

Surgical Treatment of Malignant and Aggressive Bone Tumors Around the Knee by Segmental Resection and Rotationplasty

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In patients having malignant or aggressive bone tumors around the knee joint and requiring amputation, segmental resection and rotationplasty was performed and the clinical results were analyzed.

Twenty-six patients underwent segmental resection and rotationplasty between February 1988 and June 1994. The mean follow-up period was 57 (6-120) months and the average age of patients was 21.4 (5-37) years. Out of 26 patients, there were 18 osteosarcomas (\geq stage IIB), 2 synovial sarcomas, and 6 giant cell tumors.

Clinical results were evaluated by the Shriners's rating system. Four patients were excluded due to death or amputation and the remaining twenty-two patients were included for assessment. Eighteen patients had excellent results, 3 good, and 1 fair. Range of motion of the ankle joint was -11 (dorsiflexion) - 80 (plantarflexion) degrees and daily walking activity was possible. Local recurrence developed in 2 patients and distant metastasis in 10. Early complications include 3 thromboses and 1 sepsis, and late complications were 6 nonunion, 2 malrotation and 1 stiffness of the ankle joint.

Rotationplasty, which is functionally excellent, may serve as an effective partial limb salvage procedure, especially in patients younger than 10 years old who are expected to have leg length discrepancy or loosening of the tumor prosthesis due to the growth of the medullary cavity or when amputation is inevitable for a wide resection margin.

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INTRODUCTION

The development of chemotherapy and imaging diagnostic technique has enabled us to salvage limbs rather than amputating them in the surgical treatment of malignant bone tumors. Particularly, when it is impossible to rebuild by using implants in cases who have received resection for malignant bone tumors around the knee, segmental resection and rotationplasty, whose functions and durability are excellent, with sufficient resection margin is an excellent alternative to amputation.^{1,2}

We analyzed the clinical results obtained at our hospital of twenty-six cases that underwent treatment by segmental resection and rotationplasty due to malignant or aggressive bone tumors around the knee.

MATERIALS AND METHODS

We performed a retrospective analysis in twenty-six patients who underwent segmental resection and rotationplasty for malignant or aggressive bone tumors around the knee, and who were available for follow-up. In total 26 patients, consisting of 14 males and 12 females of average age 21.4 (5-37) years, were follow-up period for 57 (6-120) months.

Of the 26 cases, there were 18 osteosarcomas, 2 synovial sarcomas and 6 giant cell tumors. The later were comprised of 4 cases with pathologic fracture and 2 recurrent cases. Staging was based on the Enneking classification, and there were, 16

cases of stage IIB and 2 of stage III for osteosarcoma, and 2 of stage IIB for synovial sarcoma, and 6 of stage 3 of giant cell tumor. In terms of lesion sites, osteosarcoma was found in 13 distal femurs and 5 proximal tibias, giant cell tumor was found

in 4 distal femurs and 2 proximal tibias, and all synovial sarcoma were found in the distal femur (Table 1). In 8 cases of 18 osteosarcomas, preoperative chemotherapy was performed with Adriamycin and Cis-platin and postoperative

