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Is a Cephalomedullary Nail Durable Treatment for Patients With Metastatic Peritrochanteric Disease?

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Abstract

Background Although cephalomedullary nail fixation is often used for metastatic peritrochanteric lesions of the femur, there is concern regarding the durability of the implant in comparison to endoprosthetic reconstruction. Previous studies have reported the proportion of patients who undergo reoperation for loss of stability, but the adequacy of the construct has not been critically evaluated in a competing risk analysis that incorporates death of the patient in the calculation.

Questions/purposes (1) What is the cumulative incidence of reoperation of cephalomedullary nails with death as a competing risk for metastatic lesions of the proximal femur? (2) What is the survival of patients with metastases to the proximal femur after cephalomedullary nailing? (3) What clinical factors are associated with implant stability in these patients?

Methods Between 1990 and 2009, 11 surgeons at one center treated 217 patients with cephalomedullary nails for metastatic proximal femoral lesions. This represented 40% (217 of 544) of the patients undergoing surgery for metastases in this location during the study period. In general, we used cephalomedullary nails when there was normal bone in the femoral head, no fracture in the neck, and a moderate-sized lesion; we favored bipolar hemiarthroplasty for femoral neck fractures and disease affecting the femoral head; finally, we used proximal femoral endoprosthetic replacement for large lesions with severe bone destruction. A retrospective study was conducted of 199 patients with cephalomedullary nails for peritrochanteric metastases from 1990 to 2009. Pathologic fracture, defined as a breach in cortex with a clear fracture line either with or without displacement, was present in 61 patients. The most common primary cancers were breast (42 of 199 patients [21%]), lung (37 of 199 patients [18%]), and renal cell (34 of 199 patients [17%]). A competing risk analysis was performed to describe the cumulative incidence of implant revision. Patient overall survival was assessed by Kaplan-Meier survivorship. A univariate analysis was performed to determine whether there was an association between revision surgery and various patient factors, including tumor histology, pathologic fracture, cementation, and radiation.

Results Loss of implant stability necessitating revision surgery occurred in 19 of 199 patients (10%). In a

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competing risk analysis with death of the patient as the competing event, the cumulative incidence of revision surgery was 5% (95% confidence interval [CI], 3%-9%) at 12 months and 9% (95% CI, 5%-13%) at 5 years. Using Kaplan-Meier analysis, the overall patient survival was 31% (95% CI, 25%-37%) at 12 months and 5% (95% CI, 3%-9%) at 60 months. Patients with lung cancer had the shortest overall survival of 11% (95% CI, 1%-21%) at 12 months, and patients with multiple myeloma had the longest overall survival of 71% (95% CI, 49%-94%) at 12 months ($p < 0.001$). Duration of patient survival beyond the median 7 months was the only factor associated with a greater likelihood of revision surgery. Factors not associated with revision included tumor histology, pathologic fracture, closed versus open nailing, cementation, gender, age, and postoperative radiation.

Conclusions The competing risk analysis demonstrates a relatively low cumulative incidence of reoperation and suggests that cephalomedullary nailing is reasonable for patients with moderate-sized proximal femoral metastasis not affecting the femoral head. For the large majority of patients, the construct achieves the goal of stabilizing the femur for the duration of the patient's life. Longer patient survival was associated with greater risk of revision surgery, but no particular tumor histology was found to have a greater cumulative incidence of reoperation. Future work with a larger number of patients and stricter surgical indications may be needed to corroborate these findings.

Level of Evidence Level III, therapeutic study.

Introduction

Metastatic bone disease at the proximal femur may be treated in a variety of ways, including intramedullary nailing and endoprosthetic replacement [3, 20]. The choice requires careful consideration because both have their advantages and disadvantages. Although cephalomedullary nailing is attractive in terms of simplicity, cost, ease of insertion, and limited extent of dissection, there may be concern regarding its stability in the presence of progressive disease [22]. Studies comparing cephalomedullary nails with endoprosthetic replacement have suggested that the latter provides more durable fixation [9, 19]. Steensma et al. reported that the proportion of patients undergoing revision surgery for cephalomedullary nailing (6.1%) was double that of endoprostheses (3.1%) [19]. Because cephalomedullary nailing was originally designed for fractures of nonpathologic bone, it may not perform as well in metastatic disease, where the bone may not heal or have delayed healing after radiation. If the patients survive an extended period of time without bony union, there could be an increased risk of implant breakage. Although endoprosthetic replacement might have an advantage in durability, it is generally more expensive and entails a more extensive operation [1]. Furthermore, serious problems have been associated with long-stemmed cemented endoprosthetic implants, including oxygen desaturation, respiratory failure, hypotension, cardiac arrest, and intraoperative death [10, 14, 17, 24]. Finally, sacrificing the patient's native hip when it is not affected by disease may lead to problems of pain and dislocation [1, 7].

