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Free Vascularized Fibular Bone Graft, a Reliable Method for the Management of Large Skeletal Defects in Orthopaedic Trauma

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Abstract

Introduction: Free vascularized fibular bone grafts have become the most commonly used free vascularized bone grafts used to treat large post-traumatic defects caused by high-energy trauma, as well as large post-traumatic non-unions.

Material and methods: We present two high energy trauma cases: a traumatic amputation of the forearm – 22C3 open Gustilo-Anderson type IIIC (case 1) with a 10 cm residual radial shaft defect and a paragliding accident resulting in a 43C3 open Gustilo-Anderson type IIIB (case 2) with a residual tibial shaft defect of 8 cm. The residual defect was treated in both cases with an osteoseptocutaneous free vascularized fibular bone graft. The follow-up was performed at 3 weeks, 3 months, 6 months, 1 year and 3 years. The bone graft showed radiological signs of integration at 3 months in both cases. The three-year follow-up revealed good clinical and excellent radiological results in case 1 and excellent clinical and radiological results in case 2.

Conclusions: Free vascularized fibula grafting provides an attractive reconstructive option for orthopedic surgery. Free fibular grafting has been proven to be an ideal choice in the management of large segmental bone defects as well as in situations of biological failure of bone healing.

Keywords: Free vascularized fibular bone graft; Large prost-traumatic bone defect; Reconstructive surgery; High-energy trauma

Introduction

It is well known that bone defects caused by trauma, tumors, pseudarthrosis and infections are highly challenging clinical situations that can often result in significant disability or limb amputation. Despite the development of bone substitutes, growth factors, endoprostheses and distraction osteogenesis, the most physiological solution is using a bone graft, an approach that remains very useful in complex cases [1,2].

Bone grafts can be broadly divided into nonvascularised (conventional) and vascularized grafts [1,3,4]. The success of conventional bone grafting mainly lies in the blood supply of the recipient bone and surrounding tissue. Without an adequate blood supply, nonvascularized grafts are not capable of remodeling, and the transplanted bone can fail to bind with the recipient bone [5]. Free vascularized fibular bone grafts (FVFGs) have become the most commonly used free vascularized bone grafts. FVFGs were initially used to treat post-traumatic bone defects; nevertheless, they are currently also used for bone defects resulting from congenital anomalies, infections and tumors [3,5,6], as well as for salvage scenarios such as difficult arthrodesis and femoral head avascular necrosis (AVN) [7-9].

FVFGs are often used to treat large prost-traumatic defects caused by high-energy trauma, as well as large post-traumatic non-unions [10].

Material and Methods

We present two cases of patients treated between 2012 and 2015 at the Orthopedics and Traumatology Clinic of the "Sf. Spiridon" Hospital in Iasi, in collaboration with the Department of Plastic and Reconstructive Surgery. The cases involved high energy trauma fractures: traumatic amputations of the forearm - 22C3 open Gustilo-Anderson type IIIC (case 1) and a paragliding accident resulting in a 43C3 open Gustilo-Anderson type IIIB (case 2).

Preoperative biplanar radiographs were used to assess the bone status and defects. Patients were regularly examined by X-ray to check for post-operative reduction, bone union evidence, hypertrophy of the transferred fibula and late complications. The follow-up was performed at 3 weeks, 3 months, 6 months, 1 year and 3 years.

Post-operatively, all the flaps were clinically monitored using the standard protocol [11]. Also, free fibula donor site morbidity was assessed in terms of weakness of foot evertors and great toe flexors and diffuse leg and ankle joint discomfort.

Surgical technique

Repeated cleaning of the wound was performed before the area was skin grafted. The fractures were externally fixed. The free vascularized fibular osteocutaneous flap was performed after the wounds had healed and the inflammation had subsided. Preoperative planning of FVFGs involved the initial exclusion of patients with peripheral vascular disease, deep venous thrombosis or previous damage to their blood vessels. The flap design depended on pathology and on the need for additional tissues.

It is important to recall that the peroneal artery should not be divided from the fibular bone during harvesting and that the main nutrient artery enters the fibula in the bone's middle third, and sometimes in

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its proximal part; thus, the FVFG must also include this section of the bone [6]. The size of the defect will determine the required bone length; however, at least 6 cm of proximal and 4 cm of distal fibula should be left behind at the donor site. Commonly, a lateral surgical approach is used for the osseous flap: Gilbert's modification of Taylor's original posterior approach (Figure 1).

In the case of tibial fracture (case 2), the transferred fibula was inlayed in the medullary canal after partial stripping of the periosteum. Kirschner (K)-wire at graft host junction was added to provide additional strength. For the forearm fracture (case 1), the fibula was fixed with a bridging plate. In open injuries, when osteocutaneous flap was used for reconstruction, the skin flap was sutured to the wound's edge.

