

Case Report

Total femur replacement: a limb-saving strategy for patients with primary malignant femoral tumors

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Abstract: Objective: The treatment of primary malignant tumors with skip or extensive bone destruction in the femur is a major challenge. We investigated the clinical effects of total femur replacement (TFR) in patients with primary malignant femoral tumors. Methods: Eleven cases of primary malignant femoral tumors treated with TFR between June 2005 and January 2015 were retrospectively reviewed. The lesions were located throughout the majority of the femur in seven cases, and the remaining four cases had skip lesions. Ten cases were in stage IIB and one case was in stage III with lung metastasis according to the Enneking system. Results: After surgery, hip dislocation occurred in one patient, and one patient suffered from transient common peroneal nerve palsy. During follow-up, local recurrence was observed in one patient, two patients died from pulmonary metastasis, and two patients died from systemic multi-metastasis. No periprosthetic infections or aseptic loosening occurred. The mean Musculoskeletal Tumor Society score was 76% (range, 56-92%). Conclusion: TFR is a reliable and effective strategy for managing primary malignant femoral tumors.

Keywords: Total femur replacement, limb-saving surgery, endoprosthesis, malignant tumor

Introduction

Treatment of primary malignant femoral tumors is difficult. With the development of chemotherapy, specifically neoadjuvant therapy and imaging technology, the 5-year survival rate of primary malignant femoral tumor has improved. However, limb-saving strategies are still required, which will lead to the phasing out of amputation. Hence, primary malignant femoral tumors with skip or extensive bone destruction still represent a major challenge for orthopedic surgeons [1].

Total femur replacement (TFR) is considered an ideal strategy that can restore femoral integrity and allow patients to resume ambulation. The function of the affected limb after TFR is acceptable and superior to amputation. Moreover, the 5-year survival rate after TFR is not reduced compared to amputation [2-5]. Here, we present 11 patients with primary malignant femoral tumors treated with TFR and discuss their clinical results.

Materials and methods

Clinical data

This was a retrospective review of data collected from our oncology database. Tumor diagnosis and stage were obtained from the database. Ethical approval from our institutional review board was granted before starting the study.

Eleven cases (five men and six women) were enrolled from June 2005 to January 2015. The mean age was 36.4 years (range, 13-84 years). Five patients had a diagnosis of osteosarcoma, three had chondrosarcoma, two had Ewing's sarcoma, and one had undifferentiated pleomorphic sarcoma. The tumors of seven cases were located throughout the majority of the femur and the other four cases had skip lesions. The tumor stage was ranked according to the Enneking system [6]. Ten cases were in stage IIB and one was in stage III with several metastatic lesions in the lung (**Table 1**). One case had pathological fracture before surgery.

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Table 1. Clinical summary of 11 patients

Variable	Data
Gender	
Male	5
Female	6
Mean age (year)	36.4
Pathogenesis	
Osteosarcoma	5
Chondrosarcoma	3
Ewing's sarcoma	2
Undifferentiated pleomorphic sarcoma	1
Tumor stage	
Staged IIB	10
Staged III	1
Mean operative time (min)	226
Mean blood loss (ml)	1160
Mean follow-up time (month)	62

Tumor stage was ranked according to Enneking system.

Surgical technique

The operation consisted of two main steps: en bloc excision of the malignant tumor, followed by functional reconstruction of the affected limb with endoprosthesis. Care was required to protect the neurovascular bundle and sciatic nerve throughout the operation.

The Watson-Jones approach was used with a long lateral incision that reached the patellar tendon and tibial tuberosity. The femoral fascia was divided to expose the inner muscles. The gluteus maximus tendon was divided and the sciatic nerve was exposed and protected. The greater trochanter with its attached abductors was osteotomized for later reattachment to the endoprosthesis if the surgical margins allowed. Otherwise, the gluteus medius and minimus, together with the external rotators, were detached from the greater tuberosity according to the margin of the lesion. The quadriceps was partly excised en bloc with the tumor boundary according to oncological surgical principles. In the proximal region, the hip capsule was divided circumferentially near the acetabulum, and then the femoral head was disarticulated. In the distal area, the patella was dislocated medially. The neurovascular bundle was exposed and carefully separated from the malignant tumor. After resection of the knee capsule, the whole femur was removed.

The proximal tibia was osteotomized and reamed for press-fit insertion of the tibial component. The endoprosthesis was implanted, and trial reduction was carried out to test stability and tension. In our series, a custom-made cemented total femur endoprosthesis was used in eight patients in the early period, and a modular cemented total femur endoprosthesis was used in three patients in more recent cases. The knee joint was reconstructed with a fixed-hinge endoprosthesis. The hip joint was reconstructed by total hip arthroplasty in one patient and hemiarthroplasty with a bipolar femoral head component in 10 patients. The reserved hip capsule was sutured around the prosthetic neck. The hip abductors were reconstructed by attaching the greater trochanter (if remaining) or the gluteus medius and minimus to the holes in the endoprosthesis. The gluteus medius and vastus lateralis were also sutured together to maintain long-term stability of the hip abductors. It was necessary to pay attention to hemostasis and eliminate the dead space. The operative incision was closed in layers over large-bore suction drains. Typical cases please refer to **Figures 1-3**.

