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What Are the Functional Results and Complications With Long Stem Hemiarthroplasty in Patients With Metastases to the Proximal Femur?

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Abstract

Background Traditional treatments for pathological fractures of the proximal femur resulting from metastatic bone disease include fixation with intramedullary nailing supplemented with polymethylmethacrylate, osteosynthesis with a plate-screw construct and polymethylmethacrylate, or endoprosthetic reconstruction. Despite the frequent practice of these treatments, treatment outcomes have not been rigorously compared. In addition, very few studies examine specific approaches to endoprosthetic reconstruction such as long stem hemiarthroplasty.

Questions/purposes This study examines survival, functional outcomes, and complications associated with long stem hemiarthroplasty in a small group of patients treated for impending and actual pathologic fractures of the proximal femur resulting from metastatic bone disease.

Methods Between 2012 and 2015, 21 patients were treated with long stem cemented hemiarthroplasty in 22 limbs. During that time, indications for this approach included lesions from metastases, myeloma, or lymphoma involving the proximal femur that resulted in an impending or actual pathological fracture. An impending fracture was classified as a painful lesion with at least 50% cortical erosion. During the study period, six patients with proximal femoral metastases not deemed to meet these indications were treated with other surgical approaches such as intramedullary nailing supplemented with polymethylmethacrylate and osteosynthesis with a plate-screw construct and polymethylmethacrylate. Mortality was tracked through medical records and phone calls to the patients and their families. Followup for the entire group of patients (n = 22) ranged from 1 to 27 months with a mean duration of 11 months. For patients with at least 1 year of followup (n = 11), the mean duration was 18 months (range, 12–27 months) and for patients with less than 1 year of followup (n = 11), the mean duration was 3 months (range, 1–11 months). Functional outcomes were evaluated according to the Musculoskeletal Tumor Society (MSTS) scoring system for lower extremities, the Eastern Cooperative Oncology Group (ECOG) Scale of Performance Status, and the Karnofsky Performance Scale (KPS) Index. Scores and complications were determined by direct patient examination, retrospective chart review, review of a longitudinally maintained institutional database, and followup phone calls.

Results Ten patients died of disease within the followup period. Before surgery, the median total MSTS score for the entire group of patients (n = 22) was 4.5 (range, 0–23),

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Each author certifies that his or her institution approved the human protocol for this investigation, all investigations were conducted in conformity with ethical principles of research, and informed consent for participation in the study was obtained.
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the median ECOG score was 3.5 (range, 1–4), and the median KPS score was 40 (range, 30–70). Postoperatively, the median total MSTS score (measured at most recent followup) for the entire group of patients was 21 (range, 5–30), the median ECOG score was 2 (range, 0–3, 68% $\leq$ 2), and the median KPS score was 60 (range, 40–100). For the 11 patients with at least 1 year of followup, the median total MSTS score (measured at most recent followup) was 27 (range, 21–30), the median ECOG score was 1 (range, 0–2, 100% $\leq$ 2), and the median KPS score was 80 (range, 60–100). For the remaining 11 patients with less than 1 year of followup, the median total MSTS score (measured at most recent followup) was 11 (range, 5–25), the median ECOG score was 3 (range, 1–3, 36% $\leq$ 2), and the median KPS score was 40 (range, 40–80). Complications included one periprosthetic fracture resulting from a fall, three cases of radiation-induced edema, and two cases of sciatica that developed unrelated to the procedure.

Conclusions Long stem cemented hemiarthroplasty results in fair levels of function in a complex population of patients whose prognosis is sometimes measured only in months and who otherwise might be disabled by their metastatic lesions. Comparative trials applying consistent indications and inclusion criteria should be performed between this approach and fixation with intramedullary nailing supplemented with polymethylmethacrylate as well as osteosynthesis with a plate-screw construct and polymethylmethacrylate.

Level of Evidence Level IV, therapeutic study.

Introduction

Pathologic fracture of the femur is an extremely debilitating complication of metastatic disease and multiple sources report that mortality quickly follows this diagnosis in many patients [1, 3, 28, 33, 34]. Of patients with advanced cancer, 50% develop bone metastases and one-third of all metastatic lesions occur in the proximal femur [8, 20, 32]. As many as 29% of these patients develop pathologic fractures and 65% of all pathologic fractures requiring surgery occur in the femur [8]. One-year survival rates after surgical treatment for metastatic lesions of the long bones or proximal femur range from 17% to 30% and 2-year survival rates are as low as 6% [28]. Treatment of pathologic fracture, therefore, is intended to restore function of the affected limb, relieve pain, improve quality of life, and facilitate custodial care as well as additional medical testing and treatment as quickly as possible. Substantial variation exists in approaching treatment for impending or actual pathologic fractures of the proximal femur [31]. Surgical interventions for pathologic fractures of the proximal femur resulting from metastatic bone disease traditionally include fixation with intramedullary nailing supplemented with polymethylmethacrylate bone cement, osteosynthesis with a plate-screw construct and polymethylmethacrylate, or endoprosthetic reconstruction [31]. Despite the frequent practice of these treatments, treatment outcomes have not been rigorously compared [31].