Table 1. Summary of Cases

Case	Sex/Age at Op	Tumor			Preop. status	Neoadjuvant ChemoTx	Date of Op	Adjuvant ChemoTx
		Dx	Site	Stage				
1	M/37	GCT	L-D-F	3	Patho. fract.		Feb, '88	
2	F/33	GCT	L-D-F	3	Patho. fract.		Jun, '88	
3	M/19	OSA	R-D-F	IIB			Nov, '88	ADR, CDDP
4	M/29	GCT	L-P-T	3	Recurred		Mar, '89	
5	F/16	OSA	L-D-F	IIB			May, '89	ADR, CDDP
6	M/18	OSA	R-P-T	IIB	Assoc. with Fib. dyspla.		Jun, '89	ADR, CDDP
7	F/28	GCT	L-P-T	3	Patho. fract.		Jul, '89	
8	F/16	OSA	R-P-T	IIB			Jan, '90	ADR, CDDP
9	F/20	OSA	R-D-F	IIB			Feb, '90	MTX, IFOS, VP-16
10	M/32	GCT	L-D-F	3	Patho. fract.		Jul, '90	
11	M/30	SSA	L-D-F	IIB			Oct, '90	ADR, DTIC
12	F/34	OSA	R-D-F	IIB			Nov, '90	ADR, CDDP
13	M/16	OSA	R-D-F	IIB		ADR, CDDP	Apr, '91	ADR, CDDP
14	F/18	OSA	R-D-F	IIB		ADR, CDDP	May, '91	ADR, CDDP
15	M/18	OSA	R-P-T	IIB		ADR, CDDP	Jun, '91	ADR, CDDP, IFOS
16	M/19	OSA	R-D-F	IIB			Sep, '91	ADR, CDDP
17	M/29	GCT	R-D-F	3	Recurred		Sep, '91	
18	M/10	OSA	L-D-F	IIB			Jan, '92	ADR, CDDP
19	M/5	SSA	R-D-F	IIB			Mar, '92	CYT, VCR, ACT-D
20	F/10	OSA	L-D-F	IIB		ADR, CDDP	Mar, '92	ADR, CDDP
21	M/14	OSA	R-D-F	IIB		ADR, CDDP	Feb, '93	ADR, CDDP
22	F/16	OSA	L-D-F	IIB		ADR, CDDP	Sep, '92	ADR, CDDP
23	F/23	OSA	L-D-F	III		ADR, CDDP	Nov, '92	MTX, IFOS, VP-16
24	F/13	OSA	L-P-T	IIB			Aug, '93	ADR, CDDP
25	F/17	OSA	R-P-T	IIB		ADR, CDDP	Jun, '94	CYT, CDDP
26	M/37	OSA	L-D-F	III	Patho. fract.		Apr, '94	ADR, CDDP

Op, Operation; Preop., Preoperative; ChemoTx, Chemotherapy; patho. Fract., Pathologic fracture; GCT, Giant cell tumor; OSA, Osteosarcoma; SSA, Synovial sarcoma; L (R) -P (D) - F (T), Left (Right) - Proximal (Distal) - Femur (Tibia); ADR, Adriamycin; CDDP, Cis-platin; MTX, Methotrexate; IFOS, Ifosfamide; DTIC, Dacarbazine; VCR, Vincristine; CYT, Cyclophosphamide).

Case	Complication	Treatment	Mets	Dur. of F/U	Status	ROM	Shriner's Rate
1	Malrotation	Syme		4 yr 2 mo		0° /90°	7
2				9 yr		30° /85°	8
3			Lung	2 yr 11 mo	DOD	5° /90°	9
4	Nonunion	AIBG		6 yr		20° /90°	10
5	Nonunion	AIBG	Lung	10 yr	NED	0° /75°	9
6			Lung	2 yr 2 mo	DOD	20° /100°	9
7				3 yr 9 mo		0° /80°	10
8	Thrombosis	Thrombectomy		9 yr 9 mo	CDF	0° /45°	
	Ulceration	Syme					
	Nonunion	AIBG					
9	Local recur	Hip D/A	Lung, Brain	8 yr 2 mo	DOD	15° /75°	9
10				3 yr 4 mo		-5° /90°	10
11			Lung	3 yr 2 mo	DOD	-5° /75°	9
12	Nonunion	AIBG		2 yr 11 mo	CDF	10° /90°	9
13			Lung	2 yr 7 mo	DOD	10° /80°	9
14				7 yr 11 mo	CDF	20° /80°	10
15			Lung	1 yr 7 mo	DOD	30° /90°	9
16	Nonunion	AIBG		7 yr 8 mo	CDF	10° /30°	5
	Stiffness	Syme					
17	Thrombosis	AK		2 yr 1 mo			
18				7 yr 6 mo	CDF	10° /85°	10
19	Nonunion	OREF, AIBG		7 yr 8 mo	CDF	0° /95°	9
20				6 yr 2 mo	CDF	25° /80°	9
21	Local recur	Hip D/A	Lung	8 mo	DOD	30° /90°	9
22	Malrotation			6 yr 3 mo	CDF	20° /70°	7
23			Lung	1 yr	DOD	30° /90°	9
24	Thrombosis	AK		8 mo	DOD		
25				5 yr 4 mo	CDF	-10° /70°	10
26	Sepsis, ARF		Lung	6 mo	DOD		

Mets, Metastasis; Dur. Of F/U, Duration of follow up; ROM, Range of motion; Syme, Syme amputation; AIBG, Autoiliac bone graft; D/A, Disarticulation; CDF, Continuous disease free survival; DOD, Dead of disease; NED, No evidence of disease; AK, Above knee amputation; OREF, Open reduction and external fixation; ARF, Acute renal failure.

chemotherapy was performed with Adriamycin and Cis-platin or Ifosfamide, Methotrexate and VP-16 in all cases. For 2 synovial sarcoma cases, postoperative chemotherapy was performed using

Adriamycin and Dacarbazine, and Vincristine, Cyclophosphamide and Actinomycin-D.

