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Rotationplasty – surgical treatment modality after failed limb salvage procedure

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Abstract Twelve patients aged between 10.9 and 64.7 (mean 28.5) years with a malignant tumour of the knee region underwent a rotationplasty after failed primary limb salvage procedure. The reasons for failure which finally lead to surgery were recurrent infection in 10 patients and local recurrence of the tumour in 2. The number of operations before the rotationplasty was performed was between 2 and 23 (mean 6.7). According to the primary tumour site, 9 patients underwent a rotationplasty type A1, 3 patients type A2, and 1 patient type BII. In 9 patients the rotationplasty was successful, but 3 patients finally had to undergo amputation. Intraoperative preservation of the vessels was difficult in these 3 patients due to infection and oedema of the arteries or massive fibrous tissues after the previous surgery. After rotationplasty, 3 of 9 patients had to undergo additional surgery because of thrombosis, pseudarthrosis and infection (n = 5, range 1–2). The mean follow-up after rotationplasty was 34.9 (range 13–65) months. The mean functional status according to the MSTS criteria in patients after rotationplasty scored 21.3 of 30 points. In the group of amputees, the score was 19 (range 16–22). Concerning the health-related quality-of-life, the mean score in physical functioning was 76.3 in the group with a rotationplasty versus 50.0 in the group of amputees. Patients with a rotationplasty reached a higher score of global health status (77.1 vs 58.3). Based on the present results we are convinced that rotationplasty can be recommended as a treatment option after a failed limb salvage procedure.

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Introduction

The knee region is the most common site of high-grade sarcoma. Since the implementation of an effective adjuvant chemotherapy, a proximal above-knee amputation can be avoided in most cases. The functional and cosmetic results are satisfying after reconstruction with modular tumour prostheses or massive allografts, composite allografts, or vascularized fibula grafts [4, 12, 14, 17, 18]. However, the complication rate after implantation allografts and endoprosthetic replacement is high (13%–25%) especially after chemo- and radiotherapy [5, 8, 19, 21]. Patients with an infected tumour prosthesis have a high rate of re-infection after revision surgery. After a failed limb salvage procedure, the possibilities of successful reconstruction are reduced.

Different investigators described a lower survival rate of the prosthesis after revision surgery [19, 21]. After failed femoral megaprostheses, Clarke et al. [5] changed the procedure into allograft prosthesis composites. However, the complication rate after revision remained extremely high. About 20% of revision surgery leads to amputation [21]. Additionally, in most cases the functional outcome of revision surgery after limb salvage in musculoskeletal oncology is worse [19, 21] than that after the primary surgery. Several strategies of revision can be undertaken, but inevitably, in some patients, an amputation is unavoidable [11]. Instead of amputation, rotationplasty can also be chosen.

Rotationplasty was first described by Borggreve in 1930 [2]. The indication was previously a patient with a femur deficiency syndrome after tuberculosis. In the 1970s, this surgical procedure was performed in patients with a high-grade malignant tumour of the knee region as a surgical alternative to amputation [20]. Winkelmann modified the procedure so that a rotationplasty could be performed even when the tumour involved the total femur or if skip metastasis occurred [23, 24, 25]. For patients with a tumour on the distal part of the femur, he recommended a rotationplasty type A1 according to the description of Van

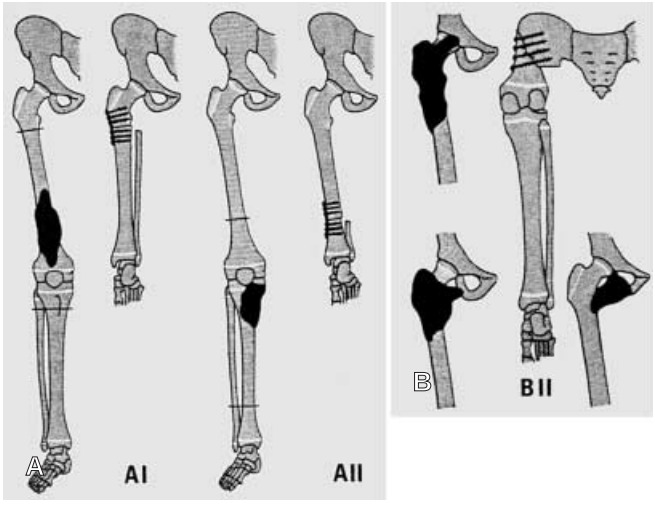

Fig. 1 **A** Rotationplasty types A1 and A2 according to Winkelmann [25]. **B** Rotationplasty type BII for tumours of the proximal femur with involvement of the acetabulum. After extra-articular resection of the acetabulum, the distal femur is fixed after rotation of the limb at the innominate bone

Nes [22]. For patients with a tumour of the proximal and middle part of the tibia, a rotationplasty type A2 is suggested [25]. If the proximal and middle part of the femur is involved, a rotationplasty type B is optional [26, 28] (Fig. 1).

