Rotationplasty for Limb Salvage in the Treatment of Malignant Tumors: A Report of Two Cases

Hsien-Chung Wang, Yen-Mou Lu, Song-Hsiung Chien, Gau-Tyan Lin, and Cheng-Chang Lu
Department of Orthopedic Surgery, Chung-Ho Memorial Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan.

Limb salvage is now more common than amputation after radical excision to treat malignant tumors. In a skeletally immature patient who has malignant tumors in a lower extremity, rotationplasty offers a more reliable and durable option than other limb salvage procedures. It is an excellent method of resolving the problem of unequal leg lengths, and preserves best limb function with few complications. Here, we present our experience with rotationplasty for limb salvage in the treatment of malignant tumors, with good functional results seen in follow-up examination 11 years after surgery.

Key Words: rotationplasty, limb salvage, osteosarcoma
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To most oncological surgeons, amputation is a standard procedure in the treatment of malignant tumors in a lower extremity. However, limb salvage surgery is now popular in solving the dilemma of excising a clear tumor margin and preserving optimal limb function. Among the options for limb salvage, rotationplasty has been successfully used to treat skeletally immature patients who have a malignant tumor around the knee, with a satisfactory rate of disease-free and overall survival [1]. This procedure is an alternative to above-the-knee amputation, with satisfactory functional results and acceptable cosmetic appearance [2]. We present two patients who were treated using rotationplasty for limb salvage of a lower extremity, one for osteosarcoma and the other for rhabdomyosarcoma.

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Address correspondence and reprint requests to: Dr. Song-Hsiung Chien, Department of Orthopedic Surgery, Kaohsiung Medical University, 100 Tzyou 1st Road, Kaohsiung 807, Taiwan.
E-mail: shchien@kmu.edu.tw

Case Presentations

Case 1

A 12-year-old girl had minor trauma to her right knee that resulted in right thigh pain for 6 months. Roentgenography revealed a lesion on the right femur, from the metaphysis to the diaphysis, with a classic sunburst and mothy appearance (Figure 1A). Magnetic resonance imaging (MRI) revealed an extracompartmental mass. The major neurovascular bundles were not invaded (Figure 1B). The remainder of the examination was negative. Biopsy corroborated the clinical diagnosis of osteosarcoma (Figure 1C). Therefore, the patient underwent three sessions of neoadjuvant chemotherapy before radical tumor excision.

In February 1991, we performed tibial rotationplasty using the technique described by Kotz and Salzer [3]. The tumor mass was excised radically between the femoral transection 6 cm above the tumor and the tibial transection just below the epiphyseal plate, after carefully freeing the sciatic and peroneal nerves, as well as preserving the popliteal vessels. Limb reconstruction used a compression side plate between the proximal femur and tibia