Resection margin was determined by the size and location of the tumor, and the length of the

femur after resection. For patients who have not attained full bone growth, potential growth was taken into account. Male patients, until 16 years, and female patients, until 14 years, show continuous growth. The distal femur grows about 10 mm and proximal tibia about 5 mm on average annually, and compensation was made in the resected limb for this loss of growth. Wide excision of tumor was achieved after microscopic confirmation of a tumor-free state in the neurovascular bundle.

On resection the skin of leg was incised in an oblique fashion in order to conform with the circumference of the thigh. After osteotomy of both femur and tibia, fixation was achieved with Dynamic Compression Plate and screws. End to end anastomosis was performed with the femoral artery and vein to the posterior tibial artery and vein, respectively. Sciatic, tibial and peroneal nerves were wrapped around each other and placed in the soft tissue, preventing it from kinking. After the confirmation of circulation, the quadriceps and sartorius muscles were attached to calf muscles, and hamstrings and internal rotators to the muscles of the anterior aspect of leg.

We analyzed data upon early complications, late complications, functional results, oncologic results, and psychiatric data, which were obtained through questionnaires.¹

RESULTS

In terms of early complications, thrombosis was found in 3 patients. In one patient thrombectomy was performed, but repetitive ulceration of the foot occurred, and ankle disarticulation was performed later. The other two patients received above the knee amputations due to leg necrosis. Another patient died of sepsis at 3 months after the operation. In terms of late complications, nonunion was found in 6 patients, autoiliac bone graft was performed, and all patients achieved osteosynthesis. One of 2 malrotations had Syme amputation due to walking disturbance caused by excessive external rotation. The other also had Syme amputation due to stiffness of the ankle joint. After operation, none of the patients had developed any psychiatric problems, and none

had wanted re-operation including amputation.

Evaluation of clinical results after operation was performed on the basis of Shriner's rating system on 22 of the 26 patients. This excluded 2 patients operated upon for femoral amputation due to thrombosis, 1 patient operated upon for Syme amputation due to repetitive ulceration of foot and 1 patient who died due to sepsis (Table 2). Of these 22 patients, excellent, good and fair results were obtained for 18, 3 and 1 patients, respectively. The average range of motion of the ankle joint on the final follow-up was -11 - 80 degrees. During the follow-up, the degree of dorsiflexion had changed from 8 to -11 degrees and the degree of plantarflexion had changed from 32 to 80 degrees. These results show that not only an increased range of motion, but also a tendency for motion to increase joint extension (Table 3). Rotationplasty prostheses were worn from 4 to 14 months while osteosynthesis occurred. Daily walking was possible and the walking distance was not limited.

Local recurrence was found in 2 cases and distant metastasis in 10. Metastasis into the lungs were found in nine patients and one patient had metastasis to both lung and brain. The average duration from operation to metastasis was 14 months (5-31 months).

For 18 osteosarcoma cases, local recurrence was found in 2 patients and distant metastasis in 9. Hip disarticulation was performed for both patients with local recurrence, however, distant metastasis was also found in both. Excision of the metastatic lesion was performed in 3 osteosarcoma cases with distant metastasis into the lungs. Two out of 16 cases of stage IIB developed distant metastasis, and wedge resection of the metastatic tumor was performed at 20 and 108 months, respectively; moreover, these did not show recurrence after 120 months. In the other case of osteosarcoma with distant metastasis into the lungs, wedge resection of the lung metastasis was performed at 77 months and 89 months, after the initial operation, but the patient died at 96 months. The patient in stage III had an operation for metastasis at 2 months after the operation but died at 12 months. Nine cases resulted in death due to disease, 8 in continuous disease free survival and 1 showed no evidence of disease

Table 2. Shriner's Rating System

Category	Results	Points
Gait	Good : able to bend knee	2
	Fair : able to bend knee partially	1
	Poor : keep knee straight	0
Height of Ankle Relative To Contralateral Knee	Within 2 cm	1
	Not within 2 cm	0
ROM of Ankle	> 45°	1
	< 45°	0
Rotation	Full 180°	1
	< 180°	0
Use of Prosthesis	Full time	2
	Part time	1
	Never	0
Prosthetic Fit	Good	1
	Poor	0
Use of External Support	None	2
	Unilateral	1
	Bilateral	0

Excellent, 9 to 10; Good, 7 to 8; Fair, 4 to 6; Poor, 0 to 3; ROM, Range of motion.

