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## Total femur replacement with 18 years of follow-up: A case report

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### Abstract

#### BACKGROUND

Osteosarcoma is one of the most common primary malignant bone tumors and is more common in adolescents. The femur is the most common site of osteosarcoma, and many patients require total femur replacement. We reviewed the relevant literature and case findings, summarized and analyzed this case in combination with relevant literature, and in doing so improved the understanding of the technology.

#### CASE SUMMARY

The case we report was a 15-year-old patient who was admitted to the hospital 15 days after the discovery of a right thigh mass. The diagnosis was osteosarcoma of the right femoral shaft. After completion of neoadjuvant chemotherapy and preoperative preparation, total right femoral resection + artificial total femoral replacement was performed. Then, chemotherapy was continued after surgery. The patient recovered well after treatment, and the function of the affected limb was good. No recurrence, metastasis, prosthesis loosening, dislocation, fracture or other complications were found during 18 years of follow-up. At present, the patient can still work and lives normally. The results of the medium- and long-term follow-up were satisfactory.

#### CONCLUSION

Artificial total femur replacement is a feasible limb salvage operation for patients

with femoral malignant tumors, and the results of medium- and long-term follow-up are satisfactory.

**Key Words:** Total femur replacement; Osteosarcoma; Medium and long-term follow-up; Case report

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**Core Tip:** Artificial total femur replacement is a feasible limb salvage operation for patients with femoral malignant tumors, and the results of medium- and long-term follow-up are satisfactory.

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## INTRODUCTION

Osteosarcoma is one of the most common primary malignant bone tumors and is more common in adolescents[1] than in adults. Since the 1970s, with the application of neoadjuvant chemotherapy, the 5-year survival rate of osteosarcoma patients has exceeded 70%[2]. After the 20<sup>th</sup> century, due to the development of reconstruction materials and surgical techniques, limb salvage has become the mainstream treatment for limb osteosarcoma patients, and 85% of patients in early and middle stages can undergo limb salvage therapy[3]. Osteosarcoma can occur in bones throughout the body, with the femur being the most common site of osteosarcoma, usually in the metaphysis of the femur[4]. However, as the frequency of cases increase, several abnormalities in case presentation stand out; for example, tumors may have jumping lesions at the other end of the femur; malignant tumors in the proximal or distal tumors may have a wide range of invasion, reaching or even exceeding 1/2 of the femur; and backbone malignant tumors involve the proximal and distal femurs. In these cases, only hip amputation or hemipelvic amputation can be performed. In 1965, Buchman *et al*[5] performed the world's first total femur replacement. The application of artificial total femoral replacement surgery avoids amputation, retains the movement and weight-bearing function of the affected limb, reduces psychological trauma, and greatly improves quality of life[6]. We report a case of artificial total femoral prosthesis replacement for stage IIB osteosarcoma of the femoral shaft and follow-up for 18 years. Combined with relevant literature reports, cases of this type are summarized and analyzed to improve the understanding of this procedure.

## CASE PRESENTATION

### Chief complaints

Find a mass in the middle and lower part of the right thigh with pain for 15 d.

### History of present illness

A 15-year-old male patient was admitted to the hospital on August 5, 2003, after finding a mass in the middle to lower part of the right thigh with pain going back 15 d.

### History of past illness

There was no previous history of pain.

### Personal and family history

There is no history of family inheritance.

### Physical examination

Physical examination demonstrated that the patient's general condition was good, and palpation of systemic superficial lymph node did not reveal swelling. No abnormalities were found in the heart, lungs or abdomen. There was localized swelling to the middle and lower thigh, and a 10 cm × 6 cm × 4 cm mass was found, characterized by hard, fixed, unclear boundaries, tenderness, increasing local skin

temperature and filling superficial veins. Left lower limb blood flow and feeling were good, and the muscle strength was grade 4.

### Laboratory examinations

Blood routine was normal, ALP 222U/L.

### Imaging examinations

X-ray showed osteolytic destruction of the middle and lower segments of the right femur, accompanied by a periosteal reaction (Figure 1A and B). Enneking staging was IIB.

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## FINAL DIAGNOSIS

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Conventional osteosarcoma of the right femur (Enneking stage: G2T2M0 Stage IIB).

