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High incidence of complications and poor clinical outcome in the operative treatment of periprosthetic femoral fractures: An analysis of 71 cases

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ABSTRACT

Background: The purpose of this observational study was to determine the clinical results of the operative treatment of periprosthetic femoral fractures over a long period of time.

Methods: The medical records of patients treated between 1993 and 2006 for a periprosthetic femoral fracture were obtained after a survey in two major hospitals. Radiographic evaluation was performed according to the Vancouver classification. All patients were contacted to fill out the Oxford hip score.

Results: A total of 80 PPFs were identified in 79 patients. For 71 patients with 71 fractures, medical records and radiographs were available. The mean age at the time of fracture was 73.4 years (range: 38–95 years). The mean interval between initial arthroplasty and the time of fracture was 6.3 years. As many as 44 fractures occurred in patients with primary hip arthroplasty (62%) and 27 fractures in patients with revision implants (38%).

All but two patients were treated operatively and 34 patients (48%) suffered from a complication, leading to a re-operation in 22 cases (33%). The most frequent indication for re-operation was re-fracture or implant failure. Vancouver type-C fractures lead to re-operations in 52% of the cases (11 of 20). A total of 36 patients (51%) were able to complete an Oxford hip score after a mean period of 64.9 months (range: 16–157 months). The other patients were lost to follow-up (45% were deceased and 4% were mentally impaired). The mean Oxford hip score was 27.8 (range: 12–57) and was significantly higher in patients suffering from a complication ($p = 0.02$) and in patients with a periprosthetic fracture (PPF) after revision surgery ($p = 0.02$).

Conclusion: The treatment of periprosthetic femoral fractures has a high complication rate and a large number of re-operations occur. The long-term clinical results are compromised by the event of a complication. The clinical results of treated fractures after a primary arthroplasty were better than after multiple arthroplasty procedures. Particularly, Vancouver type-C fractures showed high complication rates. This high complication rate should be taken into account for future studies in PPFs.

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Total hip arthroplasty (THA) is among the most successful operative procedures known to medicine, because of which the prevalence of this procedure is rapidly increasing. However, with the success the downside becomes increasingly important as well: the complications associated with THA. Although the number of serious complications on the long term is low, a serious complication is the periprosthetic fracture (PPF) of the femur. Often, these fractures occur in older, compromised patients, raising mortality rates.¹⁰ The increase in the number of patients treated with THA, as well as people getting older, create a large population 'at risk'. In the literature, the increasing incidence of PPF has been reported by a number of study groups.^{7,15}

Several retrospective studies have been published, however, with limited information on clinical outcomes.^{1,11,16} Using the Swedish Arthroplasty Register, Lindahl et al. were able to report a large prospective series and identify risk factors for PPF (e.g., stem design).⁸ Derived from questionnaires at follow-up, their patients showed an impaired hip function and low health status.

We performed a retrospective study in two hospitals and included the Oxford hip score questionnaire and a review of the complete radiologic follow-up. According to clinical observations and literature reports, we expected high major complication rates, especially re-operations. Osteosynthesis performed for Vancouver type-B fractures were expected to have a high failure rate as previously described in literature reports. We posed the following research questions: Does the treated PPF population show a high complication rate? Do these patients show an impaired functional outcome and is this influenced by the method of treatment?

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Materials and methods

The medical records and radiographs of all patients with a PPF between March 1992 and February 2006 were collected from the registers of the University Medical Centre Groningen and the Martini Hospital, both situated in Groningen, the Netherlands. Seventy-nine patients were identified with 80 PPFs of the femur. The patients' mobility in the period prior to the fracture and after fracture healing was described based on clinical notes in the medical records. Co-morbidity was described and categorised.

The trauma mechanism was divided into minor trauma, which was defined as a low-energy trauma such as a simple fall to the floor, major trauma; and high-energy trauma, for example, a traffic accident or a fall from a height and spontaneous fracture in cases where no clear trauma mechanism could be identified. Fractures were classified according to the Vancouver classification system,^{2,6} which integrates the site of the fracture, the stability of the implant and the quality of host bone stock. Type-A fractures are trochanteric, either greater (Ag) or lesser (Al). Type-B fractures occur around the stem of the prosthesis or just below it. Type B1 incorporates fractures with a solidly fixed implant. In type B2 and B3 fractures, the femoral

component is loose. In type B3, severe bone stock loss can also be observed. Type-C fractures occur well below the tip of the stem. Fractures were classified by authors according to the radiographs and operative reports. Indication for initial arthroplasty was assessed as well as the number of operations prior to the fracture. Treatment of fractures was categorised as non-operative, revision, femur-nail or open reduction and internal fixation (ORIF). ORIF was subdivided into plate-screw fixation, cable-grip plate, cerclages or a combination of the above treatment modalities. The duration of hospitalisation was also recorded. Complications were reviewed and categorised as femur-related complications (re-fracture within 1 year, nonunion and dislocation) The complications were subcategorised according to Parvizi et al.¹³ 'Major systemic complications' were deemed to be life threatening and required complex medical intervention, such as transfer to the intensive care unit. 'Major local complications' necessitated additional surgical intervention or were deemed to result in temporary or permanent functional impairment. Minor systemic or local complications (urinary tract infection, pneumonia and decubitus) required longer hospital stay or medical treatment.¹² Patients were contacted to complete the Oxford hip score, a questionnaire containing 12 items developed to measure the

Table 1
Patients with periprosthetic fractures after primary total hip replacement.

