Modular megaprosthesis for proximal femoral tumors

Adel R. Ahmed

Department of Orthopaedics, Faculty of Medicine, University of Alexandria, Alexandria, Egypt

Correspondence to Adel R. Ahmed, MD, PhD, Elhadara University Hospital, Elhadara, Lambrouzou, Alexandria, Egypt.
Tel: +20 122 240 8646;
e-mail: adeljapan@yahoo.com

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Objectives
Limb salvage surgery is the preferred treatment for proximal femoral tumors. The use of modular prosthesis following resection of the tumor is the preferred method, a procedure that is technically demanding. The resection of tumor at the level of proximal femur results in loss of abductors and other musculature necessary for hip stability. This often leads to a higher instability rate. Hip dislocation is a recognized problem after the use of megaprosthesis, with rates of dislocation varying from 1.7% to ~28%.
Patients and methods
Between March 2003 and March 2008, 15 patients in our series had resection of the proximal femoral primary malignant tumors and implantation of a modular megaprostheses, using a bipolar acetabular cup. There were seven women and eight men, with a mean age of 37 years (18–68 years). The diagnoses were osteosarcoma (two), chondrosarcoma (eight), malignant fibrous histiocytoma (two), and giant cell tumor (three). All patients had a complete tumor workup before surgery that included routine blood work, bone scan, computed tomography of the chest, and MRI of the femur. All patients had an open biopsy. They were given preoperative radiotherapy and chemotherapy as required.
Results
The mean follow-up was 5 years (range, 5 months–10 years). Two patients died of causes not related to the prosthesis. The postoperative Musculoskeletal Tumor Society score was 26 (range, 23–30) for the remaining 13 patients. There were one subluxation treated conservatively, and one erosion of the acetabulum that needed conversion into total hip replacement. No infections and local recurrence were encountered.
Conclusion
Proximal femoral modular megaprosthesis is a good option for reconstruction after resection of proximal femoral tumors.

Keywords:
malignant tumors, prosthesis, proximal femur

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Introduction

With improved survival from primary bone malignancies caused by newer chemotherapy regimens, newer imaging modalities, and better prosthetic replacement, the development of limb salvage surgical resections has flourished [1–4]. In the lower extremity, where the primary function of the skeleton is to support body weight for purposeful ambulation, the success of these massive endoprosthetic bone and joint replacements has been remarkable [5–9]. Proximal femoral replacement can restore femoral integrity and allow patients to resume painless unsupported ambulation. In authors' experience, this compromised functional capacity is superior to that achieved after hip disarticulation. Most reports of proximal femoral replacements are isolated studies [10–16]. Only few reported series have been identified. Farid *et al.* [9] reported two excellent, nine good, nine fair, and four poor results in 24 patients with a minimum of 2-year follow-up. Their amputation rate was 28%, reoperation rate was 87%, and prosthetic complications occurred in 71% of their patients. Morris *et al.* [12] reported on seven patients with total femur replacement, three for primary bone malignancy, and four for salvage procedures after failed limb-sparing surgery. Their clinical and radiological results were excellent or good at final follow-up of 23 months. Ward *et al.* [14] reported 21 patients, and the results of 19 of them were satisfactory in 16 and poor in three. Hereby, we report on nine patients evaluated by well-documented clinical, radiological, and functional methods of evaluation.

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Patients and methods

Between March 2003 and March 2008, 15 patients in our series had resection of the proximal femoral primary malignant tumors and implantation of a modular megaprostheses, using a bipolar acetabular cup. The study was approved by the institutional ethics committee in Department of Orthopaedics, Faculty of Medicine, University of Alexandria, Alexandria, Egypt. There were seven women and eight men, with a mean age of 37 years (18–68 years). The diagnoses were osteosarcoma (two), chondrosarcoma (eight), malignant fibrous histiocytoma (two), and giant cell tumor (three) (Table 1). All patients had a complete tumor workup before surgery that included routine blood work, bone scan, computed tomography of the chest, and MRI of the femur. All patients had an open biopsy. They were given preoperative radiotherapy and chemotherapy as required.