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## TREATMENT

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Biopsy of the mass revealed right femoral osteosarcoma. Adjuvant chemotherapy with doxorubicin, cisplatin, high-dose methotrexate and vincristine was administered on September 1, 2003. Thigh pain was relieved after chemotherapy, and the mass was reduced to 8 cm × 4 cm × 2 cm. Artificial total femoral replacement under general anesthesia (compartment resection of osteosarcoma) was performed on November 20, 2003. The Watson Jones incision of the hip joint was performed during surgery, which then extended to the outside of the knee joint along the outside of the thigh and distal end, starting from 3.5 cm above the tip of the femoral trochanter and ending at the lateral edge of the tibial tubercle (Figure 1C). The whole femur was resected at the surgical margin of the tumor response area (Figure 1D). According to tumor knee arthroplasty standards, the tibial plateau and medullary cavity were repaired, and a bone cement-type artificial tibia prosthesis was partially implanted and fixed in the tibial medullary cavity; attention was given to avoid varus or angulation deformities in the tibial axis. According to the size of the acetabulum, an appropriate double-acting femoral head was selected, and the reduction and rotation axes of the knee joint were installed (Figure 1E). The anteversion angle of the femoral neck was kept at 15-20°. To wash, establish hemostasis and repair the hip joint, large and small rotor stumps were sutured with the iliopsoas, gluteus maximus and gluteus medius to the ear-shaped holes of the artificial femur, the large and small trochanter attachments were reconstructed, the knee joint capsule was repaired, the lateral femoral muscle, tensor fascia lata, and iliotibial tract covering the prosthesis were sutured, and the subcutaneous tissue and skin were sutured. Two negative pressure drainage tubes were placed on the right hip and lateral knee. After the operation, the hip joint strap was fixed externally, the right lower limb was abducted 15-20° in a neutral position, and the patient was given "Ding" shoes to wear in order to prevent lower extremity external rotation. The drainage tube was pulled out 5 d after the operation, and the X-ray revealed that the prosthesis was in good position, with no dislocation (Figure 1H). After 5 d, the right quadriceps, ankle and toe functions were exercised. The postoperative pathological diagnosis was osteosarcoma of the right femur, which was considered conventional according to the WHO classification of bone tumors (Figure 1F-G). The sutures were removed 18 d after the operation, and incision I/a had healed. Chemotherapy was initiated 4 wk after surgery with the same scheme as before.

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## OUTCOME AND FOLLOW-UP

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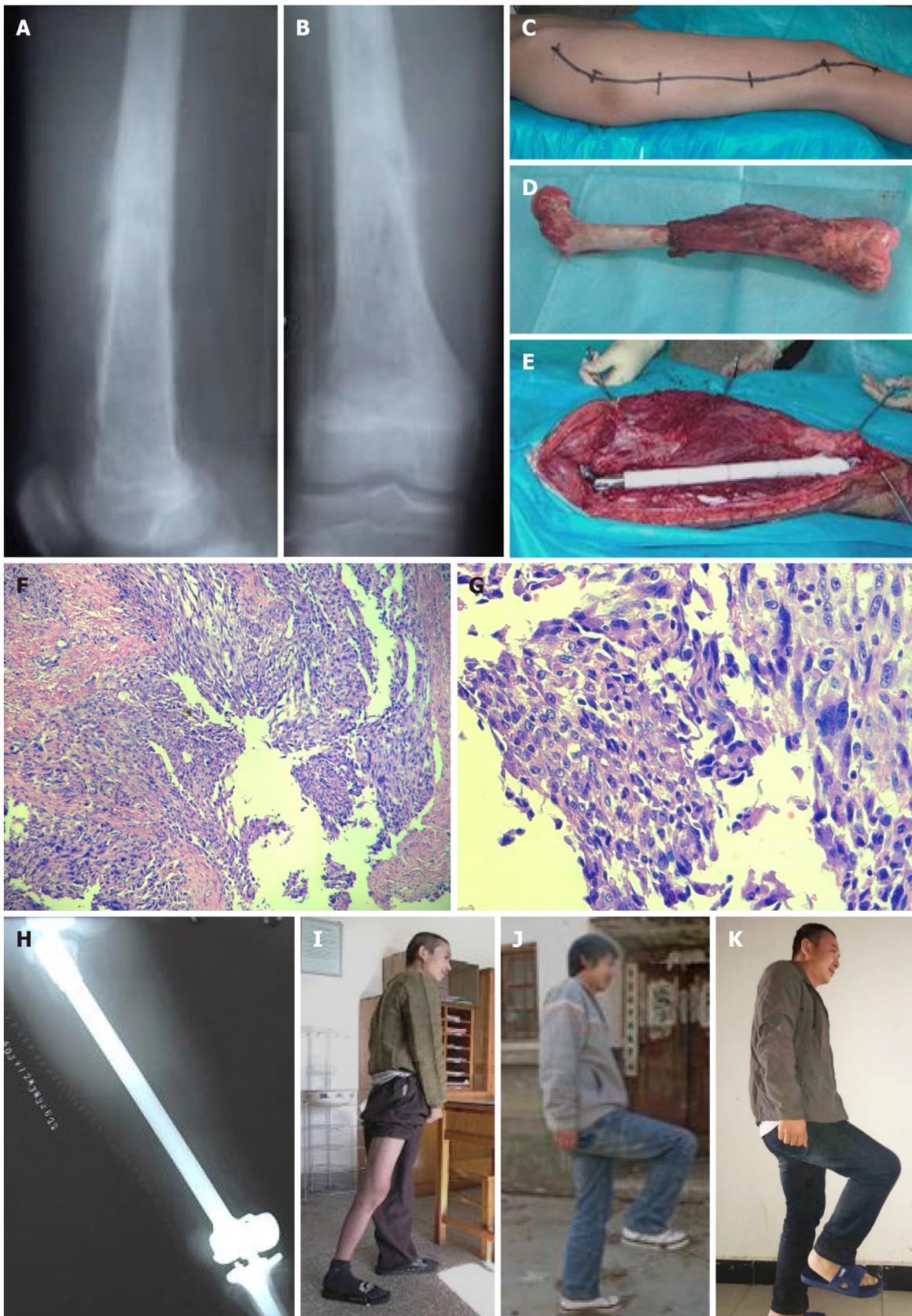
At the 6<sup>th</sup> week, the patient began to walk on crutches, kept a neutral position of abduction, and was told not to cross his knees, bend his legs, squat excessively or bend his hip no more than 90°. The patient returned to the hospital for re-examination 1 year (Figure 1I) and 4 years (Figure 1J) after surgery. Presently, the patient was followed up after 18 years (Figure 1K). There was no local tumor recurrence, with no metastasis in either lung. X-ray showed that there were no complications, including loosening, dislocation or fracture of the artificial femur. At present, the patient still works and lives normally.