Table 3. Change of Range of Motion by Physical Examination (Unit:°)

	Dorsiflexion	Plantarflexion	Total ROM
Post-operative	8°	32°	40°
Follow up	-11°	80°	69°

although distant metastasis was found. The 5-year survival rate for the 16 osteosarcoma patients in stage IIB by Kaplan-Meier analysis was 62.5% (Fig. 1).

In the cases of the 2 synovial sarcoma patients, local recurrence was not found but distant metastasis to the lung was found in 1 patient. One case showed continuous disease free survival, and the other, with distant metastasis, died of the disease.

DISCUSSION

Rotationplasty was reported by Borggreve in 1930, for leg length discrepancy by tuberculosis in

the knee joint, and was generalized by Van Nes in 1950.^{3,4} Kotz, et al. performed rotationplasty instead of amputation for the treatment of osteosarcoma of the distal femur in 1974.⁵

Although resection arthrodesis, allograft replacement, and endoprosthetic replacement are also used for sarcomas of the lower extremity, it is considered that these methods are not likely to be suitable for patients with immature skeletal growth.^{6,7} Many authors have reported upon the biological and functional merits of knee joint such as, upon; its tolerance of weight-bearing, the balancing of the leg length when growth has been completed, or the possibility in making a brace.²

Due to the advancements made in implants, especially in expandable devices that can adapt to

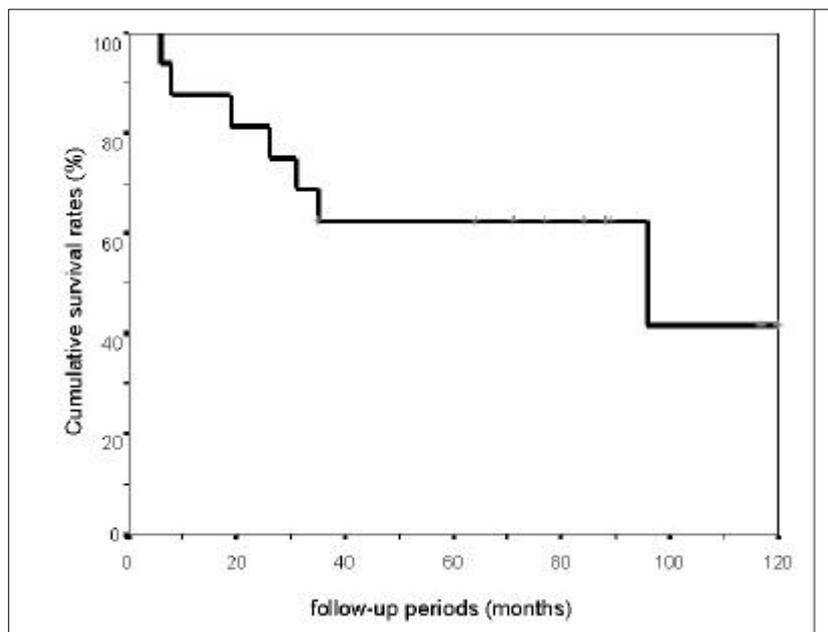


Fig. 1. Survival of enneking stage IIB osteosarcoma (5 year survival rate was 62.5%).

growing patient the number of indications for rotationplasty has decreased recently.⁸⁻¹⁰

This study observed 26 patients for 64 months by follow-up, and examined early and late complications, functional results, and the clinical results of rotationplasty. In addition, two patients younger than 10 years old were included in the study.

Functions of the knee joint were evaluated according to the method developed by Shriner and were marked out of 10 points in 7 categories. Twenty-one cases produced a result of good or better excluding 1 patient, and 18 of these cases showed a result of excellent, accounting 81.8%. The range of ankle joint was -11° - 80° , and this was similar to that found by Hanlon, et al., who found an average plantarflexion of 82° .⁶

In terms of complications, and according to Hanlon, et al., vascular complications were not anticipated for twenty-one patients with an average age of 11 years.⁶ However, many other complications were experienced, 1 fracture of metal plate, 1 malrotation and tibial fracture, 1 dorsal bunion, 1 delay of wound healing, 1 formation of skin sclerosis, 1 phantom pain, 1 ankle sprain, and of 9 sensory change, which was observed in all patients who had lesions in the distal femur. In a report by Gottsauner-Wolf, et al.,⁸ there were 7 ischemias, 8 with delayed

wound healing, 4 pseudoarthroses, 7 nerve palsies, and 1 malrotation as early complications, and 8 fractures, 2 delayed unions, 2 delayed infections, and 2 serious degenerative changes as late complications.

