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Foot reconstruction using vascularised fibula

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SUMMARY. **Vascularised fibula has been used to treat three patients with skin-bone defects of the foot following severe trauma. Similarity between fibula and metatarsal bone is obvious and makes fibula an ideal choice in the replacement of defects in the first metatarsal. Depending on the size of soft tissue defects, different combinations of fibula-skin transfer were used.**

Adequate blood supply to grafted bone is of paramount importance in the healing process by changing it to that of a fracture, thus shortening the healing period and reducing atrophy and absorption of the grafted bone. The use of vascularised fibula was first reported by Taylor *et al.*[1] The possibility of including the overlying island of skin, nourished by septo and musculocutaneous perforators from the peroneal artery, was described by Chen and Yan.[2] Minami *et al.* and Townsend[3,4] used reverse-flow vascularised fibula for defects of the lower third of the tibia. The anatomy of the fibula has been clarified in detail by Wei *et al.*[5] Vascularised fibula has had a wide application for long-bone replacement in extremity trauma[2,6] or tumour resection[2] as well as for the treatment of congenital pseudoarthrosis of the tibia[7,8] and mandible reconstruction.[9] The fibula has a number of characteristics that make it an attractive choice for foot reconstruction in cases where the first metatarsal has to be reconstructed, but no reports have been published using fibula for such a purpose. In this paper we describe three different ways of using vascularised fibula for foot reconstruction, depending on the size of soft-tissue and bone defects.

Patients and methods

Three patients with post-traumatic soft tissue and bone defects underwent reconstruction of the foot with vascularised fibula. The average size of the bone defect was 9 cm and the skin defect varied from 5 × 8 cm to 21 × 10 cm. In two cases fibula was transferred as a free flap and in one case as a reverse flow pedicle flap. In two cases overlying skin was included for soft tissue reconstruction of the dorsum of the foot. In a case where the soft tissue defect was extremely large, combined free tissue transfer with latissimus dorsi and fibula was used. Bone fixation was achieved by intramedullary inserted K wires. The remaining stump of fibula was stitched through the periosteum to the tibia in order to produce a tibiofibular synostosis and prevent valgus deformity.

Results

In all our cases transfer of a vascularised fibula was successful although partial loss of the skin was noted in the case with the reverse-flow pedicle, due to venous congestion of the flap, which was tunnelled to the defect under a tight skin bridge. In the case where a free fibula-skin flap was used, reexploration had to be done the day following surgery, because of haematoma, but the flap was salvaged. Bone healing was obtained after approximately 6–9 weeks but full weight-bearing with functional cast bracing was not allowed before ten weeks. Skin grafted donor sites of the skin-fibula flap healed primarily and there was no morbidity due to the sacrifice of part of the fibula. The contour of reconstructed feet was judged to be excellent and both arches (transverse and longitudinal) were reestablished. Patients were encouraged to wear an insole in the shoes of the affected sides and there were no stress-fractures.

Case reports

Case 1. A 10-year-old boy with a blast injury of both legs after a mine explosion had compound fractures of both tibias and left foot. He underwent primary radical debridement of all devitalised tissue and external fixators were applied on both legs. A few days later, a latissimus dorsi free flap was used to cover the exposed fracture on the right leg and the same procedure was performed a week later to cover the dorsum of the left foot. The bony defect of the first metatarsal measured about 4 cm (Fig. 1A). The flap failed due to intimal damage of the anterior tibial artery, which was used as a recipient vessel. A skin graft was applied to provide temporary cover (Fig. 1B) and 4 weeks later an osteocutaneous fibula flap was performed using 6 cm of fibula and a 8 × 5 cm paddle of skin, based distally on the peroneal vessels (Fig. 1C). The flap was tunnelled to the defect under an intact skin bridge and the fibula was dowelled into the residual 1st metatarsal bone stumps and fixed with an intramedullary K wire (Fig. 1D). Venous congestion of the flap was observed postoperatively and resulted in minor marginal skin necrosis which healed spontaneously by three weeks later (Fig. 1E). Bony union occurred at 8 weeks and this was supplemented with cast bracing for further 4 weeks, when fibular hypertrophy was noted.