Some authors have recommended greater use of endoprostheses over cephalomedullary nails for peritrochanteric metastatic disease because of the lower fraction of patients needing to undergo reoperation [1, 9, 19]. However, these previous studies did not include a competing risk analysis. Because death of patients can prevent a construct from losing stability, it would be important to assess competing risk in calculating the cumulative incidence of revision surgery. Integral to the calculation would be an accurate assessment of patient overall survival after cephalomedullary nailing, which has been reported but not in the context of a competing risk analysis [15]. Finally, given the great variability in the prognosis of different malignant diseases with respect to overall patient survival, it would be useful to know whether the risk of reoperation varies according to the type of primary malignancy or other clinical factors.

We therefore asked: (1) What is the cumulative incidence of reoperation of cephalomedullary nails with death as a competing risk for metastatic lesions of the proximal femur? (2) What is the overall survival of patients with metastases to the proximal femur after cephalomedullary nailing? (3) What clinical factors are associated with implant stability in these patients?

Patients and Methods

We performed a retrospective study of patients at a single institution treated by 11 musculoskeletal oncologists from January 1990 to December 2009. During the study time period, we surgically treated 544 patients with metastatic neoplasms involving the proximal femur (Fig. 1). Of these patients, 217 (40%) underwent cephalomedullary nailing; 278 (51%) underwent long-stem hemiarthroplasty (including calcar-replacing femoral stems); 37 (7%) underwent segmental proximal femoral endoprosthetic replacement; and 12 (2%) underwent plate fixation. Although exact surgical indications are difficult to extract in a retrospective analysis, we generally used cephalomedullary nails when there was normal bone in the femoral head, no fracture in the neck or head, and a moderate-sized lesion that did not result in marked destruction of the proximal diaphysis. Patients who had metastatic disease extending into the femoral head preventing adequate fixation with screws were generally treated with alternative methods

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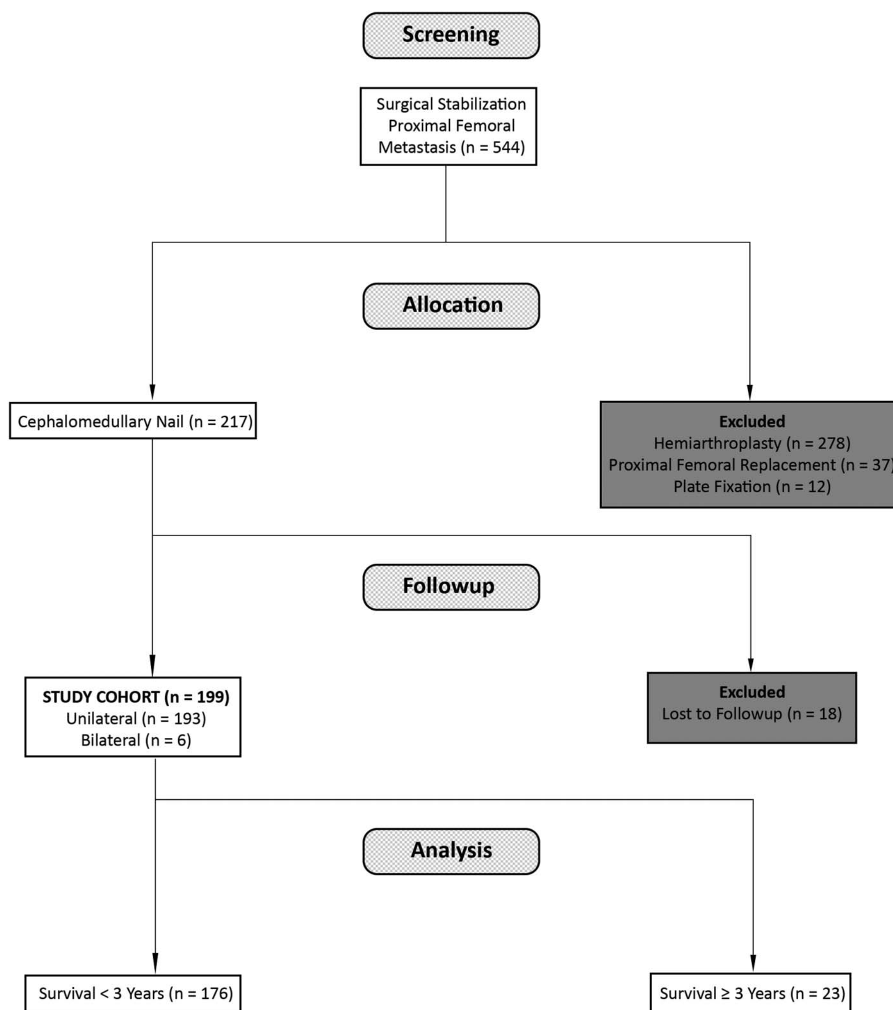

Fig. 1 Derivation of the study cohort from a query of the longitudinally maintained database in the Department of Orthopaedic Oncology began with a screen for patients with metastatic disease in the proximal femur who were treated with surgical stabilization.