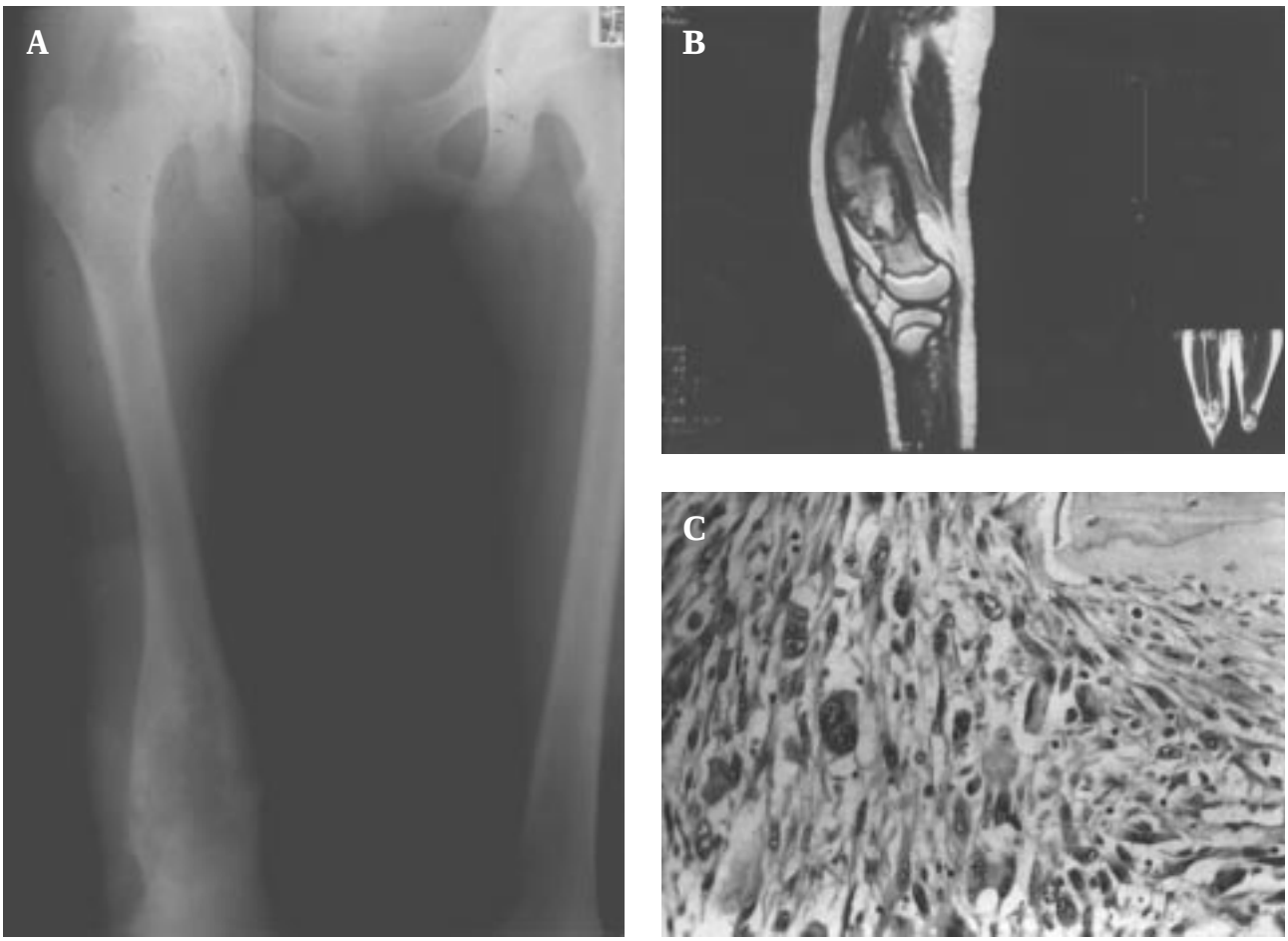

Figure 1. *Case 1. (A) Preoperative roentgenogram of the femurs showing the destructive lesion with mothy geographic pattern and sunburst on the distal right femur. (B) Magnetic resonance image showing tumor extension to the anterior and lateral compartments of the right thigh but no involvement of the main neurovascular bundles. (C) Photomicrograph demonstrating osteosarcoma with highly atypical spindle cells (hematoxylin & eosin, × 400).*

(Figure 2A). The reconstructed limb was aligned by rotating the distal stump 180°; the tibial external rotation and foot neutral valgus angle was 30° (Figure 2B). The neurovascular bundle was preserved in the medial aspect of the reconstructed limb.

Postoperative movement of the new knee joint (which had been fashioned from the ankle) was initiated as soon as the patient permitted. A temporary prosthesis was set until the wound healed. There were no immediate complications of this limb salvage procedure (such as skin problems or phantom pain). Chemotherapy was continued for 15 months. Within this period, the patient experienced no phantom sensation and still felt the foot to be in place. She was allowed to return to full weight-bearing and other activities approximately 3 months after the operation. At that time, radiographic study revealed that the osteosynthesis area had healed. The permanent prosthesis, first fitted 2 months after surgery, allowed the patient's reconstructed knee to flex from 0° to 105° (Figure 3). The patient wore the prosthesis constantly, except when sleeping and bathing.

