Reconstruction of Periacetabular Bone Tumor by Vascularized Fibula Graft and Irradiated Autograft

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Abstract. Background: Periacetabular reconstruction following malignant bone tumor resection for limb saving is extremely challenging. We attempted a new reconstruction method in two patients by combining a free vascularized fibula graft with an extracorporeally irradiated autograft. Patients: A 14-year-old boy with osteosarcoma and a 44-year-old man with chondrosarcoma were treated with wide excision of the tumor, followed by periacetabular reconstruction with an autogenous, extracorporeally irradiated osteoarticular graft combined with a free vascularized fibula graft. Results: Incorporation of the irradiated pelvic bone was achieved without any complications and the resulting limb function was good. Osteoarthritic changes were seen in one patient. Conclusion: This reconstruction method was safe and reliable for primary, limb-sparing surgery. It is best indicated when the femoral head can be preserved and the mechanical strength of the affected acetabulum is maintained.

The therapeutic outcome for malignant pelvic bone tumors has been reported as unfavorable (1, 2). For wide resection and reconstruction of the malignant pelvic tumor, Enneking and Dunham classified tumor resection according to whether the ilium (type I), periacetabular region (type II) or pubis (type III) was excised (3). Among these, periacetabular reconstruction after malignant bone tumor resection for limb conservation is extremely challenging because of the loss of the hip joint. The aim of reconstruction is to provide a functional, pain-free and cosmetically acceptable lower limb. A variety of reconstructive procedures for massive periacetabular bone loss at limb-sparing surgery are currently available, including custom-made prosthesis (4), saddle prosthesis (5), arthrodesis (3), pseudoarthrosis (6), allograft (7) and processed autograft (1). However, the functional outcomes remain unsatisfactory and there is a high incidence of major complications, including infection, loosening and hip dislocation.

In an attempt to overcome these obstacles, we used free vascularized fibula graft (FVFG) in combination with extracorporeally irradiated autograft (8) to restore the hemipelvis after periacetabular resection. We report here two cases using this procedure and review recent papers about pelvic reconstruction.

Case Report

Case 1. A 14-year-old boy had a four month history of right hip pain. Plain radiographs showed an ill-defined osteosclerotic and lytic lesion involving the right acetabulum (Figure 1a). Histological examination of the bone biopsy resulted in a diagnosis of osteoblastic osteosarcoma. There was no detectable distant metastasis. The surgical stage was defined as IIB according to the Musculoskeletal Tumor Society (MTS) classification (9). The patient received neoadjuvant chemotherapy comprising doxorubicin, cisplatin and methotrexate. With the estimation of a good response to chemotherapy, limb-sparing surgery with wide excision and implantation of an irradiated autograft and FVFG were performed. The patient was placed in the lateral position and a T-shaped incision combined with an ilioinguinal approach was used. Wide resection with 3 cm margin was planned referring to MRI findings. After dislocation of the hip joint, osteotomy was made through ilium, pubis and ischium by a bone saw. All neurovascular structures were preserved and the iliacus muscle was attached to the resected bone tumor. The right pelvic bone was resected according to Enneking and Dunham type I to III. The attached soft tissue was stripped away but the capsule of the hip joint and insertion of the hip flexor and abductor muscle were preserved. Resected bone was doubly wrapped with sterilized sheets and placed...
in a plastic container filled with saline. This container was taken to the radiotherapy department. During irradiation, vascularized fibula graft was harvested from the ipsilateral right leg. Extracorporeal irradiation was performed with 60 Gy as a bolus single dose. Total transport and irradiation time was approximately 90 minutes. The irradiated pelvis was re-implanted into its original site in the recipient and rigidly fixed with pelvic reconstruction plates and screws. Double-barreled FVFG was placed along the medial wall of the irradiated pelvis and fixed with cortical screws (Figure 1b). The vascular pedicle was anastomosed to the preserved gluteal vessels. The capsule and rectus femoris, hamstrings and gluteus muscles were repaired to the preserved attachments using bone anchoring screws. The operation time was 12 hours and intraoperative bleeding was 3,000 ml. After surgery, the patient was placed in traction for a week. Drainage tubes were removed 3 days after surgery and antibiotics were used for five days. The patient had no complication from infection. Postoperative chemotherapy was performed. Partial weight bearing was allowed after 5 months. At 18 months follow-up, hip movement was slightly restricted and the MTS functional score (9) was 86%. The patient did not need crutches and rode to school by bicycle. Plain X-ray showed the retained pelvic ring and hip joint had a normal appearance (Figure 1c).