Endoprosthetic reconstruction has been shown to improve ambulatory status and decrease pain in patients with pathologic fractures of the proximal femur [1, 5, 6, 15, 18, 19, 23]. The procedure also enables the surgeon to remove all gross disease, minimize recurrence and hardware failure, and protect the rest of the femur against progressing disease [2]. Disadvantages of endoprosthetic reconstruction include hip dislocation, leg length discrepancy, blood loss during the procedure, and intraoperative hypotension. Very few studies examine specific approaches to endoprosthetic reconstruction such as long stem hemiarthroplasty.

The purpose of this study therefore was to examine survival, functional outcomes, and complications associated with long stem hemiarthroplasty in a small group of patients treated for impending or actual pathologic fractures of the proximal femur resulting from metastatic bone disease.

Patients and Methods

Between 2012 and 2015, 21 patients with metastatic lesions of the proximal femur were treated for actual or impending fractures in 22 limbs with long stem cemented hemiarthroplasty (Fig. 1). One patient underwent bilateral hemiarthroplasties 5 months apart. Indications for this approach included lesions from metastases, myeloma, or lymphoma involving the proximal femur that resulted in an impending or actual pathological fracture. An impending fracture was classified as a painful lesion with at least 50% cortical erosion. During the study period, six patients with proximal femoral metastases not deemed to meet these indications were treated with other surgical approaches such as intramedullary nailing supplemented with polymethylmethacrylate and osteosynthesis with a plate-screw construct and polymethylmethacrylate. Contraindications included massive destruction of the proximal femur and/or soft tissue components, extensive acetabular disease, extensive pulmonary disease, minimal ambulation, an isolated lesion with no history of cancer, high risk of infection, and potential noncompliance with postoperative protocols.

During this time period, there was one patient with extraosseous disease who was treated with an intramedullary rod because of issues with compliance and infection risk. No patients with metastatic disease during this time

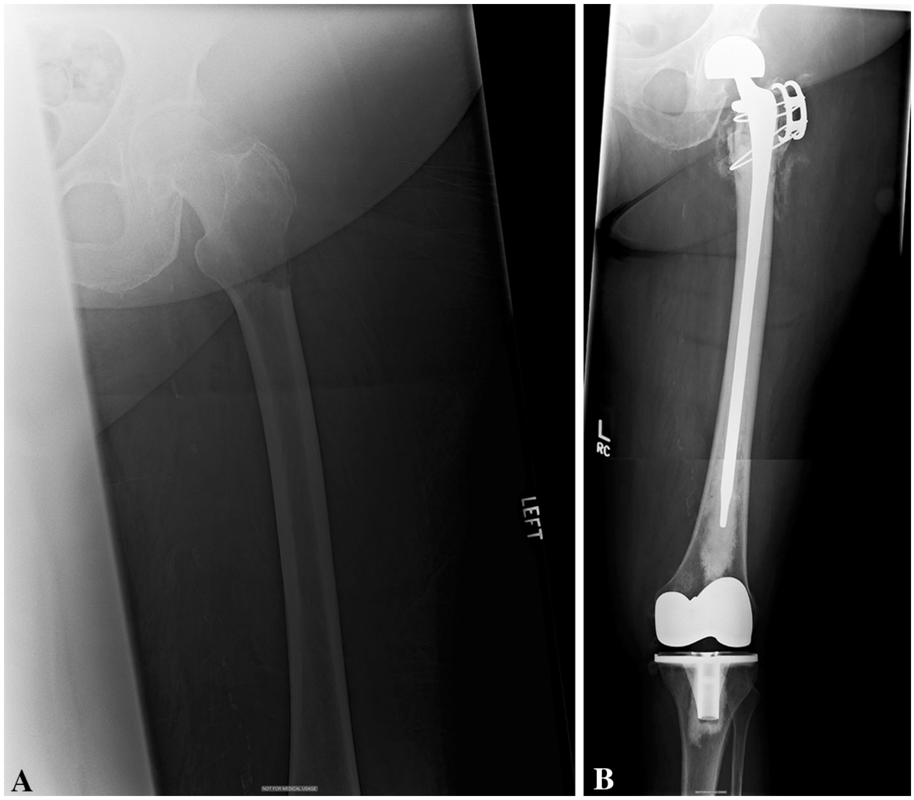

Fig. 1A–B A 72-year-old woman with metastatic breast adenocarcinoma was treated for a pathologic fracture with a long stem hemiarthroplasty. (**A**) Preoperative radiographs show an impending pathologic fracture of the left proximal femur. (**B**) Postoperative radiographs show fixation of the impending fracture with a long stem prosthesis in place. Cables were placed in this particular patient to stabilize the greater trochanter. A total knee prosthesis from prior surgery is also noted. Proximal and distal radiographs superimposed using photograph-editing software to appreciate the extent of the operation.

period were treated with proximal femoral resection and replacement.