At the most recent follow-up, which included bone scans, physical and biochemical examinations, the patient was free of tumors and had no evidence of disease. During the intervening period of 11 years, the patient was satisfied with the limb. She denied pain and did not need any medication. Her gait had a similar pattern to that of other patients who wore a prosthesis following below-the-knee amputation. She could ascend and descend stairs without needing to use a handrail or supports. She was able to ride a bicycle and motorcycle, and to jump roll. Her limb did not bother her with regard to its cosmetic appearance. Currently, she enjoys her career as a secretary (Figure 4).

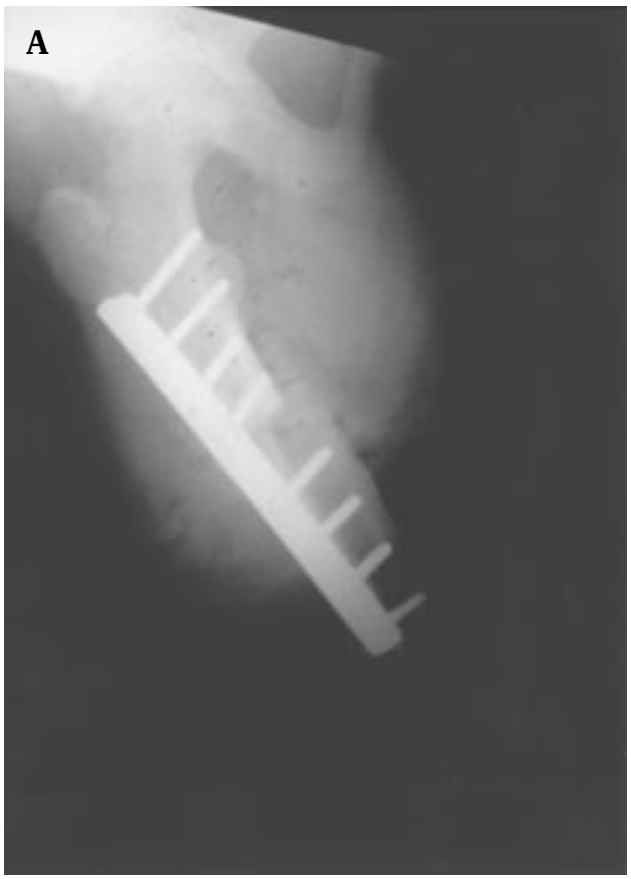

Figure 2. *Case 1. (A) Postoperative roentgenogram showing osteosynthesis with compression plate. (B) Postoperative photograph showing the alignment of the distal stump and the neutral valgus foot.*

Figure 3. *Case 1. The patient shows active flexion and extension in her new "knee" while wearing the final prosthesis.*

Figure 4. *Case 1. Photograph showing the patient enjoying general recreational activities.*

Case 2

A 17-year-old girl had suffered severe right thigh pain with a palpable mass and night pain for 18 months. This lesion had enlarged rapidly within 3 months (Figure 5A). MRI revealed a large tumor in the quadriceps with infiltration of the femur (Figure 5B). The patient was diagnosed with rhabdomyosarcoma, as proven by biopsy, and classified as IIB according to Musculoskeletal Tumor Society criteria (Figure 5C). We performed a radical resection and rotationplasty, using a similar surgical procedure to that in Case 1, in February 1991 [4]. Following radical excision of the tumor mass, with disarticulation of the hip joint and distal femoral transection 6 cm below the tumor, as well as careful freeing of the neurovascular bundles, we attached the right distal femur to the iliac bone with screws, to reconstruct the knee as the hip and the ankle as the knee (Figure 6A).

Postoperative convalescence was smooth. Three months after the operation, the patient received a prosthesis to walk with crutches and required no analgesia to control pain. The range of motion of this reconstructed hip and knee was 0° to 140° and 0° to 100°, respectively (Figure 6B).