Adjuvant treatment

The patients underwent chemotherapy and/or radiotherapy as appropriate according to the diagnosis of the tumor. In our study, eight patients received neoadjuvant or adjuvant therapies, and the other three patients diagnosed with chondrosarcoma only received surgery.

Results

The average operation time was 226 min (range, 148-310 min). A mean of 4.2 units (range, 2-8 units) of packed red blood cells was administered during the operation. No periprosthetic infection occurred. Hip dislocation occurred in one case, which was immediately treated with closed manual reduction at the bedside. Common peroneal nerve damage occurred in one patient who received an endoprosthesis elongated by 2 cm. The knee was placed in a flexion position to release tension of the common peroneal nerve, and this symptom disappeared after 3 months.

The mean follow-up time was 62 months (range, 9-118 months). Local recurrence was observed in two patients (one osteosarcoma case and

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Figure 1. A 33-year-old man with osteosarcoma who sustained sudden pain in right thigh. In X-ray, there was a tumor with pathologic fracture at the distal femur (A, B). MRI, CT and ECT showed that there was also a skip lesion appeared at the proximal femur (C-F, arrow). After the neoadjuvant chemotherapy, the patient was treated with total femur replacement (G, H). The postoperative function of the affected limb was reliable, and the functional score of MSTs was 92% at 96 months post-operation (I-K).

one Ewing's sarcoma case). Amputation was performed in the osteosarcoma patient, but the patient died from systemic multi-metastasis 2 years later. The Ewing's sarcoma patient refused amputation surgery and local radiotherapy was used. The patient is still alive with

the tumor. Two patients (including one with lung metastasis before surgery) died from pulmonary metastasis, and one patient died from systemic multi-metastasis. The other six patients are alive with no local recurrence or metastatic lesions. No periprosthetic infection or aseptic

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Figure 2. A 13-year-old girl suffered an osteosarcoma at the left femur. In X-ray, there was a tumor at the lower end of femur (A, B). CT, MRI and ECT showed that the tumor was osteogenic, without pathologic fracture (C-E). After the neoadjuvant chemotherapy, the patient was treated with total femur replacement, the functional score of MSTs was 78% at 118 months post-operation (F-H).

loosening occurred. Physical function was assessed according to Musculoskeletal Tumor Society (MSTS) guidelines [7], and the mean functional MSTS score was 76% (range, 56-92%). One patient required a wheelchair, three patients were mobilized with crutches, and the others could walk with no aid (Table 2).

Discussion

The main function of the lower limbs is to support the body weight. Unfortunately, the femur is a common site of primary malignant tumors. Initially, amputation was the only treatment option available for patients with malignant tumors with skip or extensive femur destruction. With the development of chemotherapy,

specifically neoadjuvant therapy and imaging technology, the function of the affected limb has been emphasized and limb-saving strategies are required [8-11]. If the surgery is performed well and chemotherapy is applied appropriately, the 5-year survival rate of TFR is comparable to that of amputation [12, 13].

Buchman first reported TFR surgery to treat Paget's disease, and suggested that this operation is a reliable strategy [14]. With progress in clinical technology, the indications for TFR have become more extensive. Generally, for patients with primary malignant femur tumors, TFR is recommended according to the following criteria: (1) malignant tumor involving the entire femur or with skip pathological sites that can

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Figure 3. A 60-year-old woman suffered a chondrosarcoma at the left femur. The X ray, CT and ECT showed that tumor involved almost the whole femur (A-D). T2-weighted MRI showed high signal intensity of the lesion with soft tissue mass formation around the femur (E). Thin rims of contrast enhancement were seen around the periphery of the lesion on the enhanced T1-weighted MRI (F). The patient was treated with total femur replacement, and the functional score of MSTs was 74% at 92 months post-operation (G-I).