(such as bipolar hemiarthroplasty or proximal femoral replacement). We performed bipolar hemiarthroplasty for femoral neck fractures; furthermore, we used proximal femoral segmental endoprosthetic replacement for large-sized lesions that resulted in severe destruction of bone throughout the proximal femur. Plate fixation was sparingly used and reserved for patients with severely compromised cardiopulmonary function who might not tolerate intramedullary reaming.

The present study includes 205 procedures in 199 patients who received a cephalomedullary nail for symptomatic bony metastasis in the peritrochanteric region (within 7 cm of the lesser trochanter of the femur). Six patients underwent placement of bilateral nails. The study was performed in accordance with the institutional review board after obtaining approval. Patients were followed for a minimum of 36 months unless they died of disease within that timeframe. Eighteen of 217 eligible patients (8%) were excluded because of inadequate followup. Of the 23 patients who had survival and followup beyond 36 months, all but one patient had followup within the last 5 years or within 5 years of death. This patient had followup of 11 years before being lost to followup and was included in the present series. Patients were identified from a longitudinally maintained surgical database in the Department of Orthopaedic Oncology. Clinical data, including demographic information and postoperative findings, were collected from electronic health records and imaging studies by two of the authors (DHC, PPL). The data included the type of primary tumor, extent of local and systemic disease, presence or absence of pathologic fracture (defined as a breach in the cortex with a clear fracture line through the metastatic lesion, either with or without bone displacement), use of cement, and radiation before or after

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surgery. The primary endpoint for this study is revision surgery secondary to loss of fixation, implant breakage, instability, and/or progression of disease.

There were 106 men and 93 women, ranging in age from 22 to 87 years (Table 1). The mean followup was 12 months (range, 1-242 months). Implants from four different manufacturers were used (Smith & Nephew, London, UK; Stryker, Kalamazoo, MI, USA; Zimmer, Warsaw, IN, USA; and Biomet, Warsaw, IN, USA). Proximal fixation was achieved with a blade, single screw, or two screws. Distal fixation was performed in all patients with at least one interlocking screw.

In addition to cephalomedullary nailing, 100 patients (51%) were treated by open nailing with curettage of the metastatic deposit and cement augmentation. The decision for open versus closed nailing was made in part at the attending surgeon's discretion. Although the exact reasons were difficult to ascertain retrospectively, the open procedures were generally favored for larger lesions, pathologic fractures, and certain histologies, including renal cell carcinoma and melanoma. Not all open nailings were for curettage and cementation because some patients had open nailing primarily for fracture reduction (Table 1). Eighty of 199 patients (40%) had postoperative external beam radiation to the femur after nailing. Twenty-eight patients (14%) presented with progression of disease in the proximal femur after prior radiation and before the nailing procedure. These patients did not receive reirradiation of the femur. The remaining patients did not have documented postoperative radiation for a variety of reasons, including early initiation or resumption of chemotherapy without radiation at the direction of the medical oncologist, unexpected decline of the patient with inability to have radiation, transfer to hospice care, and lack of compliance with recommended radiation treatment.

Statistical analysis was performed with the assistance of SPSS® version 23 (IBM Corp, Armonk, NY, USA). To calculate the incidence of implant revision in a competing risk analysis, the cumulative incidence function was utilized with death of the patient as the competing risk. This type of analysis was chosen because in Kaplan-Meier survivorship, patients who die without implant revision are counted as simple censoring events rather than as competing risks. The graph and table were produced by R version 3.4.3 (R Foundation for Statistical Computing, Vienna, Austria). The Gray test was used to assess differences in cumulative incidence of revision surgery among the histologic subtypes of tumors [8]. Patient overall survival was determined by Kaplan-Meier survival analysis. The log-rank test was used to determine whether there was a difference in survival curves. The distribution of patients among categorical variables was assessed by chi-

Table 1. Patient characteristics

Characteristic	Group	Value	Revision procedures	Total number
Number of patients			19	199*
Age (years)	Median	60		
	Range	22-87		
	≤ 60		9	105
	> 60		10	94
Gender	Male		8	106
	Female		11	93
Primary disease	Breast		5	42
	Lung		1	37
	Renal		6	34
	Myeloma		3	17
	Prostate		1	14
	Other		3	55
Pathologic fracture	Yes		4	61
	No		15	138
Type of nailing	Open		9	100
	Closed		10	99
Cementation	Yes		7	78
	No		12	121
Postoperative XRT	Yes		10	80
	No		9	119

*Six patients underwent bilateral cephalomedullary femoral nailing for proximal femoral metastatic disease; XRT = radiation.