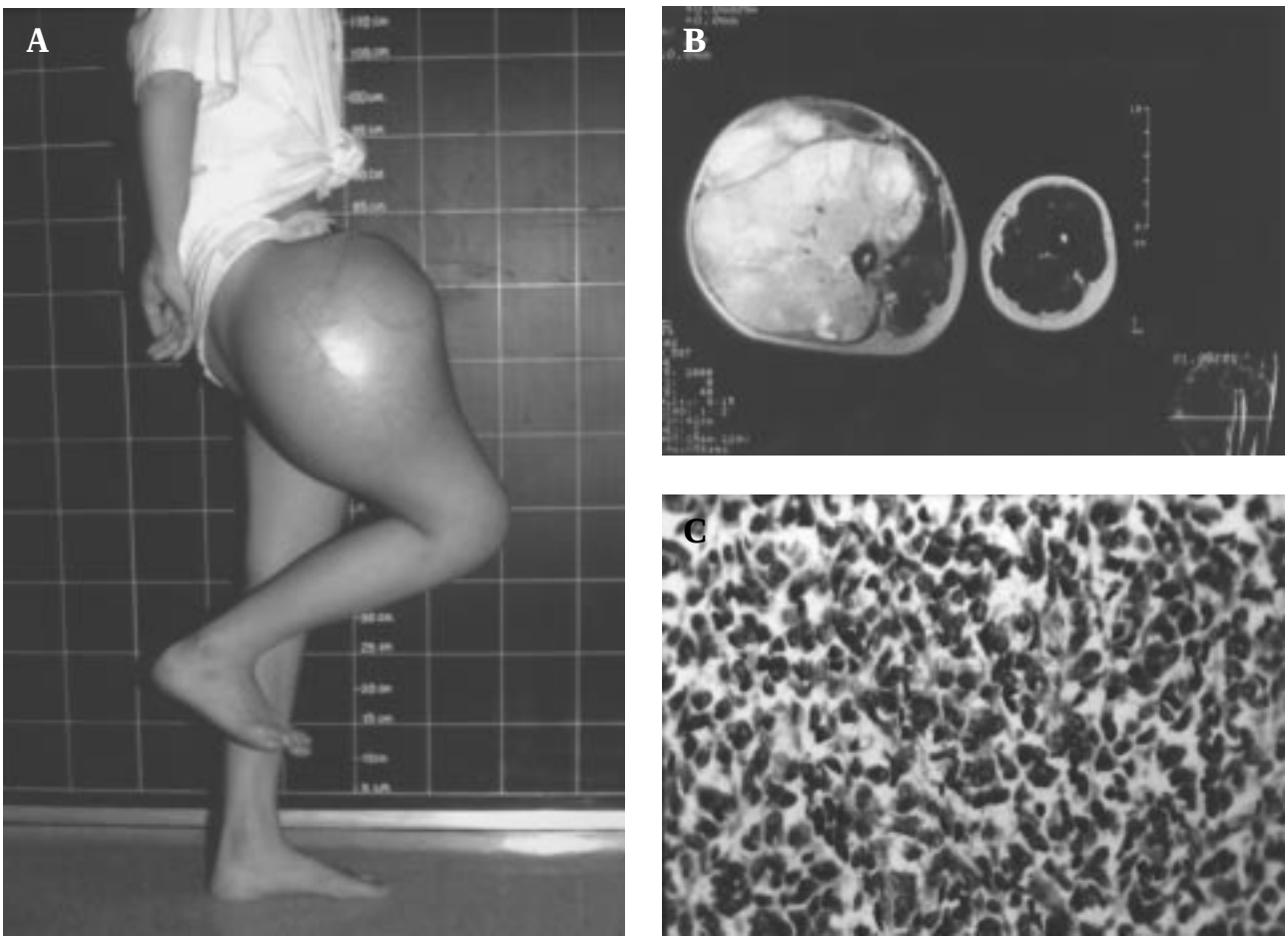

Figure 5. *Case 2. (A) Photograph showing a huge mass in the right thigh. (B) Magnetic resonance image showing a huge tumor extending to the anterior and lateral compartments of the right thigh but not invading the main neurovascular bundle. (C) Photomicrograph confirms the diagnosis of rhabdomyosarcoma (hematoxylin & eosin, × 400).*

Roentgenography at the site of osteosynthesis revealed a union at 3 months. Unfortunately, the patient died due to lung metastasis 18 months after the rotationplasty. Autopsy showed no local recurrence. During the postoperative period, the patient was satisfied with her limb and wore the prosthesis to perform daily activities.

