Surgery for pathological proximal femoral fractures, excluding femoral head and neck fractures

Resection vs. stabilisation

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Received: 6 July 2010 / Revised: 2 November 2010 / Accepted: 2 November 2010 / Published online: 1 December 2010
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Abstract Pathological femoral head and neck fractures are commonly treated by arthroplasty. Treatment options for the trochanteric region or below are not clearly defined. The purpose of this retrospective, comparative, double-centre study was to analyse survival and influences on outcome according to the surgical technique used to treat pathological proximal femoral fractures, excluding fractures of the femoral head and neck. Fifty-nine patients with 64 fractures were operated up on between 1998 and 2004 in two tertiary referral centres and divided into two groups. One group (S, $n=33$) consisted of patients who underwent intramedullary nailing alone, and the other group (R, $n=31$) consisted of patients treated by metastatic tissue resection and reconstruction by means of different implants. Median survival was 12.6 months with no difference between groups. Surgical complications were higher in the R group ($n=7$) vs. the S group ($n=3$), with no statistically significant difference.

Patients with surgery-related complications had a higher survival rate ($p=0.049$), as did patients with mechanical implant failure ($p=0.01$). Survival scoring systems did not correlate with actual survival. Resection of metastases in patients with pathological fractures of the proximal femur, excluding femoral head and neck fractures, has no influence on survival. Patients with long postoperative survival prognosis are at risk of implant-related complications.

Introduction

Up to 70% of patients suffering from malignant tumours develop bone metastases. The proximal femur is the most frequent site affected in the appendicular skeleton. Malignancies originating from the breast, prostate, lung, kidney and colon produce the highest rate of bone metastases [1]. Therapy must be tailored individually according to the estimated life expectancy of each patient [2]. The goals are to reduce pain and restore function for the expected life span. Except for femoral head and neck fractures, which are best treated by hemiarthroplasty, surgical treatment of pathological fractures of the proximal femur varies substantially [3–5]. Intramedullary devices are reported to be the best treatment option [6, 7]; however, intralesional, marginal or wide resections followed by nail, plate and double-plate fixation together with poly (methylmethacrylate) (PMMA) or modular endoprosthetic replacement are also favoured [4, 5]. There is poor evidence as to whether patients benefit more from metastasis resection followed by reconstruction or from minimally invasive intramedullary stabilisation [8]. The aim of this comparative retrospective study was to investigate the influence of surgical treatment of pathological femoral fractures on overall survival, functional outcome and complications.

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Patients and methods

We performed a retrospective comparative study of patients with intertrochanteric, subtrochanteric and mid-diaphyseal pathological fractures operated up on between November 1998 and March 2004 in two different institutions. All patients underwent surgical procedures pertaining to metastatic bone disease of the femur. Fifty-nine patients with 64 fractures were included in the study. Patients with femoral head and neck fractures were excluded. Preoperative evaluation included oncological staging in order to acquire information on the primary lesion and the presence of visceral or multiple bone metastases. Preoperative blood samples and chest X-ray were carried out prior to surgery. If information was older than three months or completely lacking, at least a computed tomography (CT) scan of the thorax and abdomen was performed. Primary lesions were identified in all patients before surgery. Inclusion criteria were pathological fracture in the aforementioned region due to histologically proven metastases, resection of metastatic tissue and stabilisation or stabilisation alone. Exclusion criteria were primary bone tumour, impending fracture and multiple myeloma. Twenty-nine patients in centre A (orthopaedic clinic) and 30 in centre B (trauma centre) met the inclusion criteria. Six patients underwent bilateral surgery, of which one patient was operated up on for an impending fracture on one side. Thus, 64 femoral fractures were analysed. Patients (fractures) were divided into two groups. One group consisted of patients who underwent stabilisation without removal of metastatic tissue (group S), and the other consisted of patients who underwent removal of metastatic tissue by intralesional ($n=20$), marginal ($n=5$) or wide ($n=6$) resection (group R) according to Enneking and co-workers [9] and stabilisation together with PMMA in a bonding technique or implantation of a tumour-arthroplasty. In both centres, the indication for resection and implantation of a tumour arthroplasty was seen if significant osteolysis or bone destruction was present cephalad to the trochanteric region. Furthermore, a solitary lesion combined with high estimated survival led to the indication for complete resection in centre A. Information was collected from clinical records, registration office and by personal contact (telephone) with patients, relatives and/or family doctors. In addition to demographic and primary tumour data, we focused on surgical techniques, postoperative mobility, implant failure, complications and revision surgery. Patients were categorised as referred if they were transferred via an external surgical department where surgical treatment of femoral fractures is routinely performed. In addition to a previously published functional score (excellent/good, fair, poor) [10], we created a score that focuses on mobility and walking aids (see Table 1). The