Mortality was tracked through medical records and phone calls to the patients and their families. Followup for the entire group of patients (n = 22) ranged from 1 to 27 months with a mean duration of 11 months. For patients with at least 1 year of follow up (n = 11), the mean duration was 18 months (range, 12–27 months) and for patients with less than 1 year of followup (n = 11), the mean duration was 3 months (range, 1–11 months). The patients included 11 men aged 43 to 87 years and 10 women aged 38 to 85 years (Table 1). Patients presented with lesions of the subtrochanteric, intertrochanteric, greater trochanteric, lesser trochanteric, femoral neck, or head regions. Some patients had tumors that spanned more than one region. Patients with impending fractures (n = 6 limbs) had lytic or combined lytic and blastic painful lesions with at least some degree of cortical erosion or penetration. No patients had large areas of segmental bone loss. Patients with actual pathological fractures (n = 16 limbs) had minimal to mild displacement and angulation. The primary tumor etiologies included myeloma (n = 6), breast adenocarcinoma (n = 4), renal adenocarcinoma (n = 2), prostate adenocarcinoma (n = 2), lung adenocarcinoma (n = 2), adenocarcinoma from an unknown location (n = 2), endometrial adenocarcinoma (n = 1), colon adenocarcinoma (n = 1), urothelial adenocarcinoma (n = 1), and chronic lymphocytic leukemia (n = 1). Two patients underwent preoperative radiation therapy, five patients underwent postoperative radiation therapy, and one patient underwent both preoperative and postoperative radiation therapy.

After removal of all gross tumor, a long stem bipolar (n = 21) or unipolar (n = 1) prosthesis was inserted and cemented. The prostheses used in this study included straight femoral stems manufactured by Zimmer Inc (Warsaw, IN, USA; n = 16), bowed femoral stems manufactured by Stryker Corp (Kalamazoo, MI, USA; n = 3), bowed femoral stems manufactured by Biomet Inc. (Warsaw, IN; n = 2), and an S-shaped bowed femoral stem manufactured by LinkBio Corp (Rockaway, NJ, USA; n = 1) (Table 2). Femoral stem length ranged from 200 to 350 mm with a mean stem length of 270 mm and 64% of patients were treated with a 300- or 350-mm stem.

Table 1. Patient population summary

Limb	Diagnosis	Age (years)	Gender	Femur	Fracture	Fracture location	Tumor location
1*	Multiple myeloma	43	M	Left	Actual	Femoral head	Femoral head
2*	Multiple myeloma	43	M	Right	Impending	Femoral head and femoral neck	Femoral head and femoral neck
3	Multiple myeloma	67	M	Left	Actual	Femoral neck	Femoral neck
4	Adenocarcinoma (breast)	72	F	Left	Actual	Greater trochanter and subtrochanteric area	Femoral neck, greater trochanter, and subtrochanteric area
5	Adenocarcinoma (renal)	75	M	Right	Impending	Femoral neck and greater trochanter	Femoral neck and greater trochanter
6	Adenocarcinoma (prostate)	87	M	Right	Actual	Femoral neck	Femoral neck
7	Adenocarcinoma (breast)	38	F	Right	Actual	Femoral neck	Femoral neck, greater trochanter, intertrochanteric area, and subtrochanteric area
8	Adenocarcinoma (renal)	67	M	Right	Actual	Femoral head	Femoral head and acetabulum
9	Multiple myeloma	46	M	Left	Actual	Femoral neck	Femoral neck and intertrochanteric area
10	Adenocarcinoma (breast)	56	F	Left	Actual	Femoral neck	Greater trochanter and subtrochanteric area
11	Adenocarcinoma (unknown)	74	M	Right	Impending	Femoral neck and acetabulum	Acetabulum, femoral neck, greater trochanter, and subtrochanteric area
12	Adenocarcinoma (lung)	73	F	Left	Actual	Femoral neck	Femoral neck, intertrochanteric area, and subtrochanteric area
13	Adenocarcinoma (breast)	79	F	Right	Impending	Femoral neck	Femoral neck, intertrochanteric area, and subtrochanteric area
14	Adenocarcinoma (prostate)	54	M	Right	Actual	Lesser trochanter	Femoral neck, greater trochanter, lesser trochanter, intertrochanteric area, and subtrochanteric area
15	Adenocarcinoma (endometrial)	80	F	Left	Actual	Femoral neck	Femoral head, femoral neck, intertrochanteric area, and subtrochanteric area
16	Multiple myeloma	73	M	Left	Actual	Femoral neck	Femoral neck, greater trochanter, and subtrochanteric area
17	Adenocarcinoma (lung)	71	M	Left	Impending	Femoral neck and intertrochanteric area	Femoral head, femoral neck, greater trochanter, lesser trochanter, intertrochanteric area, and subtrochanteric area
18	Chronic lymphocytic leukemia	80	F	Right	Actual	Greater trochanter	Femoral neck, greater trochanter, and intertrochanteric area
19	Adenocarcinoma (colon)	84	M	Right	Actual	Femoral neck	Femoral neck, intertrochanteric area, subtrochanteric area, and femoral shaft
20	Multiple myeloma	71	F	Left	Actual	Femoral neck	Femoral neck, intertrochanteric area, and subtrochanteric area
21	Adenocarcinoma (urothelial)	59	M	Left	Impending	Femoral neck	Femoral neck
22	Adenocarcinoma (unknown)	85	F	Left	Actual	Lesser trochanter	Femoral neck, greater trochanter, lesser trochanter, subtrochanteric area, and femoral shaft