Discussion

Patients with a malignant tumor around the knee present a significant challenge to oncological surgeons to reconstruct large defects resulting from radical excision. The use of adjuvant or neoadjuvant chemotherapy in the management of malignant neoplasia of a lower extremity provides low local recurrence rates after radical excision and improves survival. This alters the surgical task from amputation to preservation of limb function. The options for limb salvage procedures (e.g. arthrodesis, custom-made prosthesis, rotationplasty, bone lengthening to fill the resection gap, reimplantation after extracorporeal removal of the specimen, allograft) are described in the literature [5]. However, reconstruction of a limb in the skeletally immature patient following resection for malignant neoplasia of a lower extremity usually presents a difficult surgical task. The high functional demand and the expected future growth make these patients suitable candidates for rotationplasty or growing endoprosthesis [6].

Although expandable prostheses have been used to avoid a difference in leg length, they are associated with a high risk of primary and secondary complications, such as aseptic loosening, stem migration, broken prosthesis and

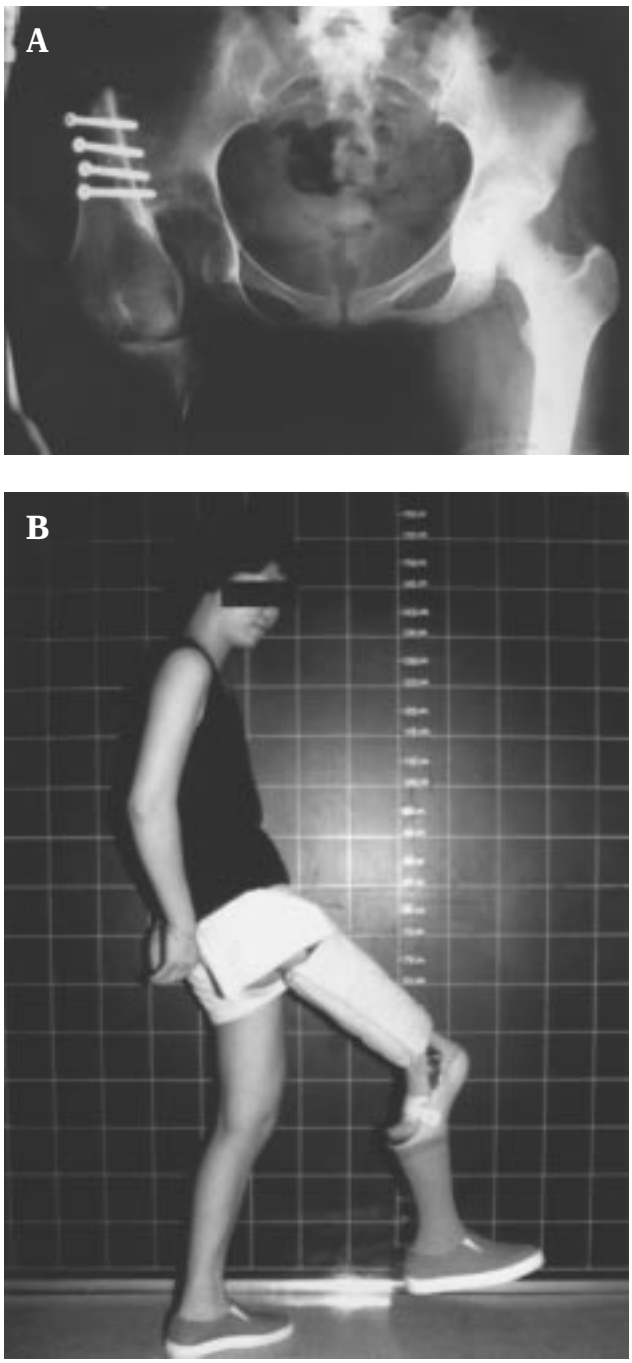

Figure 6. *Case 2. (A) Pelvic roentgenogram showing osteosynthesis of the residual femur on the ilium with screws and the fibula on the medial aspect of the limb after rotation. (B) Photograph of the patient wearing the prosthesis 3 months after surgery.*

infection, and subsequent revision in the long term. The advantage of a custom-made prosthesis is the low cost of rehabilitation, but together with any subsequent procedures, it may impose a significant financial burden on patients and their families compared to rotationplasty, a concern that is especially important in developing countries [6].