All tumors were staged according to the Musculoskeletal Tumor Society Staging System [3]. Nine patients were stage IA, a single patient was stage IIB, two patients were stage IIIB, and three patients stage IB (Table 1). At the time of the initial evaluation, all patients had a thorough oncologic examination, which included radiographs of the involved bone, scintigraphy of the entire skeleton, chest radiographs, and imaging of the neoplasm with computed tomography and MRI (Fig. 1). All patients diagnosed as osteosarcoma and malignant fibrous histiocytoma received adjuvant chemotherapy. The follow-up periods ranged from 8 to 120 months (mean, 60 months) (Table 1).

Prosthesis

Modular hydroxyapatite-coated cementless titanium prosthesis, which uses a bipolar femoral head component, was used for this series.

Surgical technique

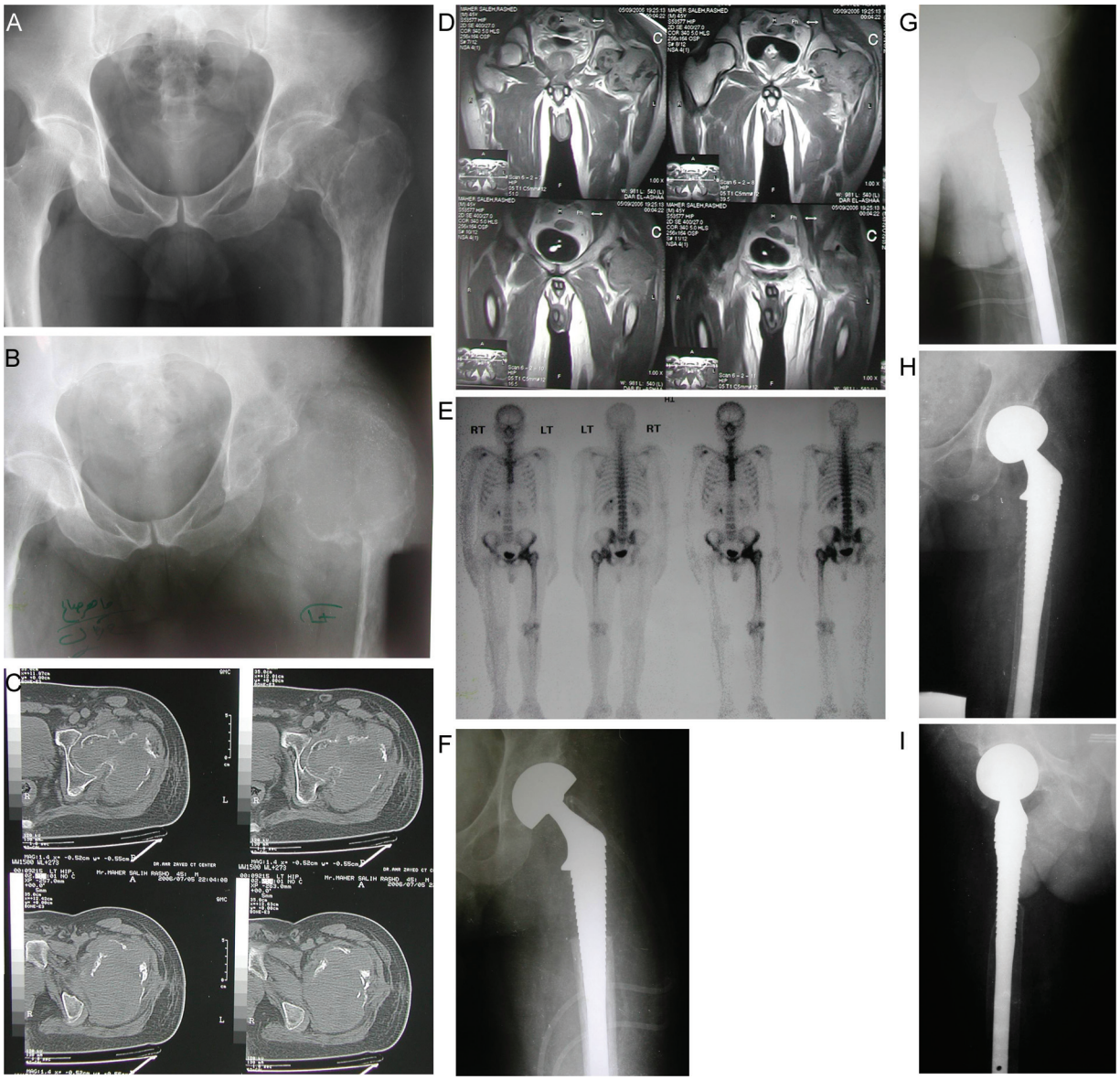
The Watson–Jones approach to the hip was used, with a long incision on the lateral side of the thigh. The gluteus medius and minimus, together with the external rotators, were detached depending on the surgical margin. The gluteus maximus tendon was divided, and the sciatic nerve was exposed and protected. Part of the quadriceps was excised en bloc with the tumor according to standard oncologic surgical principles; rectus femoris was preserved to enhance hip flexion and knee extension. The capsule of the hip was divided circumferentially near the acetabulum and the femoral head dislocated; the insertion of the psoas was divided. Whenever the surgical margin allows and to obtain reasonable stability of the prosthesis and adequate hip abduction, the greater trochanter with its attached abductors was osteotomized for later reattachment to the prosthesis, otherwise the abductors were severed from their attachment to the greater trochanter and to be sutured to special Gortex mesh covering the prosthesis. The neurovascular bundle was exposed and separated