* Patient underwent bilateral hemiarthroplasties 5 months apart; M = male; F = female.

Table 2. Surgical summary

Limb	Operation time (minutes)	Preoperative hematocrit (%)	Patient blood loss (mL)	Blood transfusion (mL)	Prosthesis manufacturer	Stem length (mm)	Stem shape
1*	94	33.9	400	350	Zimmer Inc (Warsaw, IN, USA)	300	Straight
2*	93	41.4	250	None	Zimmer Inc	300	Straight
3	100	35.6	200	400	Zimmer Inc	250	Straight
4	142	28.8	250	300	Zimmer Inc	300	Straight
5	126	39.4	1000	1234	Stryker Corp (Kalamazoo, MI, USA)	300	Bowed
6	112	32.5	500	400	Stryker Corp	250	Bowed
7	113	30.7	300	640	Zimmer Inc	250	Straight
8	188	39.2	1000	1200	Zimmer Inc	300	Straight
9	100	38.3	300	300	Zimmer Inc	200	Straight
10	127	37.5	250	None	Biomet Inc (Warsaw, IN, USA)	250	Bowed
11	163	28.6	500	900	Zimmer Inc	250	Straight
12	93	28.8	500	680	Zimmer Inc	300	Straight
13	109	38.0	100	None	Stryker Corp	300	Bowed
14	107	43.0	100	128	Zimmer Inc	300	Straight
15	132	34.3	250	None	Zimmer Inc	250	Straight
16	130	34.8	300	395	Zimmer Inc	300	Straight
17	150	30.2	400	400	Zimmer Inc	300	Straight
18	116	32.5	200	400	Zimmer Inc	300	Straight
19	102	37.3	250	500	LinkBio Corp (Rockaway, NJ, USA)	300	S-shape bowed
20	112	25.6	350	400	Zimmer Inc	250	Straight
21	105	40.8	250	300	Biomet Inc	350	Bowed
22	130	35.8	250	None	Zimmer Inc	300	Straight

* Patient underwent bilateral hemiarthroplasties 5 months apart.

Surgical Technique

A posterolateral approach to the hip was performed. The hip external rotators were released from their insertion and were each sequentially tagged with a suture and retracted. The hip capsule was then opened in a T-shaped manner and each leaf tagged with a suture.

The hip was dislocated, and the femoral neck cut was performed from the piriformis fossa to approximately 2 cm proximal to the lesser trochanter using the appropriate guide. All gross tumor tissue in the proximal femur was removed with pituitary rongeurs, hand curettes, and gynecological curettes. All intramedullary contents of the proximal femur extending distal to the subtrochanteric region were removed and the endosteal surface of the canal was vigorously curetted to remove all gross disease. The canal was thoroughly cleansed with a pulsatile canal irrigator and brush. A ball-tipped guidewire was placed down the femoral canal to the most distal aspect of the femur, and the femur was reamed in 1-mm increments from 8 mm up to 2 mm greater than the diameter of the stem. In some instances, an extra 1 mm of reaming was necessary if there was difficulty with the trial insertion as a result of the length of the bow of the stem matching with the length of the femur. The proximal femur was subsequently broached, and the length of the canal was measured using the ball-tipped guidewire. The appropriate length stem was trialed to confirm fit and then removed.

The canal was again irrigated and brushed with sterile normal saline by pulsatile lavage. Three bags of polymethylmethacrylate were mixed and allowed to cure to a doughy consistency before being injected into the femoral canal in a retrograde manner and without pressurization. The final femoral component was placed in a slow and controlled manner and the cement was then allowed to fully cure. This cementing technique is thought to reduce the risk of cardiopulmonary collapse as a result of venous extravasation from the canal. A femoral head was trialed with stability achieved in all positions without dislocation. The trial femoral head was dislocated and removed and the final femoral head was malleted into position to engage the Morse taper. The hip was subsequently reduced and the capsule and external rotators reapproximated. The wound was closed, bandages applied, and a hip abduction pillow placed. No patients required an additional incision to remove the tumor and fix the prosthesis with cement.

