# Rigid bridging of massive femur defect using double vascularized fibula graft with hydroxyapatite

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## Abstract

The presence of large and massive segmental defects of the diaphyseal bone following tumor resection is a significant problem for orthopedic surgeons. Double or folded free vascularized fibula graft (FVFG) is used in massive femur defects and is considered to be a reliable reconstructive procedure. However, folded or double fibula grafts cannot prevent stress fractures. Here, a novel surgical procedure for bridging of massive femur defects using double FVFG and hydroxyapatite (HA) with autogenous bone grafts to prevent stress fractures is reported.



**Keywords** Femur defect・ Vascularized fibula graft・Hydroxyapatite・Autogenous bone graft・Surgical treatment


## Introduction

The presence of large and massive segmental defects of the diaphyseal bone following tumor resection is a significant problem for orthopedic surgeons. The search for suitable standard methods for bridging of massive bone defects has led to the use of autogenous bone grafts, such as the free vascularized fibula graft (FVFG) [1,2], allografts [3,4], prosthesis implants [5] and distraction osteogenesis procedures [6]. Although there are an array of available methods for long-bone reconstruction of bony defects, FVFG is particularly useful in large defects [1,2]. Several papers have reported that FVFG in the femur is subject to stress fractures due to the low initial mechanical strength [7,8]. For this reason, double or folded FVFG is used in massive femur defects and is considered to be a reliable reconstructive procedure [9,10]. However, folded or double fibula grafts cannot prevent stress fractures [7,8,10]. Here, a novel surgical procedure for bridging of massive femur defects using double FVFG and hydroxyapatite (HA) with autogenous bone grafts to prevent stress fractures is reported.

## Case report

A 13-year-old girl suffered from right thigh pain in October 1999 and was diagnosed with osteoblastic osteosarcoma (Fig. 1-A, B). After diagnosis, she underwent preoperative chemotherapy with methotrexate, vincristine, cisplatin (CDDP), doxorubicin (ADR), and ifosfamide (IFO). After chemotherapy, wide resection of the femur (bone defect was 21 cm) and reconstruction, using double FVFG and external fixation, were performed in April 2000 (Fig. 1-C). For postoperative chemotherapy, administration of IFO, CDDP and ADR were initiated, and a total of three courses were administered. After we confirmed bone union on plain radiographs, external fixation was removed and the patient began partial weight-bearing in September 2001. After removal of fixation, she experienced fracture of the grafted bones a total five times (Fig. 2-A, B), and received conservative treatment after each incident. In June 2004, we performed open reduction and internal fixation using plates and screws for both fibula fractures and we placed five HA blocks (interconnected porous calcium hydroxyapatite [11,12]) (Neobone®, MMT, Japan) between fibula bones and placed corticocancellous iliac bone behind the three central HA blocks, and fixed them with thread (Fig. 3-A, B).

Free walking was enabled within three postoperative months. At present, (more than 2.5 years postoperatively), she is able to walk without assistance, discomfort or fracture. Her ISOLS scale, which is based on Enneking's criteria [13] is 93.3%, and there is no local recurrence or metastasis. Recent x-rays have revealed bridging union between the grafted fibulas at the sites where iliac bones were placed, but no union and resorption at sites where iliac bones were not placed (Fig. 4).

**Discussion**

Large bone defects, particularly in the femur, resulting from bone tumors present both surgical problems and reconstructive challenges. Reconstruction using an allograft or endoprosthesis allows bridging of the defect without difficult surgical techniques. However, neither method results in durability. Allograft alternatives have become less desirable due to concerns about graft resorption and poor revascularization, which may lead to stress fracture and nonunion, infection and transmission of infectious agents [14,15]. Endoprosthetic replacement has become an established method for early weight-bearing, but the management of loosening and infection has become a major concern [16,17]. Reconstruction using distraction osteogenesis provides bone that will develop sufficient biomechanical strength and durability, but is a complex and time-intensive procedure [18].

FVFG is probably the most suitable procedure for reconstruction of massive defects [1,2,19] because of its length, mechanical strength, durability and safety with regard to infection and transmission of infectious agents. However, reconstruction by FVFG is also associated with problems, particularly for massive femur defects. An important problem is the low mechanical stress of the fibula for femur reconstruction, and an incidence of 7-16% for stress fractures has been reported [7,8]. The fibula exhibits hypertrophy through a process of pressure transport, microfractures and callus formation; however, this hypertrophy requires a long period of time, and stress fractures [20-22] that require the absence of weight-bearing may prevent hypertrophy because by removing mechanical stimulation [23].

In order to resolve the problem of mechanical strength in single FVFG, double or folded FVFG has been used in cases with massive bone defects of the femur [8,10,24]. Although this procedure is associated with rigid strength, stress fractures cannot be prevented [19]. The present case had frequent stress factures due to mild injuries, and thus we performed additional grafts with HA and free autogenous iliac bone, which resulted in sufficient strength without immobilization. The usefulness of autogenous iliac bone grafts in the reconstruction of massive bone defect areas between fibula bones is limited by its supply and efficient thickness. Therefore, we used HA blocks with corticocancellous iliac bone. To the best of our knowledge, this is the first report concerning autogenous bone grafting (FVFG and iliac bone) with artificial bone in such a large (21 cm) defect in the femur. In this case, unions between the grafted bones and HA were not obtained without autogenous bone graft, but were obtained with autogenous bone graft. Therefore, it is possible to obtain rigid bone formation for massive bone defects in the femur using double vascularized fibula grafts and HA with autogenous bone grafts. This procedure is particularly beneficial in younger patients requiring long-term durability.

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**Figure legends**

Fig 1-A: Plain radiograph at admission.

Fig 1-B: T2-weighted MRI at admission.

Fig 1-C: Plain radiograph after tumor resection and reconstruction by double FVFG.

Fig 2-A: Plain radiograph at fracture in October 2001.

Fig 2-B: Plain radiograph at fracture in June 2004.

Fig 3-A: Anteroposterior view of plain radiograph after grafting with HA and iliac bone.

Fig 3-B: Lateral view.

Fig 4: Plain radiograph of HA graft at 2 years and 6 months postoperatively.

Figure 1-a 1-b 1-c

Figure 2-a

2-b

Figure 3-a

3-b

Figure 4