Eastern Cooperative Oncology Group (ECOG) and the Karnofsky performance status (0–5) [11] were at least three, with no correlation to overall performance status; thus, they could not be applied in this retrospective analysis. The fractures were categorised according to the Arbeitsgemeinschaft für Osteosynthesefragen [Association for the Study of Internal Fixation (AO)] Classification of Fractures as intertrochanteric, subtrochanteric, mid-diaphyseal and combined if the fracture was located inter- or subtrochanteric. No open fractures or direct extensions of metastatic tissue through the skin were seen. All patients were able to walk before the fracture occurred. Survival scores had been provided for all patients using a scoring system (0–5 points directly proportional to survival) according to Bauer et al. [2]. An alternative scoring system that was retrospectively applied did not show higher accuracy [12]. Major operative complications, such as local infections, periprosthetic fractures or substantial loss of function (e.g. after luxation), were defined as incidences needing revision surgery. Additional treatment regimes such as postoperative radiation therapy or preoperative embolisation were recorded. All analysed parameters are listed in Table 2.

Statistical evaluation

Patient characteristics are given as mean or median and interquartile range, as appropriate, and frequencies, respectively. Chi-square tests were used to detect differences in baseline characteristics. Survival curves were estimated by the Kaplan–Meier method. To assess differences in survival between groups, log-rank tests were performed. All p values reported are two-sided and are considered as statistically significant <0.05 . Statistical analysis was performed using SPSS 16.0.

Results

At the time of final data accrual, two (3.1%) patients were alive, two (3.1%) were lost to follow-up (one from each group) and 55 (85.9%) patients were deceased—all of whom died of tumour disease. Mean follow-up was

Table 1 Scoring system for postoperative mobility based on walking aid

Score	Mobility/walking aid
0	No use of walking aids
1	One crutch or cane
2	Two crutches
3	Walking frame
4	Wheelchair or bedridden

Table 2 Clinical, demographic, radiographic and surgery-related parameters of patients undergoing resection and reconstruction (group R) and patients receiving stabilisation alone (group S) for pathological femoral fractures

parameters		group S	group R
patients (<i>n</i>)		29	30
fractures (<i>n</i>)		33	31
mean age		62	65
female/male ratio		1:0,9	1:0,5
mean white blood count	10 ⁹ /L	9.2	7.8
mean haemoglobin	g/dl	11.1	11.1
referred ^a	%	14	17
primary lesion (<i>n</i>)	breast	14	10
	lung	4	6
	prostate	5	3
	kidney	2	3
	others	4	8
fracture type (<i>n</i>)	intertrochanteric	8	6
	subtrochanteric	14	13
	combined	1	1
	diaphyseal	10	11
Hardware (<i>n</i>)	intramedullary nail	33	4
	plate(s)	0	12
	endoprosthesis	0	13
	mixed	0	2
Function (<i>n</i>)	excellent/good	4	11
	fair	21	13
	poor	6	7
	0=excellent, 4=bedridden	2,2	2,3
mean function score		2,2	2,3
mean hospital stay days		20	19
mean Bauer score		2,1	2,3
Solitary metastases (<i>n</i>)		2	4
preoperative embolisation (<i>n</i>)		0	3
postoperative RTX (<i>n</i>)		21	28
major complication (<i>n</i>)		3	7
revision surgery (<i>n</i>)		2	5
median survival months		4	6
mean survival months		11	13
one year survival rate %		30	31

^a Initial transfer via external surgical department where femoral fractures are regularly treated

eight months. Overall, median and mean survival was five and 12 months, respectively (0–74 months). Overall survival rate at one year was 31%. The estimated survival revealed an average Bauer score of 2.2 (0–4), with a relative one year survival rate of 25%. Preoperative blood sample showed mean white blood cell count of 9.2 10⁹/L and mean haemoglobin of 11.1 g/dl. Distribution of primary lesions is listed in Table 3. Five (17%) patients were transferred to centre A via an external surgical department and four (14%) to centre B. Postoperative radiation therapy was performed at 48 (75%) fracture sites. Average hospital stay was 20 (five to 73) days. Three lesions were treated by intra-arterial embolisation preoperatively. Ten surgical complications occurred. Eight surgical revisions due to implant-related complications were performed.