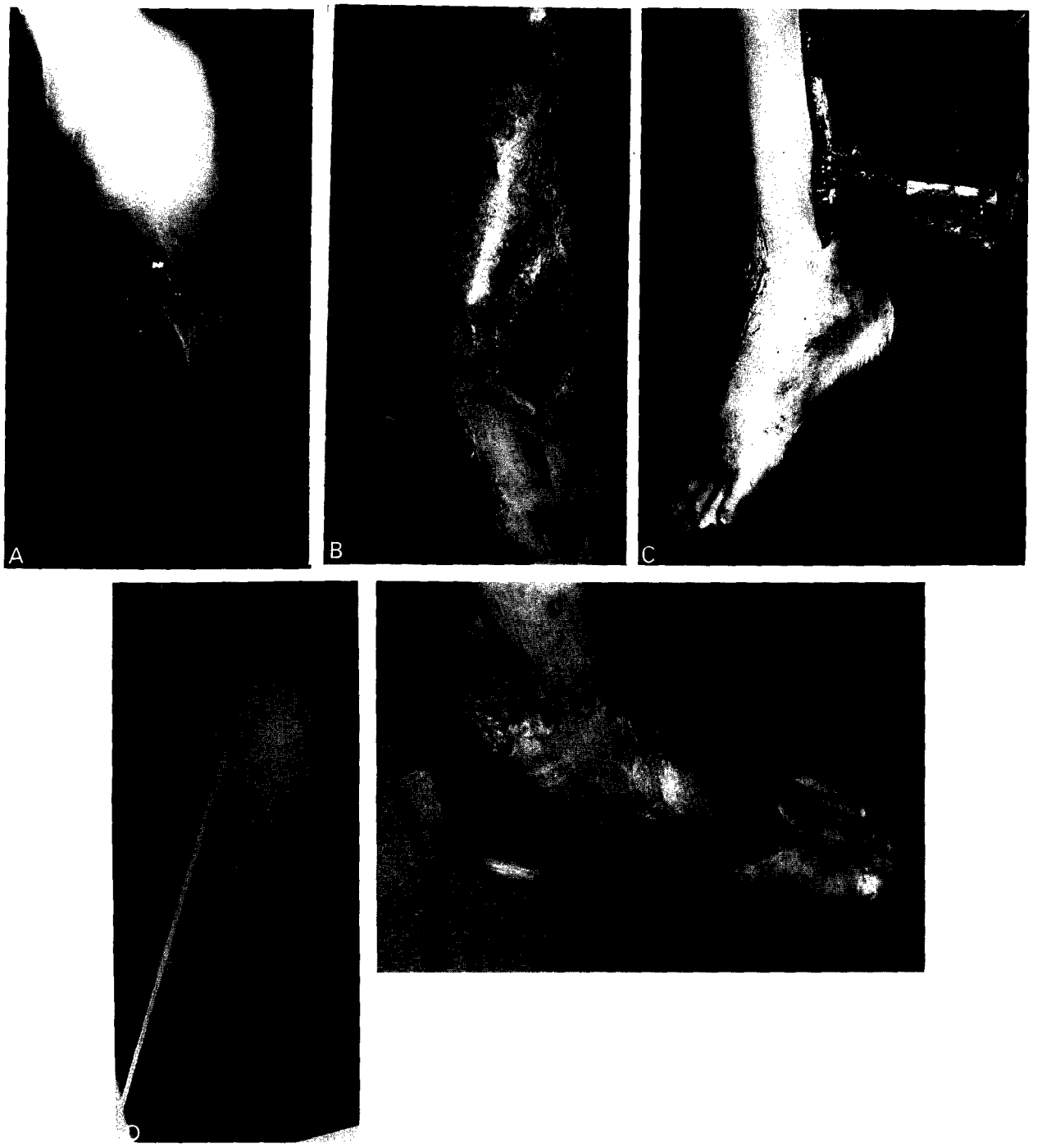

Fig. 1

Figure 1—*Case 1.* (A) Preoperative X-ray shows defect of first metatarsal bone. (B) Dorsum of the foot covered with skin graft. (C) Osteocutaneous fibular flap raised on distal pedicle. (D) Fibular graft dowelled into head and base of first metatarsal bone and fixed with intraosseous K-wire. (E) Postoperative result after 3 months. Note preserved longitudinal arch of the foot.