Rotationplasty was first described by Borggreve for limb shortening and knee joint ankylosis secondary to tuberculosis in 1930 [7]. Van Nes later popularized this procedure for proximal femoral focal deficiency [8]. In 1982, Kotz and Salzer reported encouraging results in patients undergoing rotationplasty after resection of an osteosarcoma in the distal femur [3]. Rotationplasty is now used worldwide as a salvage procedure in patients who have a malignant tumor around the knee. It provides an alternative to above-the-knee amputation [9].

Rotationplasty is the procedure of converting the ankle to function as a knee joint and preserving the foot, with the result that patients do not feel that they are amputees. In contrast to amputation or arthrodesis, this new knee has active flexion of nearly 90° and has a short rehabilitation period with a prosthesis. Additionally, the procedure has none of the problems associated with amputation stumps, such as neuroma or phantom pain. The reconstructed limb has good weight-bearing capacity when the prosthesis is worn. The functional advantage of rotationplasty is a more active and efficient gait, as well as lower oxygen consumption than above-the-knee amputation or knee arthrodesis. Further, when the skeletally immature patient with a malignant tumor around the knee undergoes rotationplasty following radical excision, the procedure not only resolves the problem of unequal leg length, but also provides better function and has fewer complications [1,2,10].

The main problems with rotationplasty are cosmetic appearance and potential psychologic issues. However, most consistent observations in many studies suggest that these problems occur only rarely [1,2,4,6,7,9,10]. Most patients testify that the appearance of the limb with a prosthesis does not prevent them from conducting their daily social activities, enjoying recreation and earning a living. They do not think of themselves as amputees, and believe that maintaining a high level of function is more important than the appearance of the limb. The incidences of surgical complications such as infection, wound problems, and thrombus are rarely reported in the literature. The possible complications may be resolved by new surgical techniques and a good surgical plan [11].

Winkelmann classified rotationplasty into five groups and noted that the procedure can be used not only in children with a sarcoma of the distal femur, but also to treat tumors in the proximal femur and proximal tibia [2,4]. Rotationplasty seems to be the best way to treat very young patients (< 7–8 years), especially in countries where a

growing endoprosthesis is not available. As an alternative to amputation or an extendable endoprosthesis, rotationplasty offers not only better functional results but also biologic reconstruction [2]. Although many have hailed the good functional and quality-of-life results of rotationplasty, the cosmetic problem is more serious than with an endoprosthesis. The decision to perform this procedure must be made on the basis of the surgeon's experience and the patient's demand. Selected patients need a well-functioning ankle joint to function as a knee joint, and their psychologic condition must be evaluated by a psychologist. The surgeon must thoroughly discuss the procedure with the patient and their family before the operation. It is important in rotationplasty that adequate tumor margin be achieved without the sacrifice of a major nerve, and that the salvaged limb has sufficient soft tissue coverage to minimize skin problems [2,4].

Rotationplasty has shown good clinical results with few complications in the treatment of malignant tumors about the knee. Custom-made endoprostheses have subsequent revision problems if the patient survives long enough, and their cost is sufficiently high to limit their application in our country. Accordingly, we chose rotationplasty in our two patients. Despite the death of one patient due to lung metastasis 18 months after surgery, she was satisfied with her limb in the performance of daily and social activities during the period following rotationplasty. We did not find any evidence of local recurrence on autopsy. The other patient stated that the appearance of the limb had never bothered her in recreation or in her career. She enjoys non-contact sports such as light jogging, and can take any transport vehicle. Over the 11-year follow-up period, we saw remarkable functional results. We suggest that rotationplasty can be a reasonable alternative to amputation for treatment of a malignant tumor in a lower extremity.

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