Comparison between group S and R

The two groups were statistically comparable with regard to all parameters except for the place of surgical treatment (Table 1). Whereas 24 of 31 (77%) fractures from group R were treated in centre A, 27 of 33 (82%) fractures from group S were treated in centre B ($p<0.0001$). Percentage of referred patients (cases—in bilateral surgery) was identical between centre A and group R (17%, $n=5$) as well as between centre B and group S (14%, $n=4$).

Primary lesion

Except for breast cancer, the primary tumour pattern was similar in both groups. The greater number of patients with

Table 3 Percentage of primary lesion

Primary lesion	Percentage
Breast	41
Lung	17
Prostate	13
Kidney	8
Angiosarcoma	3
Colon	3
Melanoma	3
Bladder	2
Liver	2
Pharynx	2
Ovar	2
Uterus	2
Vagina	2

primary breast cancer in the stabilisation group (group S $n=14$;;group R $n=10$) had no statistical impact on median preoperative survival score, which was 2 in both groups [2].

Surgery

All patients in group S were treated with a reconstruction intramedullary device. Nineteen long and four regular Gamma nails (Howmedica Ltd), four universal AO nails (Howmedica Ltd), four unreamed femoral nails (UFN; Synthes Ltd) and two standard proximal femoral nails (PFN, Synthes Ltd) were used. In group R, seven cemented calcar-replacing hemiarthroplasties (Weber Stem S-L, Sulzer Orthopedics Ltd), six

modular megaprotheses, four Howmedica Modular Resection Systems (HMRS, Howmedica Ltd) and two Limb Preservation Systems (LPS, DePuy Orthopedics Inc.) were used. Thirteen fractures were stabilised with plates (two blade plates and 11 locking compression plates—two of them with the use of two plates each—with at least three screws proximal and three distal to the bone defect). In these cases, intralesional resection by curettage and resection of macroscopic extraosseous metastatic tissue was performed before filling the defect with PMMA in a bonding technique. Five fractures were treated with curettage via an additional incision at the fracture site, PMMA and intramedullary nails (three long Gamma nails, one with an additional plate and two UFN). Mean number of administered blood units during hospital stay was 3.3 (0–19) U in group S and 3.1 (0–24) U in group R.

Functional results

Mean follow-up for group S was six months and for group R nine months. Twenty-one patients (63%) in group R and 20 (58%) in group S regained preoperative (before occurrence of trauma) mobility level. The mean mobility score (Table 1) was 2.2 in both groups.

Surgical complications

In total, ten surgical complications (15.6%) according to Sokol and Wilson [13] occurred. Details can be seen in Table 4. Seven surgical complications occurred in group R

Table 4 Clinical details and survival of patients who sustained major complications after operation for pathological femoral fracture

case	gender	age (years)	primary tumour	fracture type	primary operation	major complication	complication-specific treatment	survival (months) ^a
1	female	59	Vagina	Subtrochanteric	cemented proximal femoral replacement	deep infection	one-stage revision	74
2	female	59	Breast	peritroch	cemented proximal femoral replacement	Luxation	open reduction	26
3	female	64	Lung	Subtrochanteric	cemented proximal femoral replacement	deep infection	one-stage revision	3
4	female	66	Kidney	Diaphyseal	single plate, bonding technique	implant breakage	double plate	18
5	female	51	Breast	peritroch	single plate, bonding technique	dehiscence of skin closure	secondary skin closure	2
6	male	52	Melanoma	Diaphyseal	double plate, bonding technique	refracture	plate exchange	11
7	female	80	Breast	Subtrochanteric	cephalocondylic intramedullary device; short	refracture	cemented proximal femoral replacement	22
8	male	78	Prostate	Diaphyseal	cephalocondylic intramedullary device; long	dehiscence of skin closure	secondary skin closure	20
9	male	63	Kidney	Subtrochanteric	cephalocondylic intramedullary device; long	cutting through of cephalic screw	cemented proximal femoral replacement	48
10	female	71	Angio sarcoma	Subtrochanteric	cemented hemiarthroplasty	postoperative haematoma	lavage (twice)	3