Table 1 Summary of the patients' data

Patient numbers	Age (years)	Sex	Diagnosis/stage	Status/ functional results	*n* (%)	Follow-up (months)	Margin	Complications
1	32	M	MFH/IIA	CDF	30/30–100%	120	Wide	None
2	50	M	Chondrosarcoma/IA	CDF	24/30 – 80%	100	Wide	None
3	48	M	GCT	CDF	30/30 – 100%	95	Marginal	None
4	30	M	Chondrosarcoma/IB	CDF	24/30 – 80%	84	Wide	Erosion of acetabulum/ converted to THA
5	30	F	Chondrosarcoma/IA	CDF	30/30 – 100%	36	Wide	None
6	23	F	MFH/IIA	CDF	30/30 – 100%	70	Wide	None
7	68	F	Chondrosarcoma/IIIB	DOD	NA	8	Marginal	None
8	32	M	GCT	CDF	24/30 – 80%	60	Marginal	None
9	55	M	Chondrosarcoma/IB	CDF	24/30 – 80%	58	Wide	None
10	22	M	Osteosarcoma/IIB	NED	23/30 – 76%	60	Wide	None
11	32	F	Chondrosarcoma/IA	CDF	24/30 – 80%	56	Wide	None
12	38	F	GCT	CDF	23/30 – 76%	52	Marginal	None
13	34	F	Chondrosarcoma/IB	CDF	30/30 – 100%	60	Wide	None
14	18	M	Osteosarcoma/IIIB	DOD	NA	18	Marginal	Subluxation/conservative treatment
15	36	F	Chondrosarcoma/IA	CDF	30/30 – 100%	36	Wide	None

CDF, continuous disease free; DOD, died of disease; F, female; GCT, giant cell tumor; M, male; MFH, malignant fibrous histiocytoma; NA, not available; NED, no evidence of disease; THA, total hip arthroplasty.

Figure 1



(a) Patient number 3: he was presented with this radiography elsewhere. (b) After 5 months, he presented to us with this radiograph showing a marked osteolytic destructive lesion affecting the proximal right femur. (c) Computed tomography showing the extent of the lesion and the destruction of the proximal femur. (d) Coronal cut MRI showing the heterogeneity of the lesion, and fortunately the hip joint was not involved. (e) Tc 99 bone scintigraphy showing high activity at the periphery of the lesion. (f, g) Open biopsy confirmed the diagnosis of aggressive giant cell tumor. The proximal femur was resected and reconstructed with modular bipolar tumor prosthesis. (h, i) Radiographs at 5 years after surgery.

from the tumor, with ligation of the vessels passing to the tumor and the femur. Muscles attached to the linea aspera were divided allowing removal of the proximal femur. The parts were then assembled, and a trial reduction was carried out to test stability and tension. The glutei and the remaining vasti were attached to the holes in endoprosthesis and to special Gortex mesh covering the prosthesis.