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square and Fisher's exact test. The factors included histologic subtype of the primary tumor, curettage of tumor, and pathologic fracture at the time of presentation. Statistical significance was defined as $p < 0.05$.

Results

Loss of implant stability necessitating revision surgery occurred in 19 of 199 (10%) patients (Table 2). In a competing risk analysis with death of the patient as the competing event, the cumulative incidence of revision surgery was 5% (95% CI, 3%-8%) at 12 months and 9% (95% CI, 5%-14%) at 60 months (Fig. 2). Eighteen of 19 (95%) reoperations occurred at or before 24 months. There was one late revision surgery 89 months after nailing, which was the result of osteonecrosis, radiation osteitis, and implant breakage.

Using Kaplan-Meier analysis, the overall patient survival was 31% (95% CI, 25%-37%) at 12 months and 5% (95% CI, 3%-9%) at 60 months after nailing (Fig. 3). The median overall survival was 7 months (range, 0-242 months). Survival varied according to tumor histology. It was shortest for patients with lung cancer, who had overall survival of 11% (95% CI, 1%-21%) at 12 months and 0% at 5 years, and longest for patients with multiple myeloma, who had overall

Table 2. Patients requiring revision surgery

Patient number	Primary disease	Closed versus open	XRT	Reason for revision	Revision surgery	Time to revision (months)	Patient overall survival after revision (months)
1	Breast	Closed	No	Disease progression	Total femoral endoprosthesis	13	3
2	Breast	Closed	No	Fracture	Additional screws	4	3
3	Breast	Closed	Failed prior	Fracture	Bipolar hemiarthroplasty	3	10
4	Breast	Closed	Yes	Disease progression	Calcar replacing bipolar hemiarthroplasty	6	1
5	Breast	Open	No	Nonunion, hardware breakage (x 2)	Repeat nailing; proximal femoral endoprosthesis	5	3
6	Basal cell	Closed	Failed prior	Disease progression	Proximal femoral endoprosthesis	14	39
7	Leiomyosarcoma	Closed	Yes	Disease progression	Proximal femoral endoprosthesis	11	21
8	Lung	Open	Yes	Disease progression	Bipolar hemiarthroplasty	5	10
9	Plasmacytoma	Open	Yes	Fracture	Repeat nailing	23	45
10	Multiple myeloma	Closed	No	Screw backed out, pain	Screw removal	24	218
11	Multiple myeloma	Closed	No	Osteonecrosis, hardware breakage	Proximal femoral endoprosthesis	89	27
12	Prostate	Closed	Yes	Disease progression	Proximal femoral endoprosthesis	3	8
13	Renal	Open	No	Nonunion, pain	Bone grafting	7	48
14	Renal	Open	Yes	Disease progression	THA	7	6
15	Renal	Open	Yes	Disease progression	Proximal femoral endoprosthesis	6	5
16	Renal	Open	Yes	Disease progression	Curettage, cementation, and screws	15	36
17	Renal	Closed	Yes	Disease progression	Curettage and distal screws	10	10
18	Renal	Closed	Yes	Disease progression	Proximal femoral endoprosthesis	18	2
19	Unknown	Open	Yes	Fracture and hardware breakage	Proximal femoral endoprosthesis	15	12

XRT = radiation.

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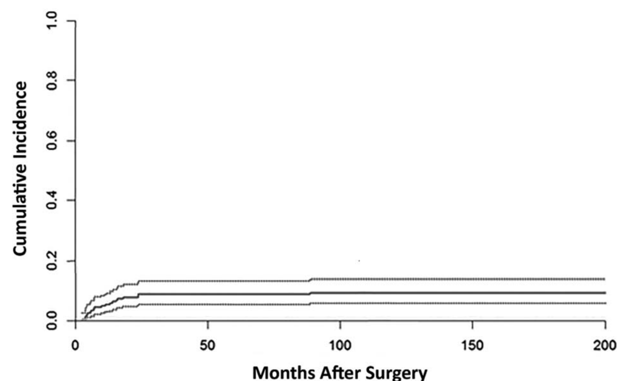

Fig. 2 The cumulative incidence of revision surgery with death of the patient as a competing risk was calculated for the entire cohort of 199 patients from the time of cephalomedullary nailing with 95% CI shown as the upper and lower lines. The cumulative incidence was 3% (95% CI, 2%-7%) at 6 months, 5% (95% CI, 3%-9%) at 12 months, and 9% (95% CI, 5%-13%) at 5 years.

survival of 71% (95% CI, 49%-94%) at 12 months and 29% (95% CI, 8%-50%) at 5 years ($p < 0.001$).