The peroneal artery and its venae comitantes were anastomosed to the donor vessels. The mean ischemic time of the grafts was 1.5 h. The fibular osteocutaneous flap donor site was covered with a split thickness skin graft. Post-operatively, intravenous antibiotics were used for 7 days and thromboembolism prophylaxis was done for 1 month.

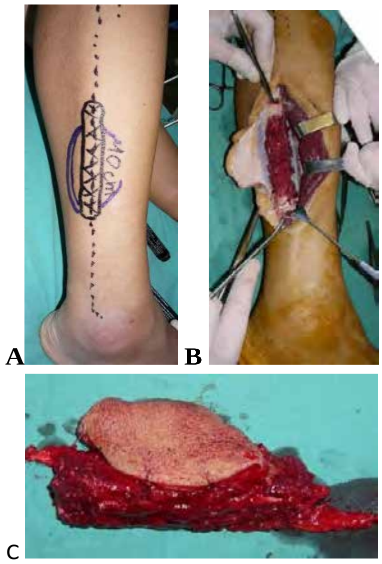

Figure 1: Intraoperative images: A. preoperative planning (dots – the projection of the fibula on the skin; the projection of the bone graft needed for harvesting – 10 cm); B. intraoperative image of the incision and the fibular graft harvested; C. FVFG harvested with a skin flap.

Case Presentation

Case 1

The first case was a 54 year old male who suffered a high-energy trauma (farm accident) that affected his right forearm (incomplete traumatic amputation). He had a 10 cm radial shaft defect and a 2 cm ulnar shaft defect. He was initially treated by end to end fixation of the ulna with a Kirschner wire and an external fixation of the radius followed by debridement, revascularization with reconstruction of both vascular axis, primary neurorrhaphy of median and ulnar nerves and tenorrhaphy of deep flexors and extensors of the forearm. After 3 months, when the infection subsided, the large radial and soft tissue defects were reconstructed with an osteoseptocutaneous free vascularized fibular bone graft (FVFG). The bone graft showed radiological signs of integration at 3 months. The three-year follow-up revealed good clinical and excellent radiological results (Figure 2).

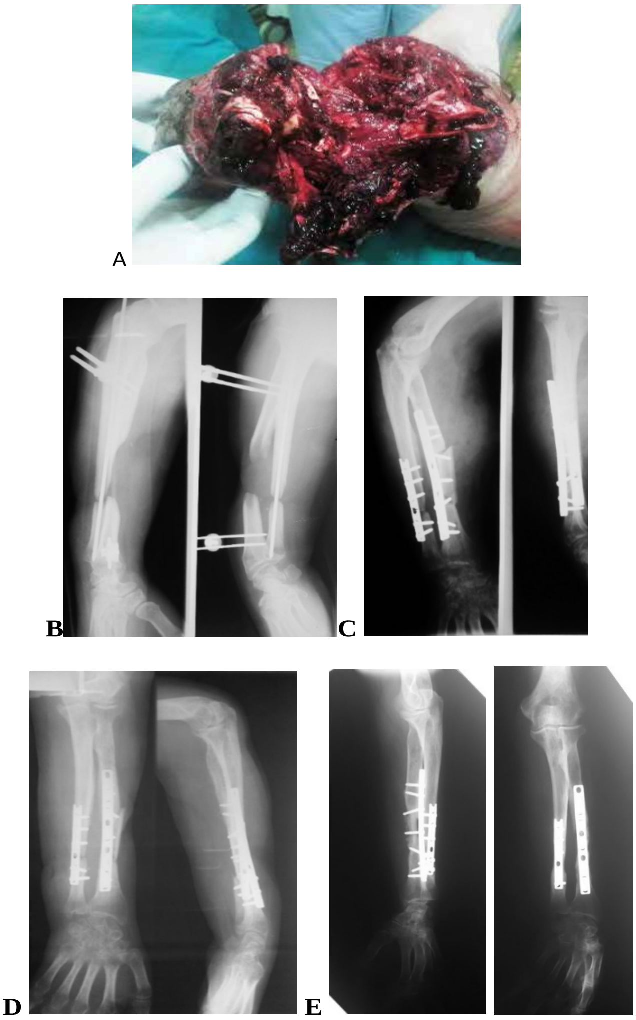

Figure 2: Case 1: A. post-traumatic image of the right forearm (incomplete amputation); B. post-operative X-Ray: fixed forearm bones with a residual 7cm radial shaft defect; C. post-operative X-Ray after FVFG; D. 3 months X-Ray after FVFG, showing callus formation; E. 3-year follow-up X-Ray.

Case 2

The second case involved a 30 year-old male patient who suffered a paragliding accident resulting in a 43C3 open Gustilo-Anderson type IIIB, a Young and Burgess LC Type I pelvic fracture, head trauma and multiple contusions. After debridement, open reduction and internal fixation (ORIF) of the fibular fracture and external fixation of the tibia fractures were performed. A residual tibial shaft defect of 8 cm and a skin defect of 9/5cm were detected. At 3 weeks, given the favorable local and general conditions, these defects were reconstructed with an osteoseptocutaneous FVFG. The patient had excellent clinical and radiological results at the 3-year follow-up (Figure 3).