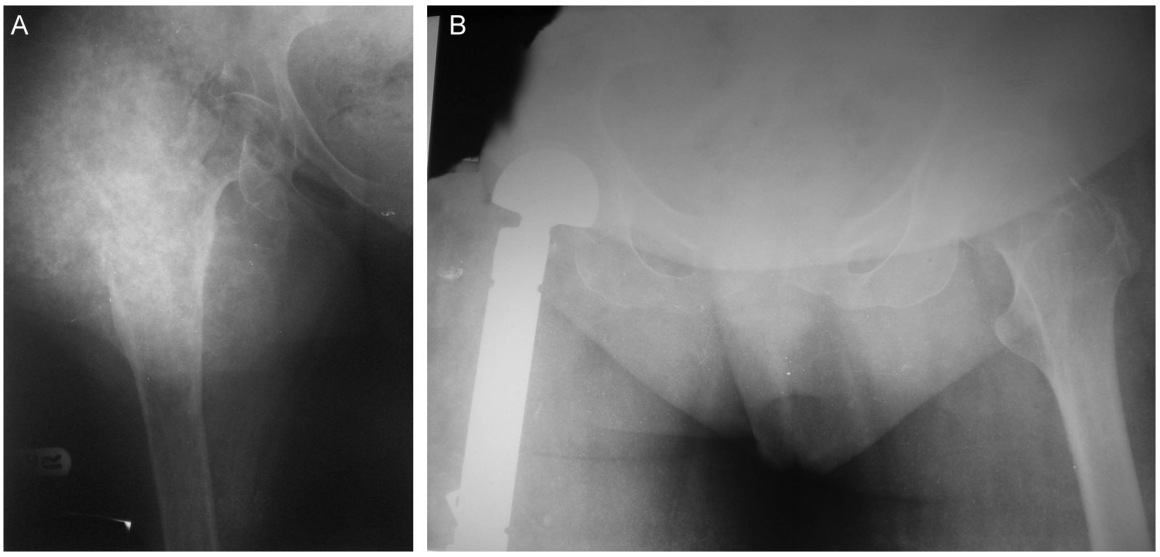
Meticulous hemostasis is essential, and the dead space was eliminated as possible. The endoprosthesis was covered with the remaining muscles and the wound closed in layers over large-bore suction drains [2,12].

The average operating time was 3.5 h and blood loss during surgery was 1.3 l.

Evaluation methods

The surgical margin of the resected specimen was evaluated according to the evaluation system of the Japanese Orthopedic Association [7]. Simply in this system, a surgical margin is evaluated according to the distance of the margin from tumor's reactive zone, and consequently is classifiable into the four categories of curative, wide, marginal, or intralesional margin. A curative margin is defined as a margin more than 5 cm outside the reactive zone, a wide margin is a margin of 4–1 cm, a marginal margin is a margin passing through

Figure 2



(a) Patient number 7; radiography of 68-year-old female patient diagnosed as having primary chondrosarcoma of the proximal femur. (b) Postoperative radiography.

the reactive zone and an intralesional margin is a margin passing through the tumor parenchyma. Moreover, a wide margin can be divided into two subgroups of adequate and inadequate wide margins. An adequate wide margin is defined as a margin more than 2 cm, and an inadequate wide margin is a margin of 1 cm [7]. For the functional evaluation, Enneking's method was used [4].

Results

Surgical margins

Wide margin was obtained in 10 patients and marginal margin in two (one osteosarcoma with previous improper biopsy done elsewhere and one huge chondrosarcoma), and the three patients with giant cell tumor of the femur were treated by marginal resection of the tumor.

Oncologic outcome

The results were as follows: continuous disease free in 12, no evidence of disease in one patient, and death due to disease in two patients. Local recurrence was not encountered in this series of patients. Both patients who died owing to disease (patient number 7 and number 14) had bilateral lung metastasis before surgery, with death due to disease at 8 and 18 months, postoperatively, correspondingly.

Complications

Major complication occurred in two patients: patient number 4 and 14. Patient number 4 was a 30-year-old male diagnosed as having secondary chondrosarcoma of the proximal right femur. He was reconstructed with modular proximal femur bipolar tumor prosthesis. Five years after surgery, the prosthesis was in good position and the patient had excellent function. Seven years after surgery, the patient developed erosion of the acetabulum with marked pain on walking. Revision of the cup of the prosthesis with cementless hydroxyapatite-coated cup over bone allograft to compensate for the eroded acetabulum was done (Fig. 3).