We found that longer duration of overall survival was the one factor associated with a higher risk of revision surgery. Using the median overall survival of 7 months as the cutoff, patients who survived longer than the median were more likely to have revision surgery ($p < 0.001$; Table 3). Because overall survival of patients differed according to the primary disease, we asked whether the cumulative incidence of revision surgery was dependent on tumor histology for the five most common tumors in a competing risk analysis (Table 4). With the numbers of patients we had, there was no observed difference in incidence of revision procedures by disease type. The cumulative incidence at 12 months varied from 0% to 11% for the five major diseases ($p = 0.39$). We did not find an association between revision surgery and the other patient characteristics that we examined, including age, gender, pathologic fracture, open versus closed nailing, cementation, and postoperative radiation. We noted that the presence of a pathologic fracture did not preclude healing of the fracture and long-term stability (Fig. 4). There were no revision operations resulting from infection of the nail. Although we have insufficient numbers of patients for a statistical analysis, it is apparent (from review of Table 2) that progression of disease was frequently associated with revision procedures (Fig. 5). This was observed in 11 of 19 (58%) patients. Of these 11 patients with progression, nine had received postoperative radiation; one had prior radiation before cephalomedullary nailing; and one did not receive any radiation (Table 2). Thirteen of 19 (68%) of patients had revision to an endoprosthesis for loss of implant stability, including three cemented bipolar hemiarthroplasties, eight proximal femoral replacements, one THA, and one total femoral replacement.

Table 3. Chi-square analysis of duration of patient overall survival and revision surgery

		Duration of overall survival (months)		
Characteristic	**Group**	**≤ 7**	**< 7**	**Total**
Revision surgery	Yes	2	17	19
	No	100	80	180
Total		102	87	199

$p < 0.001$.

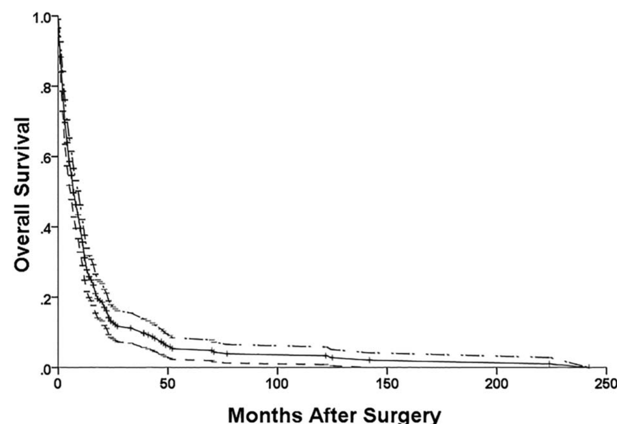

Fig. 3 Kaplan-Meier analysis of overall patient survival is depicted with 95% CIs for the entire cohort of 199 patients. Overall survival was 31% (95% CI, 25%-37%) at 12 months and 5% (95% CI, 3%-8%) at 60 months after nailing.

Discussion

Although cephalomedullary nailing is often used for metastatic proximal femoral disease, there is concern regarding its durability in comparison to endoprosthetic reconstruction. Previous studies have not emphasized the potential role that death of the patient may play in the calculated incidence of revision surgery and the perceived adequacy of the construct. Central to this analysis is an accurate measurement of patient overall survival after surgery, which has not been extensively studied. In a competing risk analysis, we found that the cumulative incidence of revision surgery at 5 years was 9%, whereas overall patient survival at 5 years was 5%. This demonstrated that for the majority of patients, the construct was intact for their remaining lifetime. Patients with longer overall survival (beyond the median of 7 months) had a greater likelihood of revision surgery, but the incidence of revision surgery was not associated with tumor histology.

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Table 4. Comparison of cumulative incidence of revision surgery among major tumor histologies p = 0.39; CI = confidence interval; N/A = not applicable

				Cumulative incidence (%)								
				6-month			12-month			5-year		
Tumor type	Number of patients	Reoperations	Deaths without reoperations	Value	95% CI		Value	95% CI		Value	95% CI	
Breast	42	5	38	9.1	2.8	19.9	9.1	2.8	19.9	11.4	4.1	22.8
Lung	37	1	36	2.7	0.2	12.5	2.7	0.2	12.5	N/A	N/A	N/A
Renal	34	6	30	2.8	0.2	12.7	11.1	3.4	24.1	N/A	N/A	N/A
Myeloma	17	3	13	0	N/A	N/A	0	N/A	N/A	11.8	1.7	32.4
Prostate	14	1	13	7.1	0.4	28.8	7.1	0.4	28.8	7.1	0.4	28.8
Other	55	3	54	0	N/A	N/A	1.8	0.1	8.6	N/A	N/A	N/A