In the present study, there were 3 complications by thrombus as an early complication, and two of these required hip disarticulation, inevitably. For the other complication, thrombectomy was adopted for treatment. But, ankle disarticulation was operated upon later due to repetitive ulceration of foot. For late complication, nonunion was found in 6 cases, and accounted for 27.2%. Osteosynthesis was found in all patients after bone graft. There were 2 local recurrences, which were treated by hip disarticulation, and 2 cases of ankle disarticulation due to malrotation and joint stiffness.

In the present study, 10 (45.5%) of 22 sarcomas metastasized. All patients died, except 1 patient. In the cases of 2 synovial sarcomas, there was no local recurrence, but 1 metastasis was observed. Continuous disease free survival was seen in 1 case, and the 1 metastatic case died of disease. In 18 osteosarcomas, there were 2 local recurrences and 9 metastasis. Hip disarticulation was performed in both local recurrences, but metastasis occurred in all cases. Nine cases died of disease and 8 had continuous disease free survival.

Metastasis was found in 1 case, but it presented with no evidence of disease. In order to prevent kinking of vessels, they were cut and reanastomosis was performed. In terms of wrapping around the sciatic, tibial and peroneal nerves, ischemia can cause necrosis or adhesion of the nerves, however in our review no such evidence was found.

In terms of fixating the femoral and tibial osteotomy sites, rotational deformities may occur due to differences in the shape of the femur and tibia. Anterior placement of the plate is recommended for better fixation.

In patients with remaining growth, resection was made longer than the contralateral side in order to compensate for growth. In patients less than 15 years old, excluding 2 patients who died due to complications, distal femoral growth was intact and a difference of 1.4 cm, 2.0 cm, 1.3 cm was found at the end of growth. The prosthesis was changed every 1 - 2 years. Patient did not feel any handicap in daily activity, however, there were some difficulties in stair climbing, hiking, and other vigorous sports activities. Patients who were younger at the age of operations were better adapted - a 10-year-old patient who was operated upon participates in basketball and other sports activities.

In our study, 6 cases of giant cell tumor were included. Five of these accompanied pathologic fracture causing tumor cells to contaminate surrounding tissues, and one case involved a huge mass with skin involvement, which could not be reconstructed with a tumor prosthesis. Nevertheless, we feel that the indications were set too wide.

Rotationplasty has many merits, as follows; it does not compromise the treatment of malignant tumor of the knee joint; it enables excellent functions of the lower extremity because it enables the new knee joint to exercise actively; it adapts to the growing patient; it is not necessary for any other operation for there is no phantom pain nor neuroma after the procedure.

However, it is true that there may be psychic trauma to the patient and their family due to the postoperative appearance, and for this reason, rotationplasty is not preferred by some doctors. However, reports by Han indicated that all the

patients who responded to the questionnaires after the operation positively stressed the functional features - such as the aspects of the procedure in which makes it possible to walk and allows a complete removal of the malignant tumor. Most of the patients felt that they had selected the most appropriate treatment for their disease. There was no patient who requested a re-operation such as amputation or who had developed any serious psychiatric problems caused by their appearance. However, it is considered that multi-dimensional cooperation among the doctors of rehabilitation, psychiatry and orthopaedic surgeon is necessary to help patients return to society as soon as possible and to return to psychological stability because the impact caused by the change in body after operation can never be excluded.

When the use of a tumoral prosthesis after resection of malignant or aggressive bone tumors around the knee joint was not possible, patients were treated by segmental resection and rotationplasty. We followed up for a period averaging 57 months, which demonstrated the functional excellence of this treatment.

In addition, when leg length discrepancy is anticipated, especially, when loosening of the tumor prosthesis is anticipated due to the growth of medullary cavity in patients that are 10 years old or less, rotationplasty may serve as a partial limb salvage procedure. Moreover, rotationplasty with its functional excellence may be considered as an effective partial limb salvage procedure if amputation is inevitable, because wide resection prevents limb reconstruction in cases of malignant tumor of over stage IIB in children or adults.

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