**Case 2.** A 44-year-old man with chondrosarcoma (grade II) of the acetabulum was treated by radical resection of the bone tumor and reconstruction with the extracorporeally irradiated (bolus 60 Gy) bone graft and 18 cm folded (double barreled) vascularized fibula graft. The surgical stage was defined as IIB according to the MTS classification (9). The right pelvic bone was resected according to Enneking and Dunham type I to III. The irradiated pelvis was re-implanted into its original site and fixed with plates and screws. Small bone defects were filled with bone cement. The hip muscles were repaired to the preserved attachments using bone anchoring screws. The operation time was 14 hours and intraoperative bleeding was 5,300 ml. After surgery, the patient had no complication from infection. Partial weight bearing was allowed after 5 months and the patient was able to return to his previous job (operator of forklift). Radiography at 3 months after surgery showed clear joint space. However, after 2 years, the subchondral bone of the acetabulum had collapsed (Figure 2a) and severe osteoarthritic changes were detected after 7 years (Figure 2b). The patient complained of mild pain and his MTS score (9) was 73%.

**Discussion**

**Periacetabular reconstruction after tumor resection.** Approximately 10-15% of all primary malignant tumors and approximately 5% of soft tissue sarcomas are located in the pelvis. Treatment of malignant tumors of the pelvis represents one of the most difficult areas in musculoskeletal oncology. Several large studies have shown 5-year survival rates of between 18% and 34%, which is much worse than that of extremity osteosarcoma (10). The reasons for such unsuccessful clinical results are believed to be: i) the three-dimensional structure of the pelvis is very complicated and wide marginal resections are difficult because of the close location of vessels, nerves and the urinary tract; ii) there is no suitable reconstructive material after tumor resection; and iii) the postoperative infection rate is very high because of the remaining dead space and the long duration of operations.

In recent years, through the development of improved imaging and surgical techniques, adequate surgical margins have been achieved with the preservation of limbs. There are several reconstructive techniques after pelvic tumor resection. In general, reconstructive options may be characterized as prosthetic, e.g. hip arthroplasty and saddle prosthesis (4, 5), biological, e.g. arthrodesis (3), the use of allograft/autograft (1, 7), and pseudoarthrosis (6); or combinatorial, such as the allograft-prosthetic composite. Selection of the reconstructive technique is influenced by the patient's age, medical status and functional demands, as well as by the location and extent of tumor resection. Reconstruction with a prosthetic replacement is unsuitable for children who have not yet reached skeletal maturity.

Beneficial results have been reported after prosthetic replacement, although there is a high risk of infection, loosening and difficulty of prosthetic fixation. Recently, as an alternative treatment option, Delloye et al. (7) used pelvic allografts in 24 patients and achieved a functional outcome of 73% in the MTS score at final follow-up. Nagoya et al. (11) reported arthrodesis between the femur and remaining pelvic ring using FVFG. Pollock et al. (12) reported on the swing procedure using the proximal femur position. The functional outcomes, however, remain unsatisfactory.

**Extracorporeally irradiated autografts and combined use of FVFG.** The technique of using extracorporeally-irradiated autografts was first introduced by Uyttendaele et al. (8) as a specific option for tumor reconstruction. They reported complications arising from nonunion and infection, but concluded that clinical results were generally similar to those from allografts. Araki et al. (13) used irradiated bone grafts following tumor resection in 20 patients. Although their overall results were good, the complication rate was unexpectedly high with nonunion between bone graft and recipient occurring in four cases and infection in three cases. No cases of local recurrence were detected in the irradiated bones. The theoretical advantages of using high-dose irradiation of bone include the total destruction of tumor cells, preservation of bone stock and absence of donor...
morbidity. Moreover, extracorporeally irradiated autografts do not contain foreign infectious agents, there will always be a perfect fit both at the host-graft junction and the hip joint, and there is no need to maintain allograft bone banks.