Assessment of Outcomes

Patients were admitted to the hospital postoperatively for approximately 3 days and subsequently discharged to either rehabilitation or home. All patients were permitted to be weightbearing as tolerated on postoperative Day 1 and instructed to follow hip precautions for 6 weeks. Patients were followed up in the office at approximately 2 weeks, 6 weeks, and 3 months from surgery. Subsequently, patients were followed every 3 to 4 months during the time period of the study. Whole femur AP and lateral plain radiographs were obtained at each visit. Most patients were treated by medical oncologists at our institution and we therefore had access to their electronic medical oncology records. As earlier noted, mortality was tracked through medical records and phone calls to the patients and their families. Patient limb function was evaluated according to the Musculoskeletal Tumor Society (MSTS) scoring system for lower extremities, the Eastern Cooperative Oncology Group (ECOG) Scale of Performance Status, and the Karnofsky Performance Scale (KPS) Index. The MSTS scoring system for lower extremities covers six domains including pain, function, emotional acceptance, supports, walking, and gait [7]. Each domain is given a score of 0 to 5 with 5 representing normal function such that the maximum total MSTS score is 30 [7]. The ECOG score describes patients' functional status on a scale of 0 (fully active) to 5 (dead) based on the patients' ability to care for themselves, their daily activity, and their physical ability [21]. The KPS score describes patients' functional status on a scale of 0 (dead) to 100 (fully active) based on their ability to perform daily activities and how much assistance is required for them to do so [14]. MSTS scores, ECOG scores, KPS scores, and complications were determined by direct patient examination, retrospective chart review, review of a longitudinally maintained institutional database, and followup phone calls.

Results

A total of 10 of the 21 patients died of disease within the followup period; nine deaths occurred within 1 year of surgery and one death occurred 1 year after surgery (Table 3). The deaths occurred at a median of 2.5 months (range, 1–12 months). None of the deaths were related directly to the procedures itself.

Before surgery, the median total MSTS score for the entire group of patients was 4.5 (range, 0–23), the median ECOG score was 3.5 (range, 1–4), and the median KPS score was 40 (range, 30–70) (Table 4). Postoperatively, the median total MSTS score (measured at most recent followup) for the entire group of patients was 21 (range, 5–30), the median ECOG score was 2 (range, 0–3, 68% $\leq$ 2), and the median KPS score was 60 (range, 40–100). For the 11 patients with at least 1 year of followup, the median total MSTS score (measured at most recent followup) was 27 (range, 21–30), the median ECOG score was 1 (range, 0–2, 100% $\leq$ 2), and the median KPS score was 80 (range, 60–100). For the remaining 11 patients with less than 1 year of followup, the median total MSTS score (measured at most recent followup) was 11 (range, 5–25), the median ECOG score was 3 (range, 1–3, 36% $\leq$ 2), and the median KPS score was 40 (range, 40–80).

One major postoperative complication occurred when a patient fell 3 months after surgery and endured a segmental diaphyseal periprosthetic femur fracture requiring surgical fixation with Dall–Miles cables (Aspen Surgical, Caledonia, MI, USA) (Fig. 2). Minor complications including radiation-induced edema and myositis were reported but responded to therapy and did not require significant alteration of the treatment plan. In addition, two patients developed sciatica 10 and 18 months after surgery unrelated to the procedure (one patient was in a car accident). Both of these patients reported no pain before the onset of sciatica. There were no thromboembolic events, cement-associated oxygen desaturation events, cardiac arrests, hypotension, death, or any other intraoperative complications (Table 2). No postoperative cardiopulmonary or neurological complications were reported. There were no infections, hip dislocations, or instances of prosthetic loosening. There were no cases of hardware failure or local disease progression.

Discussion

Pathologic fracture of the proximal femur causes severe pain and loss of ambulatory function in patients with advanced cancer. In the setting of modern life-extending advances in adjuvant therapies, surgical intervention aims to provide stable fixation for pain relief, immediate weightbearing, and restoration of ambulatory function; fixation should outlast the patient's life expectancy and minimize the risk of complications [11, 13, 16, 33]. Endoprosthetic reconstruction is a surgical modality commonly used to reach these goals, but the outcomes of specific approaches such as stem length, cement use, and