Case 2. A 12-year-old boy involved in a car accident suffered a crush injury of the dorsum of the right foot with loss of all skin and tendons (Fig. 2A). Plain radiographs revealed loss of the 1st metatarsal bone except for the head, part of the second and the whole third metatarsal bone and part of the cuneiform bone (Fig. 2B). Primary debridement and temporary fixation of bones with K wires was done by orthopaedic surgeons and amputation of the foot was considered. However, we performed a free skin fibula flap to bridge the bone defect on the medial side of the foot and replace missing skin. A 15 × 7 cm skin paddle and 9 cm long part of the fibular shaft were raised on peroneal vessels and anastomosed end-to-end to previously ligated anterior tibial vessels. Fibula was dowelled into the head of the 1st metatarsal bone and cuneiform bone and fixed in place with intramedullary K wire. On the second postoperative day, signs of insufficient venous return appeared in the skin flap. Emergency reexploration revealed a large subcutaneous haematoma compressing the vein. Circulation of the flap was restored after evacuation of the blood clot. Superficial necrosis measuring 3 × 2 cm occurred at the proximal part of the flap. The resulting small defect was subsequently grafted (Fig. 2C). The grafted fibula healed soundly 2 months after operation (Fig. 2D).

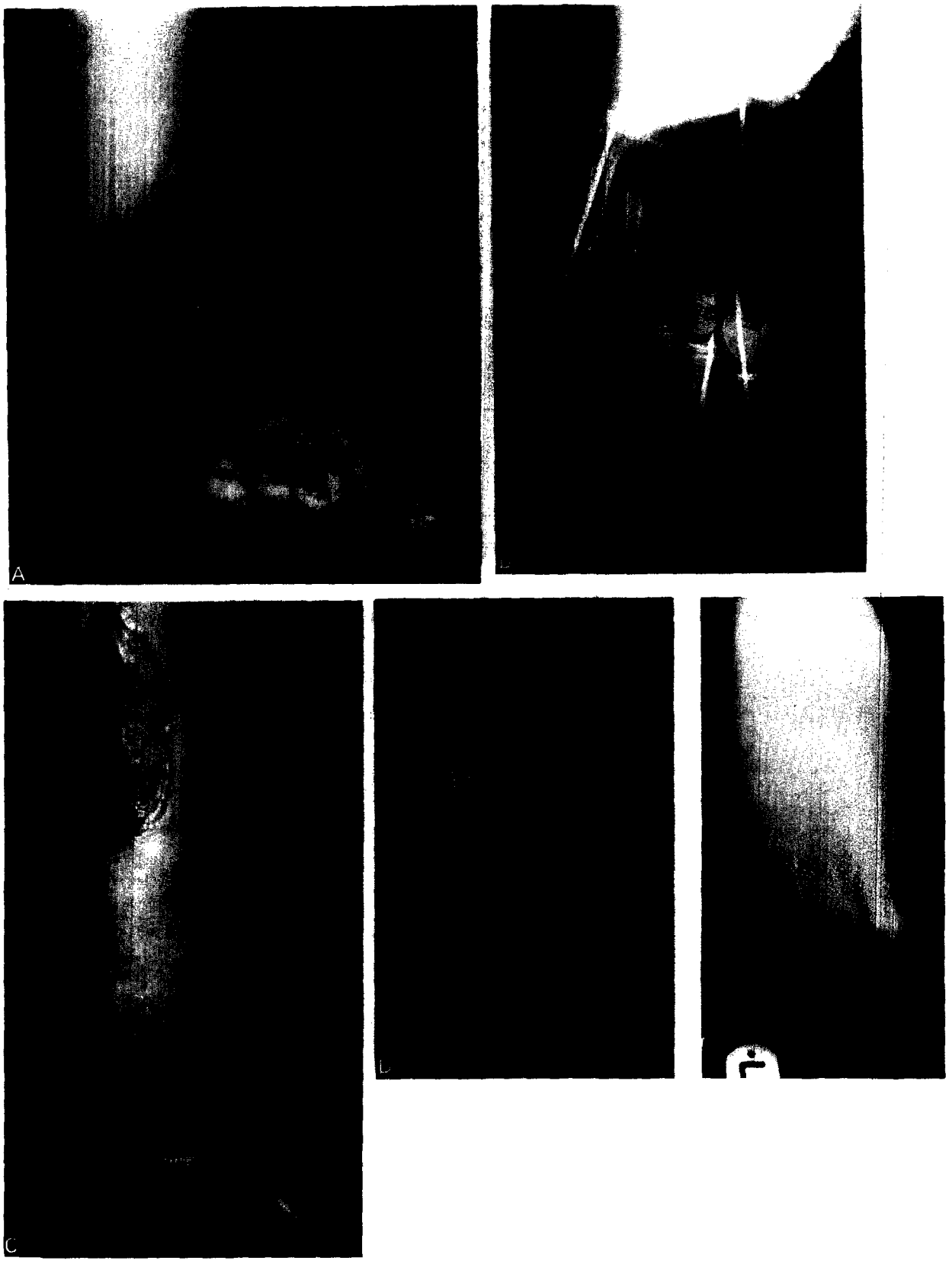

Fig. 2

Figure 2—*Case 2.* (A) Defect of the dorsum of the foot. (B) X-ray shows loss of almost whole first and third metatarsal and partial loss of second metatarsal and cuneiform bone. (C) Two months after the surgery foot is still oedematous. Good healing of donor area. (D) Postoperative X-rays taken 2.5 months after surgery.

Case 3. A 17-year-old boy was referred 7 days after sustaining a crush injury to his right foot, with extensive loss of skin from the medial aspect of the foot, tarso-metatarsal subluxation of I-III metatarsal bones and double fracture of the first metatarsal bone. Skin debridement and fixation of the first metatarsal bone was initially performed (Fig. 3A').