^a Survival after primary operation for pathological femoral fracture

and three in group S without statistically significant differences. Of all complications ($n=10$), five were categorised as mechanical implant failure due to breakage or refracture [three plate fixations (group R), two intramedullary devices (group S)]. All patients who underwent surgical revision were able to walk after revision surgery. When we focused on surgical complications in relation to surgical technique, we found three of five (60%) patients with megaprotheses, three of 12 (25%) with single- or double-plate fixation, one of seven (14%) hemiarthroplasties and three of 37 (8%) cephalocondylic intramedullary devices.

Survival

We found no difference in postoperative survival between the two groups (Fig. 1). Mean and median postoperative survival in group R was 13.5 and 7.0 (0–74) months and in group S 11.6 and 7.8 (0–38) months. Mean preoperative survival score was 2.4 in group R and 2.1 in group S [2]. No patient had a score of 0 or 5 points. This survival scoring system did not correlate with actuarial survival. Patients with a Bauer score of 1 (representing an estimated time of survival of six months) had the highest mean survival of 18.8 months. Patients with a Bauer score of 2, 3 and 4 had a mean survival of 7.8, 16.8 and 15.6 months, respectively. When we compared survival between patients with (mean 25.4 months) and without (mean 10.8 months) revision surgery, we found a statistically significant difference ($p=0.049$). This difference in survival increased when we focused on mechanical implant failure ($p=0.010$). Patients with implant failure due to nonunion and implant breakage ($n=5$) had a mean survival of 40.5 months compared with 10.5 months for the remainder (Fig. 2).

Fig. 1 Cumulative survival of patients in group R (resection and reconstruction, $n=31$, solid line) and group S (stabilisation alone, $n=33$, dotted line)

Fig. 2 Cumulative survival of patients with ($n=10$, dotted line) and without ($n=54$, solid line) postoperative complications

Major complications ($n=10$) did not have a significant impact on survival ($p=0.083$).

Adjuvant therapy

In group R, three patients underwent preoperative intra-arterial embolisation, and all but four were treated with external-beam radiation postoperatively. In group S, no patient underwent embolisation, and all but six patients underwent postoperative external-beam radiation. Information about (neo-)adjuvant polychemotherapy was inconsistent and is, therefore, not included in this analysis.

Length of stay

Average hospital stay was 19 days in group R and 20 days in group S. These figures did not alter after excluding patients who sustained major complications.

Discussion

To the best of our knowledge this is the first published comparative double-centre study on surgical treatment of pathological fractures of the proximal femur, excluding femoral head and neck fractures. Treatment regimes differ substantially between the two centres. Centre A is a tertiary referral centre for patients with bone and soft tissue tumours, most of which are treated in a curative manner, as well as for patients with pathological or impending fractures due to secondary neoplasm. Centre B, on the other hand, is a trauma centre that deals with all kinds of trauma surgery, including pathological and even impending fractures, with a long tradition of intramedullary nailing. These two centres are located in different district capitals with

different catchment areas. According to various preferences to surgical technique in these two institutions, we found a high incidence of intramedullary stabilisation without further removal of metastatic tissue in centre B and a high incidence of curettage and stabilisation or resection in centre A ($p<0.0001$).

The strengths of this study lie in the relatively large number of patients in relation to its short inclusion period, and the narrow inclusion criteria, which focus on the more challenging pathological fracture patterns of the proximal femur. The number of surgeons and the subjectivity of chosen surgical therapy may be the study's shortcomings. Further limitations are a lack of information about (neo-) adjuvant chemotherapy and actual intraoperative blood loss. Radiographic analysis beyond fracture pattern (e.g. volumetric analysis of osteolytic lesions or surrounding soft tissue masses) would have led to better comparability but was not feasible due to fracture-related bone destruction.