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## LITERATURE REVIEW

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To review the cases of femoral shaft malignant tumors treated by artificial whole femoral prostheses in China and abroad, we used the following literature search terms: ("total femur replacement" or "total femoral replacement" or "total femur and knee joint replacement" or "total femoral and knee joint replacement" or "total femoral endoprosthetic replacement") and ("malignant bone tumor" or "bone



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**Figure 1** Imaging examinations. A and B: X-ray illustrates osteolytic destruction in the middle and lower segments of the right femur, with significant periosteal reaction; C-E: Intraoperative condition; F-G: 4×10, 40×10 magnification photomicrograph, respectively, hematoxylin and eosin; H: Postoperative X-ray; I-K: Postoperative follow up after the 1, 4 and 18 years.

neoplasm" or "bone cancer" or "bone malignant tumor" or "malignant tumor of bone" or "osteosarcoma" or "Ewing sarcoma" or "chondrosarcoma"). Our search encompassed 40 years of cases in Medline and China Zhiwang. Using this strategy, we found a total of 446 cases in 37 studies. The relevant literature reports are summarized in [Supplementary Table 1](#).

## DISCUSSION

Due to existing methods of neoadjuvant chemotherapy combined with complete tumor resection and limb reconstruction have achieved satisfactory clinical results. For patients whose soft tissue conditions are not poor, the main neurovasculature is not invaded, certain limb functions can be preserved after surgery and local recurrence rate will not be increased, limb salvage surgery can be performed[7]. This osteosarcoma case included a wide range of tumor invasion and was easily combined with pathological fractures. Autologous tumor bone replantation has problems, since it is difficult to retain the intact bone shell, and the strength is reduced after inactivation of the tumor bone. Allogeneic bone replacement requires a long healing time, and has a higher propensity for fractures and joint degeneration, while artificial joints have high strength and are specially formulated according to the patient's clinical needs to fill bone defects and rebuild joint function. Patients can also bear weight and exercise soon after surgery[8]. In this case, the right femoral lesion had exceeded 1/2 the length of the femur. If lengthened knee arthroplasty had been used, the prosthesis could easily loosen due to the large leverage force and the lack of surrounding soft tissue fixation, and the tumor may recur due to the insufficient osteotomy plane. Therefore, artificial total femoral replacement was the best treatment for this case. Our experience was that during the operation, we should protect the normal muscle tissue, firmly reconstruct the attachment points of the large and small rotator muscles, repair the hip and knee joint capsule, and rebuild the muscle balance. After the operation, we should emphasize the correct posture and correct functional exercise, which plays an important role in reducing the incidence of complications and improving the limb function of patients.

Total femoral prosthesis replacement is an ideal method for removing malignant femoral tumors to preserve the limbs and maximize the function of the lower extremities. It is necessary however to pay attention to the surgical indications and case selection to determine if surgical border resection is required during the operation. Currently, the recognized surgical indications for consideration include [9-13]: (1) Malignant tumors originating from the femoral shaft accumulate in the proximal or distal femur; (2) tumors in the proximal or distal femur which have jumping lesions at the other end; (3) patients who can still save their limbs by total femoral replacement to prevent local tumor recurrence; (4) the replacement of the proximal or distal femur prosthesis or composite prosthesis fails, due to the nonunion of bone, fracture or loosening of the prosthesis, which cannot be repaired by other methods; (5) patients with multiple bone metastases on a single limb with pathological fractures who are expected to survive for > 6 mo; or (6) some benign lesions with repeated pathological fractures and long healing time and appear to have limb deformities, which have seriously affected the patient's work and quality of life. The patient described here meets indication[1]. Due to the expansion of the indications for artificial total femoral replacement, the procedure has been gradually applied to nontumor lesions, including revision of hip and knee joint replacements with serious bone defects and invalid conventional methods or serious hip and knee arthritis on the same limb side, among other conditions.