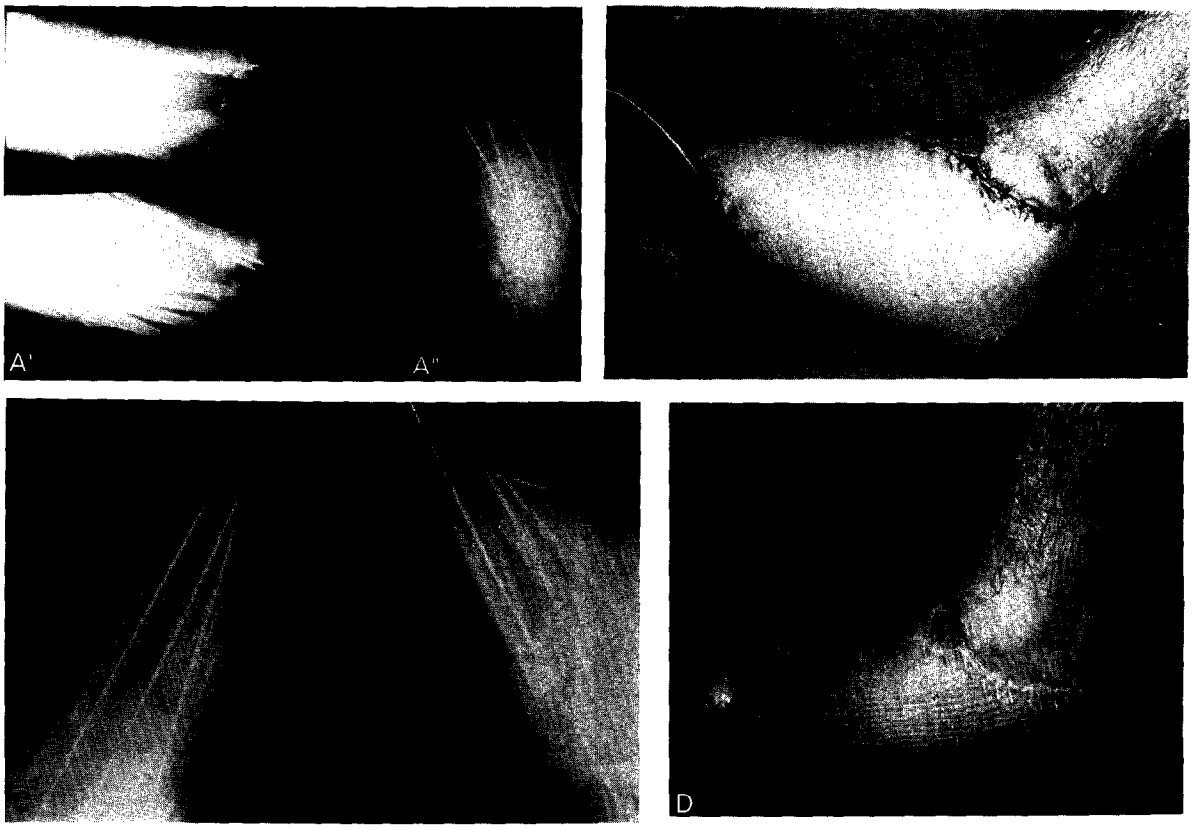

Fig. 3

Figure 3—*Case 3.* (A) Preoperative X-rays show fractures and dislocations of metatarsal bones (A′). X-ray after additional reposition of bones. First metatarsal bone shows necrotic changes (A″). (B) Latissimus dorsi free flap covering medial and dorsal aspects of the foot. (C) A 12 cm long fibular graft in place. (D) Result 1 year after the operation. Flap is bulky. Note ecchimosis due to vigorous walking.

The wound became infected, with skin and tendon necrosis. Additional debridement and further bone fixation was done (Fig. 3A″) but the first metatarsal became necrotic and it had to be removed. After the infection had subsided, a 12 cm long vascularised fibular graft and 21 × 10 cm paddle of latissimus dorsi skin-muscle flap were used to bridge the defect (Fig. 3B, C). Peroneal vessels were sutured to the arterial branch of the thoraco-dorsal vessels going to serratus anterior muscle, using vein grafts to allow better positioning of the fibular graft. The main vessels were anastomosed to the posterior tibial vessels; artery end-to-side, vein end-to-end. The fibular graft was designed slightly shorter than the actual defect in order to produce a pseudoarthrosis with the intact articular surface of the proximal phalanx and was fixed in place with an intramedullary K wire. The flap survived completely. Bony union at the proximal part occurred 9 weeks later. The skin flap was rather bulky but the patient refused further surgery (Fig. 3D).

Discussion

The foot plays a dual role; it functions as a support for the weight of the body in the standing position and as a mobile springboard during walking and running. The bones of the foot are arranged in the form of two longitudinal arches medial and lateral, and one transverse arch; the latter is particularly well marked between the shafts of the metatarsals. In the standing position the weight of the body is shared approximately equally by the heel pad and the pads underlying the heads of the metatarsals. About one third of the total weight taken by the metatarsal pads falls on the pad under the ball of the great toe, and the remainder is shared between the other toes.