One of the chief limitations of our study was selection bias, which may have been present in several forms, including choice of operative versus nonoperative treatment, type of internal fixation, cementation, closed versus open nailing, excision versus nonexcision of tumor, and overall surgical indications. Cephalomedullary nailing was generally used at our center for moderate-sized peritrochanteric disease that did not compromise fixation in the femoral head or result in marked destruction of the proximal femur. Because there could be a great deal of variation in how this broad guideline might be applied, it is possible that we may have selected more favorable patients for nailing. Other centers might find higher or lower values for the cumulative incidence of revision surgery, depending on what their criteria are for nonoperative treatment as well as endoprosthetic reconstruction. During the timeframe of the study, cephalomedullary nailing comprised less than half of the procedures for proximal femoral metastases at our center (40%), and there was a greater utilization of endoprostheses. Similarly, in another large study, the proportion of patients treated by nailing was 82 of 298 patients (28%), which was also less than half of the patients [19]. Because

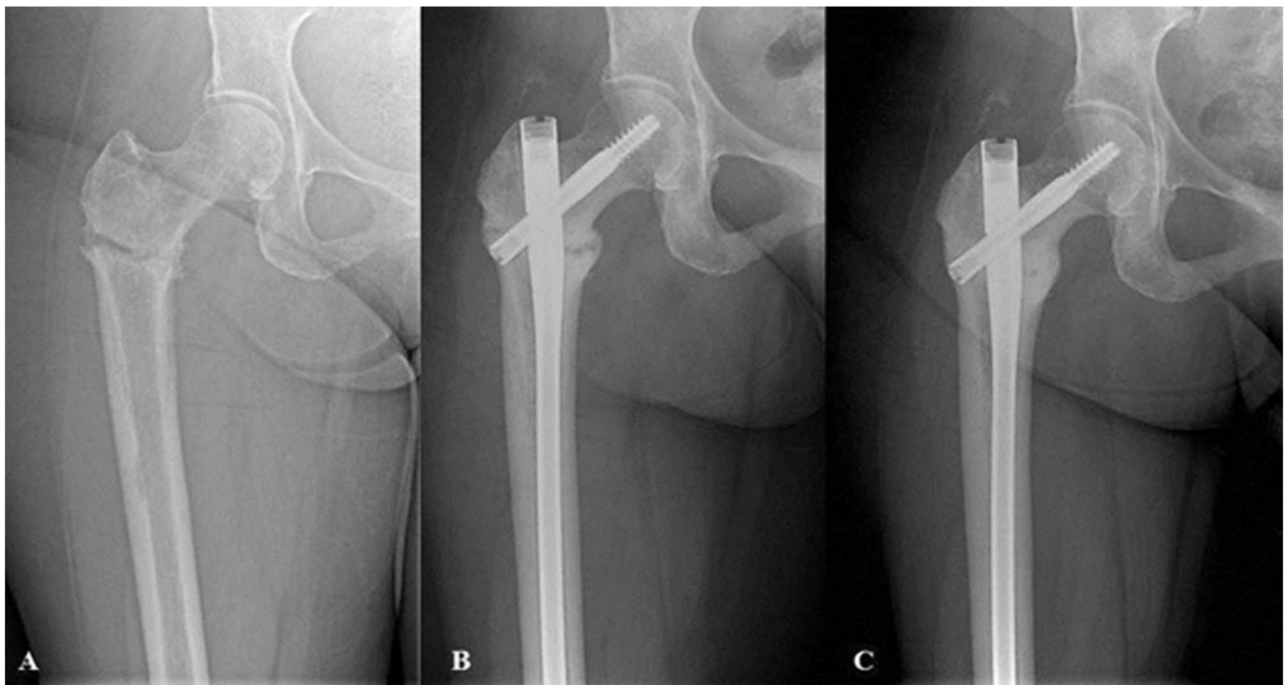

Fig. 4 A-C A 59-year-old woman with metastatic breast carcinoma presented with a subtrochanteric femur fracture. (**A**) Preoperative radiograph shows minimal displacement and a characteristic transverse fracture pattern. (**B**) Early postoperative radiograph demonstrates callus formation and reduction of the fracture. (**C**) The fracture is healed without recurrence of disease 36 months after surgery.