Good functional results in the long-term follow-up and a lower morbidity due to hospitalisation were encouraging enough to suggest this surgical procedure as an alternative to a tumour prosthesis or extendable prosthesis [10, 27].

In case of a necessary amputation, the level of amputation depends on the primary site of reconstruction. A failed prosthesis or allograft of the proximal tibia requires a lower amputation level than a failed reconstruction of the distal and middle part of the femur.

Rotationplasty can be indicated as a surgical treatment modality after severe bone loss [13]. In the present study, patients underwent revision surgery after a primary limb salvage procedure. Several strategies of revision were undertaken, but in all cases, rotationplasty as an alternative to amputation was ultimately performed. The purpose of this study was to assess the clinical and functional results of rotationplasty as an alternative to amputation after a failed limb salvage procedure.

Patients and methods

From 1980 to 1997, 12 patients (9 male, 3 female) with a high-grade malignant tumour were surgically treated by tumour resection and reconstruction by either prosthetic replacement (n = 2), allograft (n = 4), extendable tumour prosthesis (n = 4) or composite allograft (n = 1). In 1 patient no reconstruction was done. The reason for surgical re-operation was a local recurrence of a high-grade soft-tissue sarcoma (malignant schwanoma) of the femur with involvement of the extensor mechanism of the knee joint (Table 1).

The primary diagnosis was osteosarcoma (n = 7), Ewing's sarcoma (n = 1), chondrosarcoma (n = 1) and soft-tissue sarcoma (n = 3), malignant fibrous histiocytoma/spindle-cell sarcoma/malignant schwannoma). Nine patients received adjuvant chemotherapy, 2 patients additional radiotherapy, and 1 patient with chondrosarcoma received only surgical treatment (Table 1).

Rotationplasty was performed at a mean time of 68.2 (range 29–192) months after the primary limb salvage operation. Due to the site of implantation of the tumour prosthesis or allograft, a type A1 (as the original Van Nes rotationplasty), a type A2, or a type BII rotationplasty (according to Winkelmann [24, 25]) were selected (Fig. 1). The mean age of the patients at the time of rotationplasty was 28.5 years (range 10.9–64.7 years).

The mean time between primary surgery and first revision was 17.1 (range 0–125, median 9) months.

The follow-up period after rotationplasty was 34.9 (range 13–65) months. The patients were clinically examined, and the complication rate before and after rotationplasty was evaluated. The functional outcome was examined according to the MSTS criteria [7]. The quality-of-life data were evaluated according to the guidelines of the European Organization for Research and Treatment of Cancer (EORTC) [1].

Table 1 Details of patients in study undergoing rotationplasty

Patient no.	Initials	Sex	Age (years)	Histol. diagnosis	Primary reconstr.	No. of surgeries[a]	Type[b]	Success
1	DG	M	39	MFH	Allograft	4	A1	Amputation
2	HK	M	25	Ewing's sarcoma	Allograft	6	A1	Rotationplasty
3	HAT	M	24	Osteosarcoma	Tumour prosthesis	6	A1	Rotationplasty
4	KJ	F	11	Osteosarcoma	Extend prosthesis	5	A1	Rotationplasty
5	TC	F	28	Osteosarcoma	Allograft	23	A1	Rotationplasty
6	HC	M	23	Osteosarcoma	Tumour prosthesis	6	A1	Rotationplasty
7	SD	M	14	Osteosarcoma	Extend prosthesis	5	A2	Rotationplasty
8	WC	F	19	Osteosarcoma	Extend prosthesis	10	A2	Amputation
9	LW	M	35	Chondrosarcoma	Comp. allograft	2	BII	Amputation
10	HHD	M	51	Spindle-cell sarcoma	Allograft	6	A1	Rotationplasty
11	SP	M	14	Osteosarcoma	Extend prosthesis	3	A2	Rotationplasty
12	WJ	M	65	Schwanoma	Local recurrence	4	A1	Rotationplasty

[a] Number of surgeries before rotationplasty
[b] Type of rotationplasty according to Winkelmann [25]

Results

Complications leading to rotationplasty

The mean number of operations due to complications was 6.7 per patient (range 2–23) before the rotationplasty.

The primary reconstruction for limb salvage in 6 patients was prosthetic replacement (extendable tumour prosthesis = 4; modular tumour prosthesis = 2). In all 6 patients with prosthetic replacement, revision was necessary due to local infection, which is an average number of 7.0 (range 4–11) operations per patient. Infection of the tumour prosthesis was the primary reason for revision in 4 patients. In 2 patients with an extendable tumour prosthesis, an extension was performed with subsequent infections 8 and 10 months after the extension.

Four patients with implantation of allograft developed a local infection: one developed after the primary surgery, 3 developed after revision of pseudarthrosis and multiple surgical lengthening and soft-tissue operations. The maximum number of re-operations in this group was 23, since this patient finally underwent rotationplasty.