Discussion

The fibula is a long and straight tubular bone, which is not difficult to harvest, as long as the donor site morbidity is minimal, up to a graft length of 20 cm [12]. The anatomy is predictable, and its size and shape allow for a satisfactory fixation of femoral, tibial and humeral defects. Reconstruction of free fibula flap in long bones is a useful and versatile procedure for defects greater than 6-8 cm [13]. Free vascularized fibula grafting should be employed in specific clinical situations. Currently, FVFG indications fall into two categories: segmental bone defects greater than 6 to 8cm, such as those seen in post-traumatic or post-infectious bone loss and tumor resection; smaller bone defects following biological failure of healing, as seen in recalcitrant fracture nonunions, congenital pseudarthroses and osteonecrosis [14]. Contraindications may include: chronic infections, diabetes, immunosuppression, alcohol, tobacco, drug abuse and obesity.

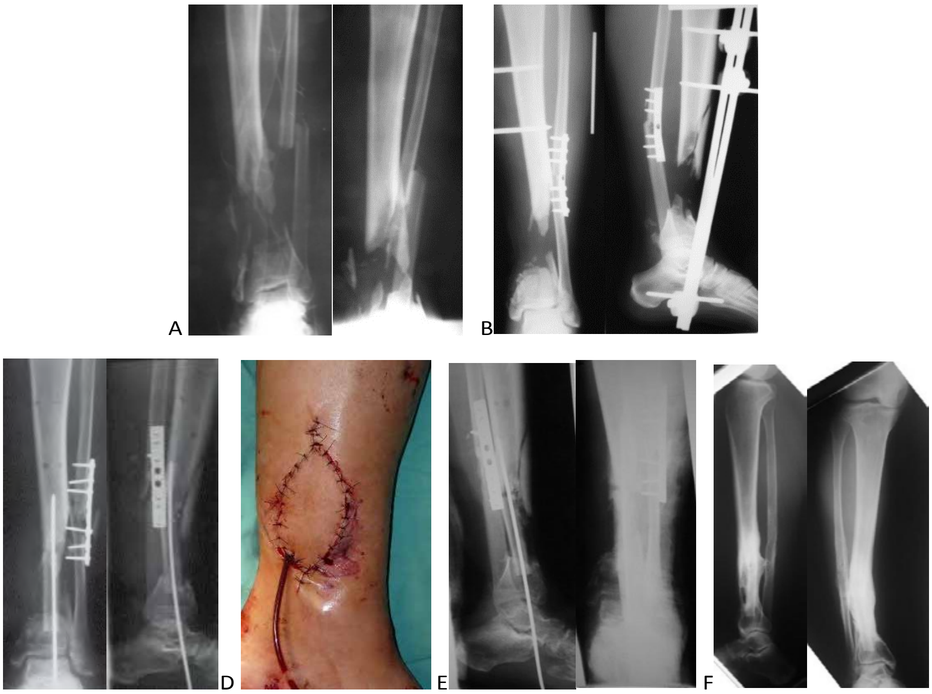

Figure 3: Case 2: A. preoperative X-Ray: 43C3 open fracture; B. post-reduction X-Ray: ORIF of the fibular fracture, where the length of the leg and external fixation of the tibial shaft facture can be observed; C. post-operative X-Ray after FVFG; D. post-operative image after wound closure and skin defect correction; E. 3 month post-operative X-Ray showing signs of callus formation with fibular graft integration; F. 3-year follow-up X-Ray.

The two patients who suffered from high energy trauma were male, as male patients are more exposed to the external environment [15].

The overall success rate of the procedure, as estimated from literature, varies from 76% to 100%, with a healing time in the 3.7 – 8.9 months interval [14]. In a large Mayo cohort, the primary and secondary union rates in vascularized fibular grafts performed for non-osteomyelitis indications were 69%-84%, respectively; but, if defects with infections are considered, the union rates fall to 49% and 77% [16]. A meta-analysis of 13 different series involving 317 reconstructions for atrophic non-unions resulted in a mean time for fracture consolidation of 5.5 months in 87% of patients [17]. In cases of severely injured limbs complicated by infection and large bone defects, the successful reconstruction rate was lowered to 71.5% [18].

In our cases, the bone defects ranged from 8 cm to 10 cm; the treatment was performed in two stages; the complete healing was obtained in both cases, with a mean period for X-Ray evidenced bone union of 4.5 months.

Conclusion

Free vascularized fibula grafting provides an attractive reconstructive option for orthopedic surgery. Free fibular grafting has been proven to be an ideal choice in the management of large segmental bone defects as well as in situations of biological failure of bone healing.

Conflict of Interests

Authors and co-authors have no conflict of interests to disclose.

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