Patient number 14 developed subluxation of the reconstructed hip that was treated conservatively by abduction brace, and the patient died of disease at 18 months postoperatively. Neither infection nor local recurrence was encountered in this series of patients.

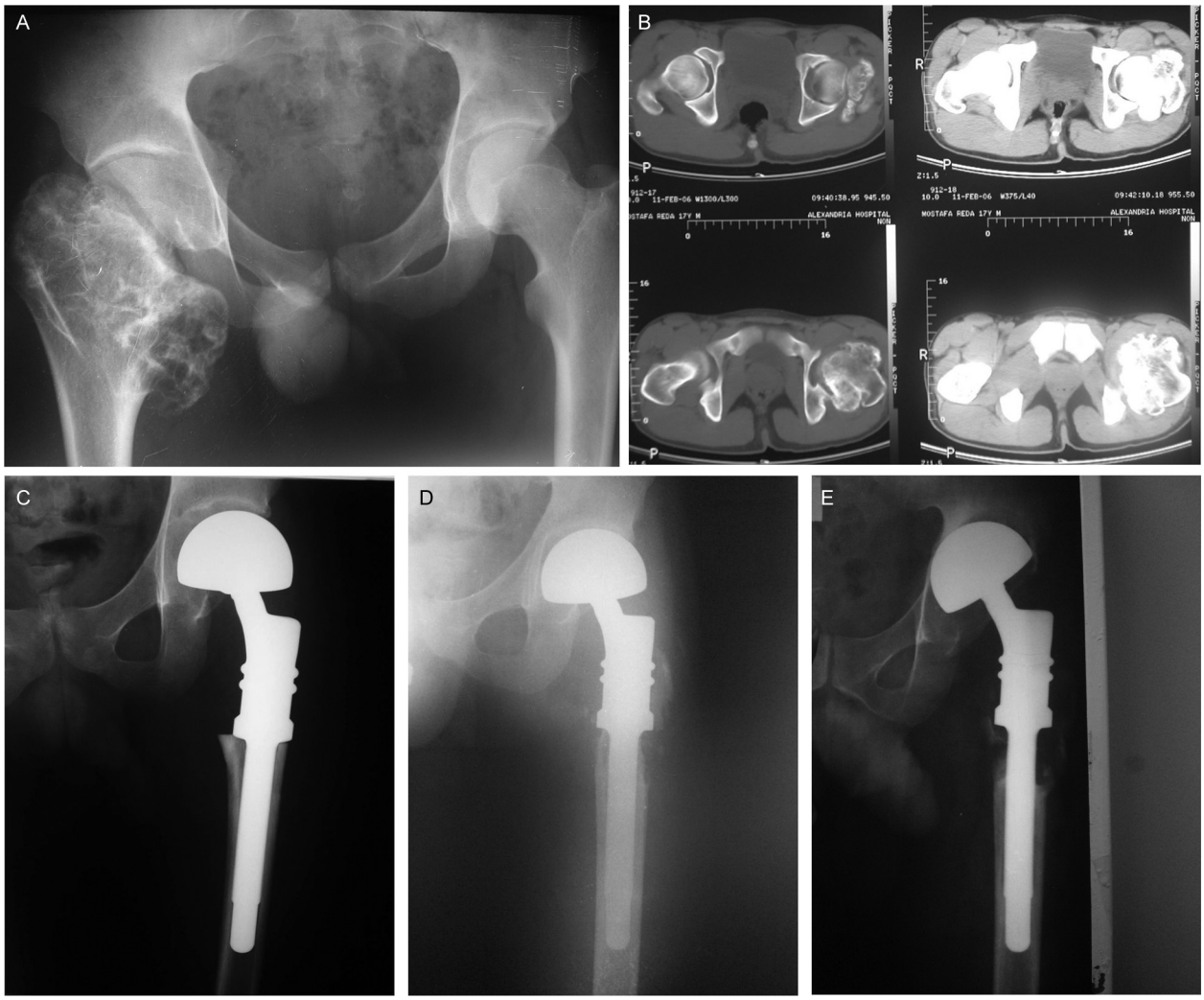
Functional results

Competence of the abductors of the hip and extensor mechanism of the knee is the major determinant of functional outcome of these patients. The flexion range of knee motion ranged from 60 to 120° (mean, 100°).

All the evaluated patients can walk independently (Table 1).