Figure 1. Case 1: a, Radiograph taken before surgery showing an ill-defined osteosclerotic and lytic lesion involving the right acetabulum. b, Three-dimensional computed tomography showing osteotomy site, internal fixation and position of double-barreled vascularized fibula graft. c, Radiograph taken at 18 months’ follow-up, showing retained pelvic ring and almost normal appearance of the hip joint.

Figure 2. Case 2: a, Radiographs taken after surgery and b, at 7 years’ follow-up, showing progression of severe osteoarthritic changes of the hip joint.
Irradiation at 50 to 70 Gy leads to total destruction of cells within the radiation field but has minimal impact on matrix proteins such as collagens and bone morphogenetic proteins (14) that are essential for bone formation.

Other techniques that are capable of destroying tumor cells in resected bone include autoclaving, pasteurization and repeated freezing-thawing with liquid nitrogen. Satcher et al. (1) reviewed their autoclaved autografting in combination with total hip arthroplasty after resection of primary sarcoma of the pelvis. The functional outcomes were favorable by the MTS system, with eleven judged as excellent, two as good and two as fair.

From the same group as Uyttendaele, Sys et al. (15) reported on 15 patients with malignant pelvic tumor who underwent reconstruction by re-implanting extracorporeally irradiated osteoarticular autograft. The complication rate was unexpectedly high, with problems reported in 13 patients. Most mechanical complications related to the use of hip arthroplasties. Internal fixation of the graft failed in one case, infection was seen in three cases and seven patients died after local recurrence. In light of these results, the most serious problem associated with irradiated and re-implanted acetabulum is not bony union between irradiated autograft and recipient, but rather to mechanical weakness. If the acetabulum shows mechanical weakness due to tumor invasion and the tumor has invaded into the hip joint, our procedure is obviously not indicated.

Graft incorporation is influenced by the vascularity of the graft bed and the mechanical environment. Because the graft is essentially acellular and avascular, all ingrowths must be initiated on the recipient side. The roles of FVFG used in our two patients are i) to support the mechanical strength of the irradiated bone graft, ii) to achieve early bony union to the pelvic ring, and iii) to enhance neovascularization to the avascular graft. Additionally, FVFG can close the dead space and hence decrease the infection rate.

Osteoarthritis change of the hip joint. The long-term changes that occur in the reconstructed hip joint are unknown. Clinical data on the state of articular cartilage following irradiation are controversial. Takahashi et al. (16) reviewed six patients that received reconstructions with irradiated autogeneic osteochondral grafts. They confirmed the presence of viable chondrocytes detected by S-100 protein in three patients after a mean of 20 months. In contrast, Sabo et al. (17) reported degenerative changes to cartilage in a canine model. Chen et al. (18) reported that the incidence of loss of articular cartilage due to the collapse of subchondral bone was 21%. Sys et al. (15) performed five total hip arthroplasties in 15 patients due to postoperative avascular necrosis of the femoral head. A similar reconstruction to our procedure was reported by Kubo et al. (18). They treated a 13-year-old girl with periacetabular osteosarcoma. The femoral head gradually collapsed within several months after surgery. Four years after surgery, the hip joint showed severe degenerative change resulting in osteoarthritis, however the patient was pain free and ambulatory using crutches. Some degree of articular change clearly occurs after irradiation and cannot be prevented even with the combined use of vascularized bone graft. Secondary procedures such as surface replacement prosthesis are necessary to treat the osteoarthritis in these cases.

Conclusion

Two cases with malignant acetabular tumor were treated with wide excision of the tumor, followed by periacetabular reconstruction with an autogenous, extracorporeally irradiated osteoarticular graft combined with a free vascularized fibula graft. It is best indicated when tumor has not invaded to the hip joint and the mechanical strength of the affected acetabulum is maintained.

References


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