Table 3. Results summary

Limb	Radiation	Length of followup (months)	Preoperative total MSTS	Preoperative ECOG	Preoperative KPS	Postoperative total MSTS	Postoperative ECOG	Postoperative KPS	Complications	Death (months postoperative)
1*	No	16	15	2	60	30	0	100	–	–
2*	No	11	17	2	60	25	1	80	Sciatica	–
3	No	13	1	4	30	21	2	60	Stroke	–
4	No	19	1	4	30	21	1	70	Sciatica	–
5	No	22	18	2	60	25	1	80	–	–
6	Preoperative	1[†]	1	4	30	8	3	40	Edema[‡]	1
7	Postoperative	14	1	4	30	26	1	80	–	–
8	Preoperative and Postoperative	19	17	2	60	27	1	80	Edema[‡]	–
9	No	10	8	3	50	12	2	50	–	–
10	Postoperative	27	1	4	30	30	0	100	–	–
11	No	14	19	2	60	30	0	100	–	–
12	No	4[†]	1	4	30	14	2	60	–	9
13	No	22	23	1	70	29	0	90	–	–
14	Postoperative	19	1	4	30	30	0	100	Myositis[‡]	–
15	Preoperative	2[†]	0	4	30	10	3	40	Edema[‡]	4
16	No	12[†]	0	4	30	21	2	60	Periprosthetic fracture	12
17	Postoperative	2[†]	14	2	60	5	3	40	–	5
18	No	1[†]	23	1	70	11	3	40	–	3
19	Postoperative	2[†]	0	4	30	11	3	40	–	2
20	No	1[†]	1	4	30	7	3	40	–	1
21	No	1[†]	20	2	60	11	3	40	–	1
22	No	1[†]	17	2	60	12	2	50	–	2

* Patient underwent bilateral hemiarthroplasties 5 months apart; [†]followup ended with patient death; [‡]radiation-induced; MSTS = Musculoskeletal Tumor Society; ECOG = Eastern Cooperative Oncology Group; KPS = Karnofsky Performance Scale.

Table 4. Performance status outcomes

Patient population	MSTS total	MSTS pain	MSTS function	MSTS emotional	MSTS supports	MSTS walking	MSTS gait	ECOG	KPS
All patients preoperative	4.5 (0–23)	0.5 (0–4)	0.5 (0–4)	1 (0–1)	0.5 (0–5)	1 (0–4)	1 (0–5)	3.5 (1–4)	40 (30–70)
All patients postoperative	21 (5–30)	5 (2–5)	3 (1–5)	5 (0–5)	2 (0–5)	3 (0–5)	3 (0–5)	2 (0–3)	60 (40–100)
< 1 year followup preoperative	8 (0–23)	1 (0–4)	1 (0–4)	1 (0–1)	1 (0–5)	2 (0–4)	2 (0–5)	3 (1–4)	50 (30–60)
< 1 year followup postoperative	11 (5–25)	4 (2–5)	1 (1–4)	5 (0–5)	0 (0–5)	0 (0–4)	0 (0–5)	3 (1–3)	40 (40–80)
> 1 year followup preoperative	1 (0–23)	0 (0–4)	0 (0–4)	1 (0–1)	0 (0–5)	0 (0–4)	0 (0–5)	4 (1–4)	30 (30–70)
> 1 year followup postoperative	27 (21–30)	5 (2–5)	4 (3–5)	5 (4–5)	5 (2–5)	4 (3–5)	5 (3–5)	1 (0–2)	80 (60–100)

Values expressed as median (range); MSTS = Musculoskeletal Tumor Society; ECOG = Eastern Cooperative Oncology Group; KPS = Karnofsky Performance Scale.

type of prosthesis continue to be controversial [15, 31, 35]. This study seeks to elucidate the survival, functional outcomes, and complications associated with long stem cemented hemiarthroplasty in a small group of patients treated for impending and actual pathologic fractures of the proximal femur resulting from metastatic bone disease. A total of 10 of the 21 patients died of disease during the followup period; none of the deaths were directly attributable to endoprosthetic reconstruction. The MSTS scores, ECOG scores, and KPS scores were fair, and most patients saw significant improvement in pain and functional mobility with few complications.

This study had a number of limitations. First, the small number of patients is not likely to adequately represent the population distribution; uncommon complications and outcomes are less likely to be detected by a study of this size. Accordingly, we found median measurements to be the most accurate representation of the data, but this will limit the comparison to studies reporting mean values. The small size, however, allowed for all patients to be treated by the same surgeon using the same technique, which was critical to the goal of the study. Second, the study has no control group, which limits the meaningful comparison of surgical outcomes. Although the standardized scores allow some degree of analysis in the context of prior research, future studies should aim to more directly compare the outcomes of long stem hemiarthroplasty with outcomes of other surgical approaches. Third, the study is limited by selection bias. A total of six of 27 patients were treated with alternative therapy during the study period. Metastatic disease has a complicated and variable presentation, and appropriate treatment must be customized for each patient. Exclusion criteria leading to this selection included massive destruction of the proximal femur and/or soft tissue components, extensive acetabular disease, extensive pulmonary disease, minimal ambulation, an isolated lesion with no history of cancer, high risk of infection, and potential noncompliance with postoperative protocols. Fourth, the performance status scoring systems used (MSTS, ECOG, KPS) provide valuable quantification of functionality but are also a source of assessment bias because they do not adequately address the overall health and quality of life of these patients. These are important and complex parameters to consider in addition to function, although given the number of deaths within 1 year of surgery, it should be noted that many patients are in a palliative stage of care. Finally, the study is limited by the short length of followup. Maximal benefit is unlikely to be achieved in patients who died within 3 months of surgery, which would skew our results toward overall lower functional outcomes. However, the outcomes in these patients are still clinically important given the poor prognosis and presentation of comorbidities with metastatic disease.