In one patient with an intralesional resection of a high-grade, malignant, soft-tissue sarcoma of the middle and distal femur, tumour cell contamination occurred in the ventral, medial and lateral compartments of the thigh. This patient underwent a second resection. The margins after revision were still intralesional. Therefore, rotationplasty was performed as an alternative to amputation of the limb.

Results of rotationplasty

Rotationplasty type A1 according to Winkelmann [25] (which is comparable to the Van Nes procedure) was performed in 8 patients, type A2 was performed in 3 patients, and type BII in 1 patient. The type of surgery was based on the localisation of the primary reconstruction of the distal femur (type A1), the proximal tibia (type A2) or the proximal femur including the acetabulum (type BII).

Six of 12 patients underwent successful rotationplasty without any complications.

After rotationplasty, 3 patients had to undergo 5 re-operations because of thrombosis of the femoral artery (n = 1), pseudarthrosis (n = 1) or infection (n = 3). After revision they were disease-free with a normal rehabilitation: by 6–8 weeks after the operation, a prosthesis could be fitted, and physiotherapy including gait training was started.

The third patient, who suffered from a thrombosis of the artery after rotationplasty, developed a peroneal nerve palsy. Six months later a slight recovery of the peroneal nerve was noted. Consequently, the start of gait training was delayed. The active range-of-motion of the former ankle joint was reduced from 45° plantar-flexion to a dorsiflexion of 10°.

Three of 12 patients had to undergo amputation (Table 1). In 2 patients it was intraoperatively impossible to preserve the vessels because of severe oedematous infiltration or infection of the artery. The third patient, who suffered a local recurrence of a chondrosarcoma after reconstruction with a tumour prosthesis, with tumour invasion of the femoral artery, was scheduled to undergo type BII rotationplasty, but an external hemipelvectomy had to be performed instead. An adequate preoperative evaluation with magnetic resonance imaging was not possible because of artefacts of the implanted metal endoprosthesis.

Functional results and quality-of-life

Function after rotationplasty is better than after amputation. According to the MSTS criteria, patients with rotationplasty received a median total score of 23 of 30 (average 21.3). Compared to a group of patients with a rotationplasty (n = 33) examined in our institute previously, there is a slight difference (24/30). Patients with amputation after failed rotationplasty (n = 3) received a lower score of 19 points (median 19).

According to the quality-of-life parameters, patients with a rotationplasty had higher scores than patients after failed rotationplasty and subsequent amputation. The parameter of physical functioning is 76.3 in the rotationplasty group and 50.0 in the amputee group. The global health score in the rotationplasty group is 77.1 vs 58.3 in the amputee group.

Discussion

Failures in tumour surgery are frequent. Since the era of adequate multimodal chemotherapy protocols, a high number of survivors are expected to reach a normal age. The aim of surgical treatment of a malignant extremity tumour is limb salvage in order to retain the option for a good functional result. However, since the use of tumour prostheses or massive allografts carries high complication rates because of infection of the implanted material, fracture of the graft or non-union are described [6, 15, 16, 19]. Recurrent surgical treatment cannot be expected to solve the problems in every patient. Therefore, the solution in some cases can only be amputation.

Rotationplasty is a treatment option in patients with a malignant tumour of the distal or the proximal femur, when the tumour mass involves the extensor mechanism and a limb salvage procedure is not possible. Recent results of a comparative study between endoprosthetic replacement and rotationplasty have shown that the functional results are very similar according to the MSTS criteria. The quality-of-life data are similar or even better in the group of patients with a rotationplasty [10].

As the present study shows, rotationplasty is a treatment option which can be performed not only for primary tumours of the femur but also as a reconstruction modality to avoid amputation after a failed limb salvage procedure. Compared to a group of patients (n = 33) with primary rotationplasty examined in our institute previously

[10], the functional results after rotationplasty as revision were a little lower but better than in patients after amputation [3, 9].

However, rotationplasty after failure of a limb salvage procedure is not possible in every case. If there are recurrent infections of the dorsal compartment of the leg, the vessels, especially the artery, can be involved. Therefore, a preparation can be impossible because of infection or oedema or the surrounding scar tissue. In those cases, the risk of an amputation is high.

Another problem can be the site of the primary reconstruction. In case of the proximal tibia, only a rotationplasty type A2 according to Winkelmann [29] can be performed. For this type of rotationplasty, it is important to save all three vessels: anterior tibial, posterior tibial and fibular arteries. Three of our patients required a type A2 rotationplasty, but it was possible only in 2 patients. The other patient had to undergo amputation because of problems in preparing the vessels of the lower leg.

We conclude that rotationplasty can be recommended as a surgical procedure after failed limb salvage procedure. The intra- and postoperative complication rate is high; however, when the procedure is consolidated 2 months after rotationplasty, no further complications are to be expected. The functional outcome and the quality-of-life parameters after rotationplasty as revision surgery are comparable to those of primary rotationplasty after tumour resection. In case of a failure after a proximal tibial tumour, the risk of loosing the leg is high because of the anatomy and the vascularisation of the lower leg, especially when recurrent infection is the reason for revision.

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