According to Enneking's functional evaluation method [4], the function of the reconstructed limbs ranged from 23 to 30 (mean, 26). Using the International Society of Limb Salvage radiographic evaluation method [5], all the available radiographs show excellent results (Figs 1–4). Excellent results also were seen for the radiographic evaluation of the reconstructed hip according to the method of Morris *et al.* [12].

Figure 3

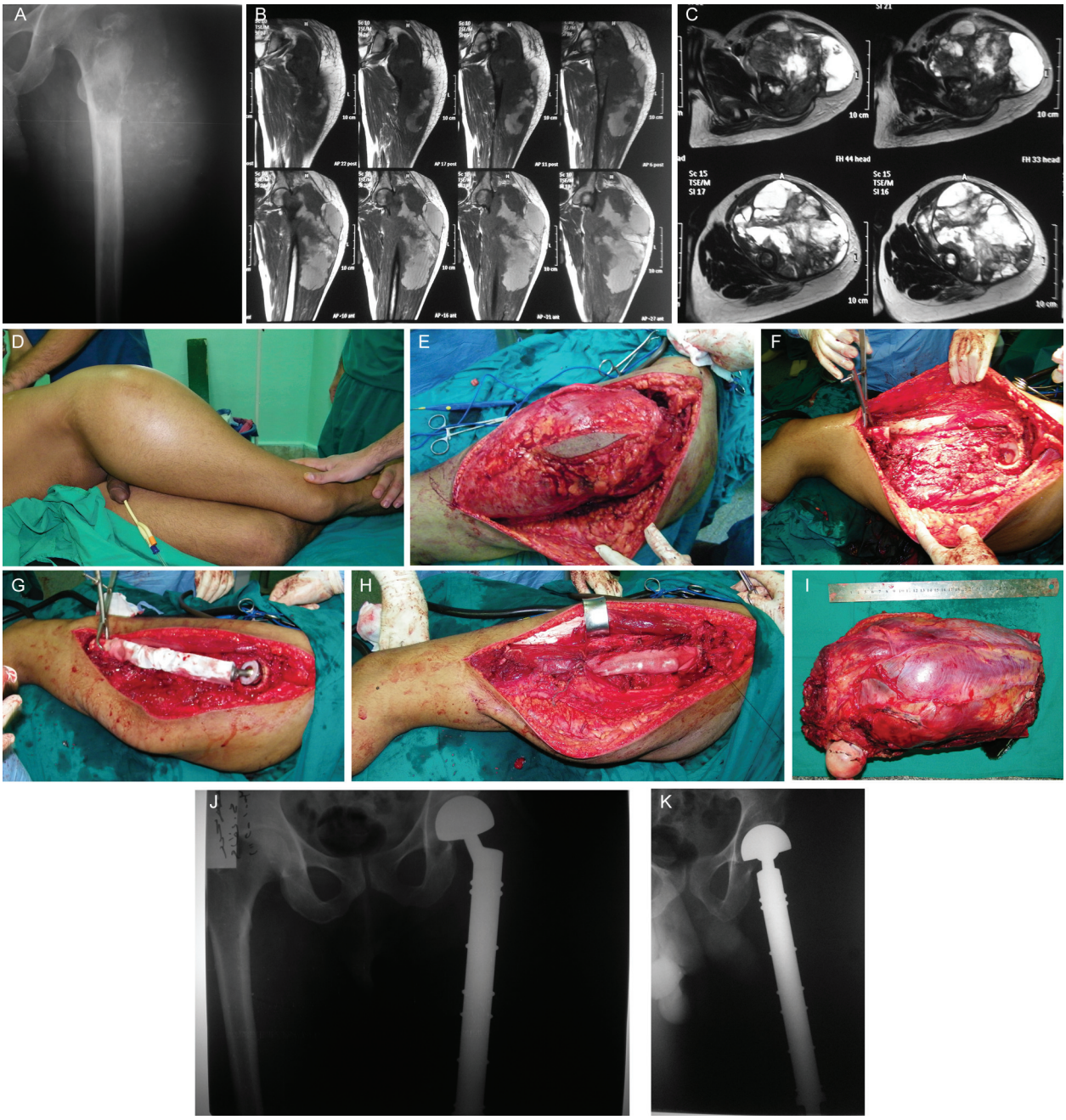


(a) Patient number 4, a 30-year-old male patient diagnosed as having secondary chondrosarcoma of the proximal right femur. (b) His computed tomography. (c) He was reconstructed with modular proximal femur bipolar tumor prosthesis. (d) Five years after surgery, the prosthesis was in good position, and the patient had excellent function. (e) Seven years after surgery, the patient developed erosion of the acetabulum with marked pain on walking. (f) Revision of the cup of the prosthesis with cementless hydroxyapatite-coated cup over bone allograft to compensate for the eroded acetabulum.