Since Buchman's first customized cobalt chromium molybdenum alloy femoral prosthesis was applied[5] the design of the whole femoral prosthesis has been improving with the progress of biomaterial technology. Early prostheses were all homemade[14], later developed into custom-made prostheses[9,15-18], and then assembled prostheses[15,16]. At present, patients can use assembled prostheses without waiting for the prosthesis to be manufactured, and they can also be assembled according to their own specific conditions. Metal materials have also evolved from titanium nitride[15] and stainless steel[19] to titanium alloys[20]. The prosthesis used in this patient was a customized titanium alloy prosthesis, and the design was based on the patient's bilateral total femoral X-ray. The length of the customized prosthesis was the same as the healthy leg or slightly shorter by 1-2 cm, and the size of the femoral head was similarly measured. A bipolar artificial femoral head is recommended to reduce the dislocation of the hip joint prosthesis[21]. The use of a rotary axis knee joint can reduce the loosening of the knee prosthesis[22]. In recent years, there have also been many special types of total femoral prostheses developed. Since traditional total femoral replacement requires the removal of many muscle attachment points, the function of the affected limb is poor after surgery, and hip dislocation is more common. Ward *et al*[10] and Gorter *et al*[23] have developed a full-femoral intramedullary prosthesis to replace the traditional full-femoral prosthesis. This surgical method retains the attachment points of some bones and muscles, maintains stability to the maximum extent, and yields better function. Additionally, complications of hip dislocation cannot easily occur, and the risk of incision infection is also reduced. To solve the problem of unequal lengths of the lower limbs after total femoral replacement in children, Schindler *et al*[24] designed an extendable total femoral prosthesis. In response to the problem of deep infection and abscess formation after total femoral replacement, Glehr *et al*[25] applied a silver ion-coated total femoral prosthesis to reduce the incidence of postoperative infection

complications.

There are few reports including long-term follow-up after total femoral replacement surgery, which are mainly based on case reports. The main reason for this is related to the poor effect of postoperative radiotherapy and chemotherapy, the early occurrence of distant metastasis and the short overall survival period. It is generally acknowledged that the first case of total femoral replacement was performed by Professor Buchman in 1965, but actually, the earliest case can be traced back to 1952 and was also performed by Professor Buchman. This case was followed up for 35 years and is also the case with the longest follow-up time reported in the literature. It was reported by Present in 1990[14]. This case was diagnosed as having multiple fibrous dysplasia in the left femur and secondary low-grade chondrosarcoma. Thirty-two years after total femoral replacement, the patient underwent hip arthroplasty due to severe pain in the thigh and sinus formation. Postoperative examination showed that there was no recurrence of the tumor. Nakamura *et al*[21] reported 2 patients with total femoral replacement surgery, including over 10 years of follow-up. One case was diagnosed as osteosarcoma with skin necrosis that occurred after the operation requiring a skin graft. There was no loosening, dislocation or local recurrence of the prosthesis after 12 years of follow-up. The MSTS score of the postoperative patients was 60%. Another patient was diagnosed with Ewing's sarcoma, and sciatic nerve palsy occurred after surgery, requiring external fixation and crutches. After 11 years of follow-up, no prosthesis loosening, dislocation, or local recurrence was found. The functional MSTS score of the patient after operation was 63%. The patient in this paper was followed up for 18 years. The patient did not experience local tumor recurrence or distant metastasis. The images suggest that the prosthesis has not been loosened, dislocated, or broken. The patient could walk normally on crutches, and the current MSTS score was reported as 67%.

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## CONCLUSION

Artificial total femur replacement is a feasible limb salvage operation for patients with femoral malignant tumors, and the results of medium- and long-term follow-up are satisfactory.

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## FOOTNOTES

**Author contributions:** Yang YH collected the data of case, reviewed the literatures and drafted the manuscripts; Chen JX and Chen QY help to collect the data of the case; Yang ZZ, Yuan T, and Sun HP carried out the operation and revised the manuscript; Xie L and Yao ZH reviewed the literatures and revised the manuscript; Wang Y, Zhou YB and Wang HW were collecting medical images; all authors read and approved the final manuscript; Yang YH, Chen JX, Chen QY, Wang Y, Zhou YB, and Wang HW are co-first authors.

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