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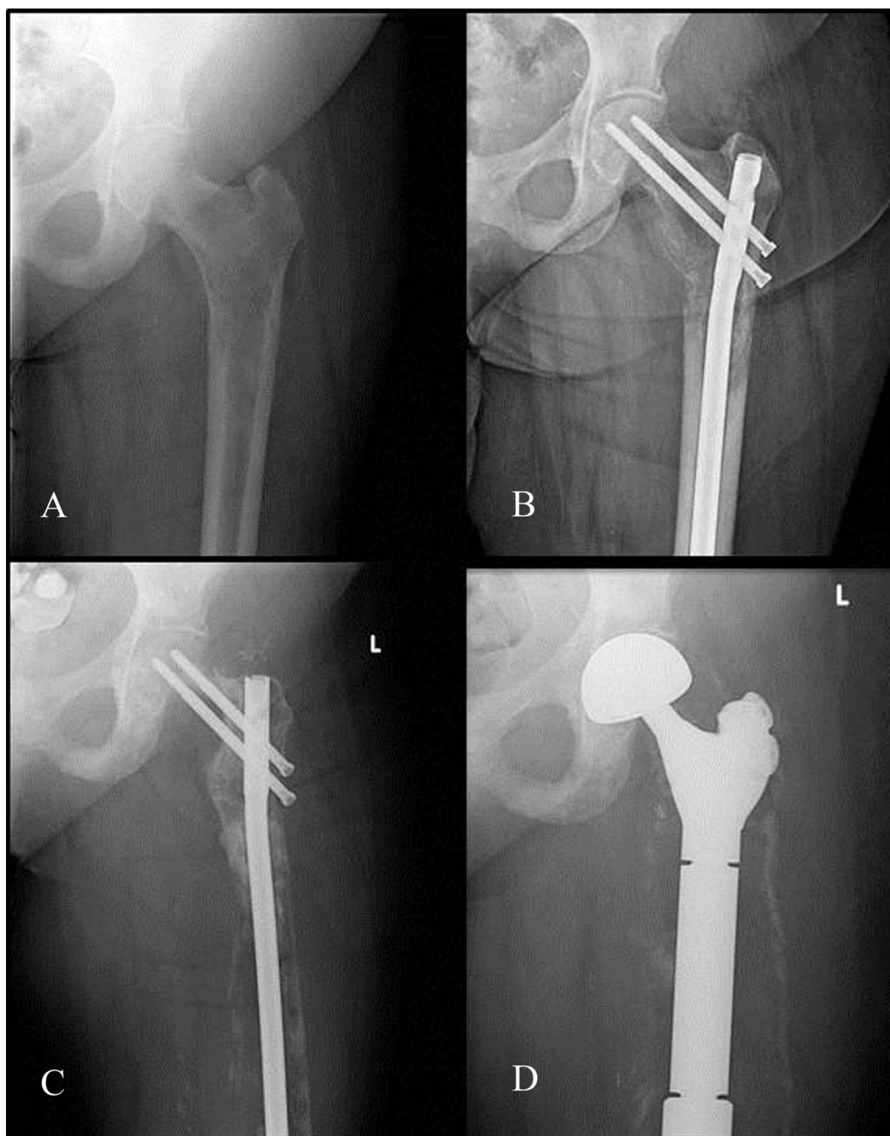

Fig. 5 A-D A 62-year-old woman with metastatic ductal carcinoma of the breast presented with an impending pathologic fracture of the left proximal femur 11 years after modified radical mastectomy and chemotherapy. (**A**) Preoperative radiograph shows a moth-eaten appearance of the bone. (**B**) Six months after nailing, the bone is still intact. (**C**) Thirteen months after surgery, there is progression of disease and marked loss of bone. (**D**) Revision of the implant to a total femoral prosthesis was performed.

there was no resection or endoprosthetic cohort in this study, we cannot make a meaningful comparison to this type of surgical treatment. Further work seems necessary to determine whether increasing the use of cephalomedullary nailing over endoprostheses would increase the cumulative incidence of revision surgery, and more work is needed to define better the indications for the procedure.

Selection bias could also have been present in the application of curettage and cementation. We did not find an association between these factors and the need for revision surgery, but patients were not randomly selected for curettage and cementation. Patients who had what was perceived at the time to be more aggressive histologies, including renal cell [12] and melanoma [11], were more likely to undergo curettage and cementation, whereas patients with diseases that were considered more likely to respond to medical treatment, including breast, prostate, and myeloma, were less likely to undergo curettage and cementation. Given the lack of equivalent groups for comparison, we are not able to conclude from the data

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whether open nailing with curettage and cementation had a beneficial effect for some patients.

Other limitations of the study include transfer bias, which is a challenge in the study of patients with skeletal metastases. We had to exclude 18 patients (9%) for lack of followup, and one long-term survivor was not seen in the clinic for the past 5 years. There is the possibility that we did not identify some of the patients who experienced loss of fixation of the construct. Inadequate followup would make the results of the study seem better than they really are.

