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Case report

Do stress fractures induce hypertrophy of the grafted fibula? A report of three cases received free vascularized fibular graft treatment for tibial defects

Yong Qi [a, b, *], Hong-Tao Sun [a], Yue-Guang Fan [c], Fei-Meng Li [a], Zhou-Sheng Lin [a]

[a] Department of Orthopaedics, Guangdong Second People's Hospital, Guangzhou 510317, China
[b] Guangzhou University of Traditional Chinese Medicine, Guangzhou 510405, China
[c] Department of Orthopaedics, The First Affiliated Hospital of Guangzhou University of Traditional Chinese Medicine, Guangzhou 510405, China

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ABSTRACT

The presence of large segmental defects of the diaphyseal bone is challenging for orthopedic surgeons. Free vascularized fibular grafting (FVFG) is considered to be a reliable reconstructive procedure. Stress fractures are a common complication following this surgery, and hypertrophy is the main physiological change of the grafted fibula. The exact mechanism of hypertrophy is not completely known. To the best of our knowledge, no studies have examined the possible relationship between stress fractures and hypertrophy. We herein report three cases of patients underwent FVFG. Two of them developed stress fractures and significant hypertrophy, while the remaining patient developed neither stress fractures nor significant hypertrophy. This phenomenon indicates that a relationship may exist between stress fractures and hypertrophy of the grafted fibula, specifically, that the presence of a stress fracture may initiate the process of hypertrophy.

Introduction

The presence of large segmental defects of the diaphyseal bone following tumor resection, infection, or trauma is a challenging problem for orthopedic surgeons. There are no established methods for reconstruction of such defects. Although a number of methods are available for reconstruction of diaphyseal bony defects, free vascularized fibular grafting (FVFG) is considered to be a particularly reliable procedure.[1–3]

Many papers have focused on the clinical effect of FVFG for reconstruction of long-bone defects.[4,5] The most common clinic complications following FVFG are nonunion, malunion, loosening or breakage of the internal fixation devices, and stress fractures.[6] To the best of our knowledge, few reports have addressed stress fractures of the grafted fibula. It remains unknown that to what degree stress fractures affect the grafting outcome and whether there is relation between stress fractures and hypertrophy.

We herein report three cases of patients who underwent FVFG for tibial defects. The follow-up period ranged from 2 to 7 years. All the three patients achieved clinical and radiological union.

Case report

Case 1

A 47-year-old female sustained an open tibial and fibular injury in a motorcycle accident in September 2007. She underwent primary treatment in another hospital, i.e. internal fixation of the fibula and wound closure using a microsurgical flap. Six months later, she presented to our hospital for reconstruction of the tibial defect. FVFG was conducted to bridge the tibial defect (Fig. 1A). Both ends of the transferred fibular graft have inserted into the marrow cavity of the tibia. Two screws were used to strengthen the fixation at each end (Fig. 1B). Partial weight-bearing was permitted when partial radiological union was observed after three months. The patient experienced mild pain in the right lower leg at eight months postoperatively, which lasted for three months. However, the patient did not seek any treatment. A stress fracture was found radiologically at 12 months postoperatively (Fig. 1C). A large bone callus had formed around the fracture site, with significant

* Corresponding author. Department of Orthopaedics, Guangdong Second People's Hospital, Guangzhou 510317, China.
E-mail address: yongqi1979@163.com (Y. Qi).

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Fig. 1. Case 1. A: X-ray of tibial defect. **B**: X-ray shows bony healing of the grafted fibula six months postoperatively. **C**: A stress fracture was found 12 months postoperatively with a large bone callus. **D**: The grafted fibula became nearly as strong as the tibial shaft 66 months postoperatively.

hypertrophy. No special intervention was performed because the patient felt no pain at the time of visit. X-ray showed that the transferred fibular graft had become nearly as strong as the tibial shaft when the patient returned for check-up 66 months postoperatively (Fig. 1D). She could walk and jump normally without any pain.

Case 2

A 28-year-old man presented for treatment of large segmental tibial defects in his left leg following segmental resection for tibial osteomyelitis (Fig. 2A). FVFG was done to reconstruct the large tibial defects. The surgery was very successful, and the patient could walk with full weight-bearing one year postoperatively. He returned for a routine X-ray examination two years later, and no significant hypertrophy was seen except for a slight thickening at the ends of the grafted fibula (Fig. 2B). He returned again two months later because of a one-month history of leg pain. X-ray examination showed a stress fracture in the middle of the grafted fibula (Fig. 2C). Hypertrophy was significant at both distal and proximal ends, and a moderately sized bone callus had formed around the fracture site. The patient was recommended to avoid weight-bearing walking for three months, and the pain disappeared quickly after the adjustment in walking way. X-ray examination at three and six years showed that the stress fracture had healed but the hypertrophy was very significant. The diameter of the grafted fibula was nearly identical to that of the normal tibia (Fig. 2D).