Apart from malignant bone tumours, little is known about the influences on survival of pathological fracture and subsequent surgery, incidence of local recurrence or metastatic dissemination [14, 15]. So far, no precise data has been published concerning the need for resection of metastatic tissue in pathological fractures. Fractures are associated with significant haematoma and thus contamination of the surrounding tissue by tumour cells. In these cases, complete resection of the metastatic lesion is often not possible. This was one reason for excluding impending fractures in this study. However, even in cases of impending fractures, statements are divergent in the literature concerning the role of curative resection [4]. On the one hand, osseous metastases can be regarded as a spreading of tumour cells, representing a systemic malignant disease. On the other hand, resection or even debulking of malignant tissue may help reduce the burden of malignant disease and facilitate postoperative therapy (e.g. radiotherapy) [16]. Palliative surgical treatment aims to improve quality of life in the first place; survival is secondary. Whereas functional results are hard to compare with those reported elsewhere due to different scores and lack of prospectively evaluated data, survival represents a comparable parameter. Cole et al. compared "reamed" versus "solid" femoral nails for treating impending and actual pathological fractures and reported no influence on outcome [17]. According to Capanna et al., reinforced osteosynthesis, including curettage and use of PMMA, is recommended as the least necessary surgical option for pathological femoral fractures, with a tendency towards total resection and implantation of megaprosthesis if the estimated survival is over one year and there is a lack of response to local adjuvant therapy (e.g. renal cell carcinoma, adenocarcinoma) [4]. In other words, osteosynthesis alone is not regarded as sufficient in proximal femoral fractures. This was confirmed by a recently published

retrospective study [18]. In our study, seven major complications occurred in the resection group versus three in the stabilisation group without statistically significant differences. Van Doorn et al. published a literature review on clinical studies about surgical treatment of actual and impending pathological fractures of the femur ($n=947$) and found an overall complication rate of over 14%, with failed stabilisation in 10%. In a multicentre retrospective analysis ($n=110$) of impending and actual pathological femoral fractures stabilised with a cephalocondylic intramedullary device (Gamma™ nail, Stryker Orthopaedics, Mahwah, NJ, USA) without separate curettage or use of PMMA, the same group reported a complication rate of 5%, with two cases of implant breakage [6]. Schneiderbauer et al. performed a retrospective study on patient survival after arthroplasty for metastatic disease of the hip and reported a postoperative complication rate $<9\%$ [19]. In a study by Chandrasekar et al. on 100 tumour prostheses implanted for metastatic disease of the femur, postoperative complications were divided into dislocation (3%), infection (6%) and perioperative mortality (3%); however, there was no information on overall percentages [20]. These reports are hardly comparable, and mean postoperative survival rates between 4.5 [17] and 16 [21] months reflect the heterogeneity of the reported cohorts. Wedin et al. compared osteosynthetic reconstruction and endoprostheses for surgical treatment of proximal femur metastases and found that the complication rate was almost twice as high (16.2%) in osteosynthetic reconstruction as in endoprostheses (8.3%) [5]. This ratio was similar after exclusion of femoral head and neck fractures in their study in which endoprostheses were almost exclusively used. According to our findings, postoperative survival time was the most important risk factor for treatment failure. Five of ten major complications that occurred in our series were related to implant breakage and/or stabilisation failure due to reduced bone stock, with a significantly higher postoperative survival rate. This fact begs the question of preoperative estimation of survival. Leithner and co-workers compared preoperative prognostic scoring systems [22]. The best results were obtained by a modified Bauer scoring system. In the underlying group of patients, this scoring system, as well as the original Bauer score, did not correlate with actual survival. Retrospectively, these patients would have profited from resection and endoprosthesis implantation to facilitate lifetime load-bearing capacity.

Patients who undergo surgery as a result of pathological proximal femoral fractures, excluding femoral head and neck fractures, do not profit from curettage or marginal and wide resection in terms of postoperative survival. A complication rate of 15.6% in the study population showed no statistically significant affinity to surgical technique. Patients with implant-related complications show a significantly

higher rate of survival. Further studies should focus on preoperative prognostic scoring systems and individualised surgical techniques in relation to survival.

Acknowledgements The authors thank Christina Levy for proofreading the manuscript.

Conflict of interest The authors declare that they have no conflict of interest.

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