Another limitation is the study period, which encompassed a 20-year span. It is possible that improvements in medical, radiation, and surgical treatment during this time period may have affected the overall survival of patients as well as the likelihood of local disease progression. National cancer statistics have shown a gradual decrease in cancer death rates over the past few decades [6]. During this timeframe, there have been important developments in specific treatments for the primary types of malignancies that metastasize to bone, including breast, prostate, renal cell, and lung cancer [6]. Furthermore, there has been increasing use of bisphosphonates and other inhibitors of RANK ligand, including denosumab, for osseous metastases [5]. We did not attempt to assess the impact of specific medical treatments on the control of metastatic disease. Our study period ended in 2009, which is a weakness of the study. The reasons for this were because the initial data collection was started in 2012, but the completion of data acquisition as well as the synthesis and analysis of the data took longer than anticipated. A potential problem with this is that the results of the study may represent more of a historic perspective on how peritrochanteric disease was treated in the past than how it may be treated now. The relatively high proportion of patients undergoing open nailing may be an indirect indication that the surgical approach in the past relied more heavily on physical methods of tumor removal than current practice. A final limitation is the number of patients. Although the present study was one of the largest series of patients undergoing cephalomedullary nailing for peritrochanteric disease, the number of patients may still be too small to perform a meaningful multivariate analysis and to detect an association between various factors and revision surgery.

We found that the cumulative incidence of revision surgery was 5% at 12 months and 9% at 5 years, when death was incorporated as a competing risk. Previous studies reported a similar proportion of patients undergoing revision surgery, ranging from 6% to 16% [9, 19, 21, 23], but these studies did not attempt to use a competing risk analysis to modify the estimate of patients needing revision surgery over time. In general, the cumulative incidence is overestimated in noncompeting risk analyses [4] and may not be appropriate when there is a high proportion of patients experiencing the competing risk (patient death). The consequences are not trivial. Overestimate of the risk could lead surgeons to pursue other more costly and elaborate treatments that might not be necessary.

Overall patient survival after cephalomedullary nailing for metastatic disease declined precipitously after surgery. It was 31% at 12 months and 5% at 5 years. Although these figures were similar to previously reported data, the prior study did not incorporate the data into a competing risk analysis to gauge the stability of the construct [15]. It is likely that some patients died before the constructs became unstable. This does not necessarily imply that the procedure is a poor choice for these patients. On the contrary, percutaneous closed nailing may be an appropriate procedure for debilitated patients with advanced disease and short expected survival. For the group of patients with lung carcinoma, which was the second most common primary disease in our series, we observed only one revision procedure in this group, possibly related to short survival of these patients.

Of the various factors that we studied, only duration of patient survival beyond 7 months (median survival) was associated with a greater likelihood of revision surgery. However, despite varying overall survival among different tumor types, there was no observable difference in cumulative incidence of reoperation for different tumors. In contrast, one previous study suggested that breast cancer might have a lower risk of revision surgery and reported no loss of fixation in 18 patients [18]. The discrepancy in results may be attributable in part to the greater number of patients in our study, which included 42 patients with breast cancer, but selection bias could also play a role, as discussed previously. It may be interesting to note that multiple myeloma, which had a substantial proportion of patients with relatively long survival beyond 3 years, did not have a higher incidence of reoperation in our study. This observation raises the possibility that improvement in medical treatment that prolongs overall survival of patients might also result in better control of bone disease. It will be interesting to see in the future whether this will be true for certain diseases such as renal cell carcinoma that have traditionally been regarded as having aggressive behavior in bone and for which high rates of local progression after intralesional treatment of osseous metastases have been reported in the past [7, 13]. Surprisingly, the proportion of revision operations in patients who had pathologic fractures was not higher than those without fractures. Although some authors have advocated cephalomedullary nailing for pathologic subtrochanteric fractures [16], our data differ from the results of other authors, who found a higher risk of loss of fixation for patients with pathologic fractures as opposed to intact bone with impending fracture [2, 9]. The reason for the discrepancy is not altogether clear but may again be attributable in part to patient selection, as alluded

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to previously. In our study, there might have been a greater proportion of patients with relatively favorable histologies such as myeloma that might have had a better chance of fracture healing. Our results suggest that the presence of a pathologic fracture by itself is not a strict contraindication to nailing. The fracture may heal for some patients or the nail may remain sufficiently stable for the patient's life despite nonunion.

In conclusion, cephalomedullary nailing seems to be a reasonable choice for patients with moderate-sized proximal femoral metastases not affecting the femoral head. We believe that moving to resection and endoprosthetic replacement for all patients with proximal femoral metastatic disease may not be appropriate. In a competing risk analysis, the cumulative incidence of reoperation compares favorably to patient overall survival. For the majority of patients, the construct achieved the goal of stabilizing the femur for the duration of the patient's life. Overall survival was longest for multiple myeloma and shortest for lung cancer. Longer patient survival was associated with greater risk of revision surgery, underscoring the importance of time for the integrity of the construct, but no particular tumor histology was found to have a greater cumulative incidence of reoperation. Pathologic fracture, curettage, cementation, and radiation showed no association with revision surgery in this study. However, greater numbers of patients may be needed to corroborate these observations, and stricter surgical indications might also affect the results of the analysis.

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