[10] In spite of its important function and frequency of injury, there are not many papers in the literature regarding reconstruction of soft tissue and bone defects of the foot. Conventional bone grafting and latissimus dorsi free flaps have been the treatment of choice for smaller bone defects.[11] In 1983, Taylor[12] published the use of vascularised anterior iliac crest for the reconstruction of 1st metatarsal bone in three cases.

The fibula is now a well-recognised source of vascularised bone and has important advantages over other donor sites. It is a long straight bone with high cortical density. It is easy to dissect, with predictable anatomy and rather low donor site morbidity. Similarity between 1st metatarsal and fibula is obvious. The possibility of including an island of thin, well vascularised skin on the same pedicle, whether as a free or distally based reverse-flow pedicle, makes the vascularised fibula almost ideal for foot reconstruction. However, there are certain limitations which should be respected in order to achieve the best result. In order to reach the distal part of the foot, the most proximal part of the fibula-skin flap has to be taken and it makes a reverse-flow based flap suitable only for smaller skin-bone defects, as we have shown in our first case, while the limited amount of available skin prevents the use of this flap for covering large skin defects and other sources of skin cover should be found, as in our third case. For moderate size defects

a free skin-fibula flap was used. We have chosen the injured leg as a donor site in harvesting the fibula in all three cases in order to prevent any damage to the healthy one. High cortical density of fibula and postoperative thickening of the bone enable the reconstructed arch to withstand weight-bearing pressure while standing or walking.

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