Fig. 2A–D A 73-year-old man with multiple myeloma was treated for a pathologic fracture with a long stem hemiarthroplasty. (**A**) Preoperative radiographs show a pathologic fracture of the left proximal femur. (**B**) Postoperative radiographs show fixation of the fracture with a long stem prosthesis in place. A total knee prosthesis from prior surgery is noted. Proximal and distal radiographs are superimposed using photograph-editing software to appreciate the extent of the operation. (**C**) A fall 3 months postoperatively resulted in a segmental periprosthetic diaphyseal fracture. (**D**) The patient was treated with surgical reduction and fixation with Dall–Miles cables.

This is a complex group of patients, and for many of them, a proximal femoral pathologic fracture is an end-of-life event. Not surprisingly then, nearly half of the patients in this series (10 of 21) died within 1 year of the hip reconstruction. This is comparable to the survivorship reported by Harvey et al. [10], in which overall patient survival at 1 year after undergoing endoprosthetic reconstruction or intramedullary nail fixation for proximal femur metastases was 51%. Hattori et al. [11] reported a 1-year survival rate of 69%, although this represents only eight patients who underwent endoprosthetic reconstruction. Sarahrudi et al. [28] reported a 1-year survival rate of 17% in a population in which 94 patients were treated with intramedullary nail fixation, 23 with endoprosthetic reconstruction, and 22 with open reduction and internal fixation. In this study, 76.7% of patients presented with

Table 5. Performance status outcomes from other studies

Study	Operative strategy	Performance status	Outcome
Harvey et al., 2012 [10]	Endoprosthetic reconstruction (proximal femur reconstruction) (n = 113)	Mean MSTS	21 (range, 12–27)
	Intramedullary nail (n = 46)		24 (range, 8–30)
Steensma et al., 2012 [30]	Endoprosthetic reconstruction (n = 197)	ECOG ≤ 2	61%
	• Long stem cemented hemiarthroplasty (n = 163)		
	• Proximal FEMUR RECONSTRUCTION (n = 33)		
	• Standard length hemiarthroplasty (n = 1)		
	Intramedullary nail (n = 82)		88%
	Open reduction and internal fixation (n = 19)		47%
Potter et al., 2009 [25]	Endoprosthetic reconstruction (proximal femur reconstruction) (n = 39)	Mean MSTS	20 (range, 13–27)
Selek et al., 2008 [29]	Endoprosthetic reconstruction (n = 45)	Mean MSTS	Pathological fracture at 2 months: 14.06
	• Proximal femur reconstruction (n = 35)		Impending fracture at 2 months: 16.64
	• Long stem cemented hemiarthroplasty (n = 5)		Surviving patients at 1 year: 19.8
	• Thompson prosthesis (n = 5)		

MSTS = Musculoskeletal Tumor Society; ECOG = Eastern Cooperative Oncology Group.

multiple metastases at the time of fracture. Selek et al. [29] reported a 1-year survivorship of 27% after endoprosthetic reconstruction. Our results are consistent with typical survival rates, but the apparent disparity in survivorship in recent research reaffirms the need for detailed reporting of patient preoperative status and a more rigorous examination of specific surgical techniques.

Most patients who present with proximal femoral bone metastases have severe pain with ambulation or are unable to walk. Long stem hemiarthroplasty in this series restored functional ambulation and relieved pain in most of the patients. These improvements are particularly evident in patients who reached at least 1 year of followup as shown by the increased MSTS subscores and total score (Table 4). Of the patients with less than 1 year of followup, nine died of disease. Six of these patients died within 3 months of surgery. The performance status scores for this group of patients are lower likely as a result of disease and comorbidities, short length of recovery time, or a combination of these factors. We believe the functional status of this group of patients is clinically important and that these results may be particularly useful in the palliative care of patients with limited predicted lifespans. Of note is the substantial improvement in the MSTS pain subscore in this group of patients despite lack of improvement in mobility. Although there was no comparator group in this series, we believe these outcomes compare favorably to those reported for other forms of fixation, namely intramedullary nailing, osteosynthesis, and alternative forms of endoprosthetic reconstruction. In peer-reviewed studies regarding outcomes for surgical treatment of metastatic bone disease of the proximal femur, the methods of functional status assessment are extremely inconsistent and often subjective, although some have used validated assessment tools (Table 5). It should be noted that the incorporation of these assessments is also inconsistent or not described, which limits the value of comparison. Furthermore, no study reports MSTS subscores, which, as stated previously, may be particularly relevant in the clinical decision-making for patients with short expected lifespans. These findings highlight the need for rigorous comparison trials for approaches to surgical fixation that apply consistent indications and inclusion criteria as well as a standardized assessment method.