Discussion

A high-grade malignant sarcoma (stage IIB), with a proposed 30% incidence of skip lesions, has been the indication for this procedure [11]. Nowadays, as imaging by computed tomography and MRI has made it possible to clarify the anatomic location of the lesion, involvement of a large segment of the femur by a nearby malignant soft tissue tumor became another indication for total femur replacement. Moreover, total femur replacement is indicated in the presence of a metastatic lesion involving a large segment of the femur to provide those patients with a functional limb and remain pain free in their short-life expectancy. Hence, the indication for complete excision of the femur in the treatment of primary tumors is rare, but this radical procedure will usually be necessary when skip lesions are demonstrated or when there is a massive intramedullary extension of a diaphyseal sarcoma. Occasionally, total femur replacement will be required as a revision surgery after the failure of previous attempt at limb salvage surgery, in metabolic bone diseases, or for revision of failed arthroplasties [12]. Recently, Mankin *et al.* [10] described 15 patients with total femur replacement; their patients were a heterogeneous group not only in the pathology underlying removal of the whole femur, which included neoplastic and non-neoplastic conditions, but also in the type of reconstruction, which included 10 patients with allografts implanted with total hip replacement and total knee replacement implants, and five patients only had metallic implants. Our group patients although they are small in number with only 15 patients, they all have sarcoma and all

Figure 4



(a) Plain radiography of a 22-year-old male (patient number 10), showing extensive periosteal osteosarcoma of his left femur. (b, c) MRI (coronal and axial cuts showing the extent of the lesion). (d) Intraoperative picture showing how huge the lesion is. (e) Intraoperative picture showing lesion after its longitudinal and circumferential dissection. (f) Intraoperative picture showing the acetabulum and the thigh after removal of the lesion. (g, h) Intraoperative picture showing the prosthesis in place covered with Gortex nonabsorbable mesh to facilitate attachment of the muscles including hip abductors to the prosthesis. (j) The resected specimen of 30-cm length. (k, l) The postoperative radiography 1 year after surgery.

were treated by a single method of reconstruction using a metallic proxima femur prosthesis with bipolar femoral head. Although the difference between our group of patients and that of Mankin *et al.* [10] is evident, we share with them the difficulty of the technique and the complexity of the reconstruction.

Although our series is small, the functional results for the hip and knee were excellent or good. It is imperative to select those patients in which at least either the hip abductors or the knee extensors could be saved. This was also reported by Morris and colleagues. Lack of these muscles produced a poor functional result as the patients cannot control their limbs.

The advantages of the modular endoprosthesis used in this study are manifested by its ease to assemble during surgery, so the problems using custom-made prostheses

are avoided. The bipolar hip is easier to insert than a conventional acetabular socket; it is inherently more stable, and better than unipolar type of prosthesis regarding long-term wear. These findings are in line with those reported previously [11–16].

We have had no postoperative dislocation with this system. Only a single patient required conversion to total hip replacement 7 years after surgery owing to erosion of the acetabulum. Osteotomizing the greater trochanter and its reattachment with its abductors to the prosthesis is a good method for maintaining the hip abduction and to provide soft tissue stability to the reconstructed hip, provided that it will not compromise the surgical margin. However, if resection of the trochanter or the abductors is indicated, then reattachment of the remaining abductors to the prosthesis, especially if covered with Gortex nonabsorbable mesh (Fig. 4), in addition to the tensor fascia lata, is another alternative to maintain hip stability and to improve the gait. Previous reports have showed variable results and most show high complication rate, so this procedure should only be considered when the alternative is hip disarticulation and the patient should be informed of the potential risk of this massive reconstruction. Maintaining abductors of the hip and extensors of the knee is the mainstay for success of this procedure.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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