Case 3

A 44-year-old male sustained severe trauma to the right lower leg in December 2012. He developed severely comminuted open fractures of the tibia and fibula. The seriously contaminated tibial segment was removed (Fig. 3A). When no sign of infection was observed three months later, he underwent FVFG combined with a locking plate for tibial defect reconstruction. The postoperative rehabilitation protocol was identical to that for the other two patients. The grafted fibula experienced a smooth union, and function was excellent at the last follow-up (two years). No stress fractures

Fig. 2. Case 2. A: Large segmental tibial defects are present in the left leg following segmental resection for tibial osteomyelitis. **B**: X-ray shows no significant hypertrophy in the shaft of the fibula 24 months postoperatively. **C** A stress fracture occurred 26 months postoperatively. **D**: X-ray six years postoperatively showed that the stress fracture had healed and the hypertrophy was very significant.

Fig. 3. Case 3. A: Large segmental tibial defects in the right leg caused by trauma. **B** and **C**: Radiological films at 20 months and 24 months after surgery. No stress fracture or significant hypertrophy occurred during the 2-year follow-up period.

occurred during the two years follow-up period. Since no significant hypertrophy was observed, the grafted fibula was still very slender (Fig. 3B, C).

Discussion

FVFG is not the gold standard technique for the treatment of large defects of long bones. However, it is one of the best choices because of its superiority in terms of graft length, mechanical strength, durability, and safety against infection and transmission of infectious agents.[1–3]

As a reconstructive option, one of the benefits of vascularized bone is its ability to hypertrophy.[4] After the process of hypertrophy, the grafted fibula becomes strong enough to bear weight. Although the exact mechanism of hypertrophy is not completely known, mechanical loading of the graft appears to be a critical factor.[7,8]

Most studies of FVFG focus on the clinical effects after reconstruction of long bone defects caused by trauma or tumors. Few reports have addressed its complications. The most common complications related to this surgery are nonunion, fixation failure, infection, and stress fractures. In clinical practice, such complications may profoundly affect the surgical outcome. This is a substantial problem for patient's rehabilitation process.

One complication that concerns both patients and surgeons is stress fracture[9] because the fibula is too tenuous to bear the weight of the body. According to previous clinical reports, the incidence of stress fracture is around 10% (range, 7%–16%).[1,9] Potential mechanisms include excessive mechanical stimulation upon the fibular graft or misalignment following inappropriate fixation. Some methods used to reduce the occurrence of this complication include placement of conventional plates, external fixation, use of a locked plate system, and delayed load-bearing.[10,11] In a study by Sun et al,[4] no stress fractures occurred after the use of a locked plate system, and not all patients developed significant hypertrophy; in particular, no significant hypertrophy developed in the middle of the grafted fibula. This is because the biomechanical characteristics of the locking plate provide a state of relative stability that shielded the graft from stress and prevent hypertrophy. In the present study, screws were used at each end to fix the transferred fibular graft to the tibia in Case 1 and Case 2, and a locking plate was used in Case 3. Both fixations provided enough stability to ensure that no fixation failure occurred before bone union.

The postoperative treatments were almost identical among all the three patients. However, the rehabilitation process was different, especially the timing and degree of postoperative hypertrophy. In the first patient, a stress fracture occurred in the early postoperative period, and significant hypertrophy quickly developed. The second patient exhibited no significant hypertrophy until a stress fracture occurred 26 months postoperatively. The third patient exhibited no hypertrophy because no stress fracture occurred during the 2-year follow-up period.

We hypothesize that there is a relation between stress fractures and hypertrophy of the grafted fibula. The development mechanism of stress fracture may be the same as that of hypertrophy, or stress fractures may initiate bony hypertrophy. During this process, weight or excessive external force causes micro-stress fractures and hemorrhage underneath the periosteum, which then activates osteoblasts and osteoclasts and eventually leads to increased bone mass and bone remodeling.

In conclusion, the three cases described in this report indicate that stress fractures may stimulate hypertrophy of the grafted fibula. But we only have three cases and multicenter clinical studies are need for further investigation.

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