Complications in this series were uncommon, although this must be considered major surgery by any definition, and these patients can be medically complex. Alternative treatments have been associated with dislocation, infection, nonunion, and disease progression, often requiring reoperation. Intraoperative complications such as hypotension, oxygen desaturation, embolization, and cardiac arrest have also been reported [2, 9, 12, 22, 24, 26–28]. Of note, Barwood et al. [4] reported acute oxygen desaturation and hypertension in 11 of 45 patients treated with intramedullary nail fixation for metastatic tumors of the femur with actual or impending fractures. Of these 11 patients, three died and two required intensive postoperative care. Complications arising from other surgical approaches to this problem are relatively common (Table 6). By comparison, our findings are relatively promising; we observed no

Table 6. Failure rates and complications from other studies

Study	Operative strategy	Failure rate	Complication
Harvey et al., 2012 [10]	Endoprosthetic reconstruction (n = 113)	0%	Dislocation (n = 10)
			Infection (n = 10)
	Intramedullary nail (n = 46)	11%	Nonunion (n = 4)
			Nonunion and nail breakage (n = 6)
			Infection (n = 1)
			Painful hardware (n = 1)
Steensma et al., 2012 [30]	Endoprosthetic reconstruction (n = 197)	3%	Dislocation (n = 5)
			Painful disease progression (n = 1)
	Intramedullary nail (n = 82)	6%	Nonunion/painful progression (n = 3)
			Nonunion/implant fracture (n = 1)
			Screw cutout (n = 1)
	Open reduction and internal fixation (n = 19)	42%	Nonunion (n = 2)
			Painful disease progression (n = 3)
			Screw cutout (n = 2)
			Implant fracture (n = 1)
Sarahrudi et al., 2009 [28]	Endoprosthetic reconstruction (n = 23)	8.6%	Periprosthetic fracture (n = 2)
	Intramedullary nail (n = 94)	3.2%	Nail breakage (n = 1)
			Screw loosening (n = 1)
			Periprosthetic fracture (n = 1)
	Open reduction and internal fixation (n = 22)	20%	Periprosthetic fracture (n = 2)
			Screw cutout (n = 2)
Potter et al., 2009 [25]	Endoprosthetic reconstruction (n = 61)	9.8%	Infection (n = 3)
			Dislocation (n = 4)
			Aseptic loosening (n = 2)
			Symptomatic wear (nv1)
Manoso et al., 2007 [17]	Endoprosthetic reconstruction (n = 13)	0%	None
Wedin and Bauer, 2005 [33]	Endoprosthetic reconstruction (n = 109)	8.3%	Pulmonary emboli (n =2)
			Cerebrovascular event (n =1)
			Dislocation (n = 15)
			Periprosthetic fracture (n = 4)
	Open reduction and internal fixation/intramedullary nail (n = 37)	16.2%	Nonunion (n = 3)
			Stress fracture (n = 1)
Barwood et al., 2000 [4]	Intramedullary nail (n = 45)	Not reported	Acute oxygen saturation and hypotension (n = 11)

hardware failures and a single periprosthetic fracture treated with cables as the only major complication. However, a much longer followup period and larger sample size is needed to detect less common complications and to develop a more complete safety profile for long stem cemented hemiarthroplasty.

Long stem cemented hemiarthroplasty appears to provide an adequate means for treating impending and actual pathologic fractures as a result of metastatic disease of the proximal femur in selected patients. Overall patient survival is comparable to that seen with other surgical approaches to metastatic bone disease. Patients with longer postoperative lifespans can be sufficiently palliated with substantial pain relief, return of mobility, and a higher degree of function provided there are no compounding variables related to their underlying disease negatively impacting recuperation. Even in patients with poorer prognosis, long stem cemented hemiarthroplasty may still be a useful means of pain control. Major complications were uncommon in this series, although a longer followup period is desirable to detect less common complications or potential hardware failure. Rigorous trials applying consistent indications and inclusion criteria are needed to directly compare long stem cemented hemiarthroplasty with other forms of endoprosthetic reconstruction as well as intramedullary nailing supplemented with polymethylmethacrylate and osteosynthesis with a plate-screw construct and polymethylmethacrylate.

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