfer and compression-distraction to stimulate the nonunion site. Early weight-bearing is possible, which reduces the risk of osteoporosis and stiffness in adjacent joints. A major advantage of this technique is that it can be used to achieve realignment of the limb, either during or before the treatment of the nonunion. In patients with bony defects, the mean healing time is 170 days without and 270 days with bifocal extension–distraction. The major drawback of this technique is that is not very well tolerated with a significant pin track infection rate [9].

Free fibular transfer with microanastomosis requires microsurgical technique. Donor site morbidity is related to the fact that the graft must be taken from a healthy limb. Al-Zahrani et al. [2] found no difference in healing rates between free fibular grafting and fibular transposition (92%). His rate of fatigue fractures was similar with the two techniques (26%). However, Enneking et al. [6]

reported fatigue fractures in 45% of cases, perhaps because their patients were undergoing bone tumour treatment and adjuvant protocols. We used a contralateral free fibular graft in combination with ITF in one patient; necrosis of the graft associated with infection occurred after 7 months. Furthermore, we reported no fatigue fracture of the fibula.

Ipsilateral fibular transposition, also referred to as the Huntington procedure, offers the advantages of internal fixation without the risks of using hardware at a site vulnerable to infection. The fibula serves as a biological plate that is firmly secured to the tibia and strengthened by iliac crest graft. The transposed fibula increases the length and strength of the limb, and restores its normal alignment. Chacha et al. [4] and Hertel et al. [12] studied the vascular supply to the fibula. They reported that the vascular supply to the transposed fibula (peroneal artery and muscular–periosteal network) appeared normal on angiograms obtained 6 and 8 weeks after fibular transposition. Huntington [13] transferred the fibula to both the proximal and the distal tibial segments in order to prevent pes valgus deformity. Among our eight patients whose nonunion healed, four had 5–12° of pes valgus, three had 0–5° of pes valgus and one had 5° of pes varus. However, the leg length discrepancy and the neurological impairments may contribute to the ankle deformity.

De Meulemeester et al. [5] reported a 1-year healing rate of 75% and Ruskowski [23] noted a marked fibular hypertrophy in all his 18 patients, of whom 12 were followed up for more than 10 years. Campanacci and Zanoli [3] found no significant association between age and time to healing. Fowles et al. [8] used ipsilateral fibular transposition in six patients with tibial defects ranging from 0.5 to 14 cm. No valgus deformities were noted, none of the patients had symptoms related to the tibio-fibular synostosis and healing was achieved within 4 months.

The data from our series suggest that following three factors were clearly associated with a poor outcome:

- (a) An increased time between the injury and treatment with the ITF. In the two patients who required amputation, the procedure was done 21 and 72 months after the injury, respectively. We suggest that fibular transposition should be considered earlier. Vascular supply alterations caused by multiple previous surgical procedures probably compromise the chance of healing. Campanacci and Zanoli [3] recommended that IFT be performed within the first year.
- (b) Location of the nonunion near one of the ends of the tibia: in two of the three failures, the nonunion was in the proximal third of the tibia. It is often difficult to obtain fibular fragments of sufficient length to bridge a tibial gap located near one end of the bone.
- (c) Absence of bone grafting during the fibular transposition procedure. In our series, the three most recently treated patients (cases 5, 6 and 9), in whom cortical-cancellous bone grafts were implanted; healing was achieved within 7–9 months.

In our opinion the presence of a fistulous track with no purulent discharge does not contraindicate fibular transposition. The literature suggests that fistulae tend to heal at the same time as the nonunion [25].

## 5. Conclusions

We believe that no single method of treatment for tibial nonunion should be given preference over the others. Rather, the entire armamentarium should be put to optimal use. Our findings and data from the literature show that ITF is a good procedure both for filling tibial defects and for healing tibial nonunions. Advantages of this technique include the fact that the graft is composed of strong cortical bone, and is oriented along the mechanical axis of the tibia, thus facilitating early weight-bearing. The operative time and the hospital stay are relatively short and the risk of donor site morbidity from the contralateral leg is eliminated.

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