Table 2. Respective diagnosis, stage, complication and follow-up time of 11 patients

No	Age	Sex	Diagnosis/stage	Tumor site	MSTS	Complication	Follow-up time (mon)
1	13	F	Osteosarcoma/(IIB)	Majority	78	Hip dislocation	118
2	43	M	Ewings' sarcoma/(IIB)	Majority	74	Local recurrence	37
3	15	F	Osteosarcoma/(III)	Skip lesion	68	Pulmonary metastasis	9
4	19	M	Osteosarcoma/(IIB)	Majority	80	Common peroneal nerve palsy	84
5	84	F	Chondrosarcoma/(IIB)	Majority	56	Systemic multi-metastasis	33
6	21	F	Osteosarcoma/(IIB)	Skip lesion	74	Systemic multi-metastasis	25
7	34	M	Chondrosarcoma/(IIB)	Skip lesion	90	None	77
8	32	M	Ewings' sarcoma/(IIB)	Majority	84	None	79
9	33	M	Osteosarcoma/(IIB)	Skip lesion	92	None	96
10	60	F	Chondrosarcoma/(IIB)	Majority	74	None	92
11	46	F	Pleomorphic sarcoma /(IIB)	Majority	66	Pulmonary metastasis	32

MSTS, Musculoskeletal Tumor Society.

be resected en bloc; (2) the neurovascular bundle and sciatic nerve can be reserved; and (3) essential muscle can be restored to cover the endoprosthesis and provide motive power. Recently, it was reported that patients with distant metastasis can also be treated with TFR,

particularly those with low-grade malignant tumors [15, 16]. In the present study, 11 primary malignant femur tumors (10 cases of IIB and 1 case of IIIB) were treated with TFR and obtained satisfactory results. Finally, six patients are alive and free of tumors, and one

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patient has survived with tumor burden. Most of the patients could walk with no aid (64%) and the mean MSTS score was 76%. In this study, we also performed TFR in one patient with lung metastasis. Although the patient died from pulmonary metastasis 2 years later, she had an improved quality of life, which could not have been achieved by amputation. Encouraged by the reliable function of the affected limb, we suggest that TFR is also a favorable choice for patients with distant metastasis.

To achieve en bloc resection of malignant tumors, large amounts of soft tissue are always lost, which may result in weakness and instability of the affected limb. Therefore, the management of related joint kinematics and soft tissue reconstruction is important [17, 18]. Hemiarthroplasty of the hip could provide a larger femoral head, which would be inherently more stable than total arthroplasty. In this series, only one patient received total hip arthroplasty, with the other ten patients treated with hemiarthroplasty. The hip joint was further reinforced by purse string closure of the reserved hip capsule if possible. Hip dislocation occurred in only one case after the operation. Closed manual reduction was applied immediately at the bedside and hip dislocation did not relapse. The MSTS of this patient was 78% at the last follow-up. Abductor reconstruction is another key point, which promises kinematics and stability. In our cases, we preferred direct attachment of viable tendinous abductors and vastus lateralis to the endoprosthesis. The gluteus medius and vastus lateralis were also sutured together to reinforce long-term stability of the hip abductors. In cases of severe muscle loss of the abductors, we preferred to wrap polypropylene knitted non-absorbable mesh around the prosthesis. The remaining muscles could be sutured tightly to the mesh. Although the use of synthetic materials may increase the risk for deep prosthetic infection [19], no infections were found in our cases when synthetic mesh was used. We believe this is a safe and effective method to enhance hip stability in cases with severe muscle loss.

TFR is a complicated surgery that requires wide operative exposure and a long operative time, resulting in considerable blood loss. In our study, almost all cases required perioperative transfusions (minimum, 2 units; maximum, 8 units). Therefore, careful hemostasis was crucial during the operation. In recent years,

tranexamic acid (TXA) has been applied both topically and intravenously during surgery, and this has remarkably lowered blood loss [20, 21]. We recommend the routine use of TXA in this procedure.

As the majority of cases of osteosarcoma and Ewing's sarcoma occur in young adolescents or children with the potential for bone growth, estimating growing ability of the affected limb should be emphasized. Hence, a longer endoprosthesis was always used in such young patients. In our study, one patient who received an endoprosthesis elongated by 2 cm, and this patient developed transient peroneal nerve palsy after surgery. Therefore, care is required when using a longer endoprosthesis.

Local recurrence and metastasis are common complications in patients with malignant bone tumors. To obtain a sufficient tumor margin, en bloc resection of the tumor according to oncological surgical principles should be emphasized. A wide margin could not always be obtained, particularly in cases in which the tumor is close to the neurovascular bundle. Sometimes, the marginal margin is compromised, and intralesional surgery should be strongly avoided. The use of neoadjuvant chemotherapy is important to eliminate potential residual or metastatic lesions. In our series, four cases only reached a marginal margin, two patients with a satisfactory tumor necrosis rates had tumor-free survival, and the other two patients with compromised tumor necrosis rates died from metastasis. Similar results were also observed in previous studies that reported that the incidence of local recurrence was inversely proportional to the effectiveness of chemotherapy [22, 23].

In conclusion, TFR is a good and reliable limb-saving strategy for treating primary malignant femoral tumors, particularly those with skipped or extensive bone destruction. It is associated with a low relapse rate and offers predictable physical function.

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Disclosure of conflict of interest

None.

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