Age	Sex	Indication	Implant type	Implant years	Trauma	Vancouver	Treatment	Complication	Re-operation	Patient deceased	Oxford
80	M	OA	Stanmore	1/12	No	Type B1	ORIF	Maj C	No	Alive	N/A*
82	F	OA	Stanmore	16 1/4	No	Type B1	ORIF	Maj C	No	3 mnd	N/A
79	M	OA	Stanmore	23 1/4	No	Type B3	Other	No	No	Within 5 years	N/A
60	M	OA	Mallory-Head	1 7/12	min	Type B1	ORIF	No	No	Alive	12
80	M	OA	Stanmore	12 5/12	min	Type B1	ORIF	No	No	Within 2 years	N/A
85	F	OA	SHP	5 5/12	min	Type B1	ORIF	No	No	Alive	31
93	F	OA	Mc Kee Ferrar	15 1/4	min	Type B1	ORIF	No	No	>5 years	N/A
57	M	OA	SHP	1	min	Type B2	Revision	No	No	Alive	20
64	M	OA	SHP	3 2/3	min	Type B2	Revision	Fem C	Yes	Alive	39
61	F	OA	judet	11 5/12	min	Type B2	Revision	No	No	Within 5 years	N/A
78	F	OA	SHP	2 1/6	min	Type B2	ORIF	Min C	Yes	Within 5 years	N/A
72	F	OA	SHP	4 11/12	min	Type B2	Revision	Min C	No	Alive	34
72	F	OA	SHP	3/4	min	Type B2	Revision + ORIF	No	No	Alive	N/A
75	F	OA	SHP	4 5/12	min	Type B2	Revision + ORIF	No	No	Alive	42
79	F	OA	Stanmore	14 1/12	min	Type B2	Revision + ORIF	No	No	>5 years	N/A
90	F	OA	Harris Monoblock	14 1/12	min	Type B2	Revision	Min C	No	Within 2 years	N/A
81	F	OA	SP	11 5/6	min	Type B2	Revision + ORIF	No	No	Alive	19
81	F	OA	Harris Monoblock	10 1/2	min	Type B2	Revision	No	No	Alive	18
64	M	OA	SHP	3 1/4	min	Type B3	Revision	No	No	Alive	39
87	F	OA	Mc Kee Ferrar	23 2/3	min	Type B3	Revision + ORIF	Min C	No	Within 2 years	N/A
64	F	OA	SHP	1 1/12	min	Type C	ORIF	No	Yes	Alive	12
68	F	OA	SHP	3/4	min	Type C	ORIF	No	Yes	Alive	15
80	M	OA	Stanmore	15 5/12	min	Type C	ORIF	Min C	Yes	>5 years	N/A
83	M	OA	Stanmore	13 1/12	min	Type C	ORIF	Maj C	No	3 mnd	N/A
84	F	OA	Stanmore	5 1/12	min	Type C	ORIF	No	No	Within 5 years	N/A
83	F	OA	Stanmore	1 1/3	min	Type C	ORIF	No	No	Within 5 years	N/A
95	F	OA	Monoblock Muller	7 1/3	min	Type C	ORIF	No	No	Within 5 years	N/A
81	F	OA	SHP	5 5/6	min	Type B2	Revision + ORIF	No	No	Alive	29
61	F	OA	SHP	5/12	min	Type C	ORIF	No	No	Alive	26
39	M	RA	SP	16 1/12	min	Type A g	Revision + ORIF	No	No	Alive	29
67	M	RA	Proplast	17 1/4	min	Type B2	Revision + ORIF	Maj C	No	Alive	15
64	M	RA	SHP	1 1/3	min	Type C	ORIF	Fem C	Yes	Alive	18
77	F	OA	Harris Monoblock	13 11/12	min	Type B2	Revision + ORIF	Fem C	Yes	Within 1 year	N/A
86	F	Fx	Monoblock Muller	6 1/2	min	Type B2	Revision + ORIF	Maj C	Yes	Within 1 year	N/A
85	F	Fx	Zweimuller	6 1/4	min	Type B2	Revision + ORIF	Fem C	Yes	Alive	31
89	F	Fx	Stanmore	7 11/12	min	Type B3	Revision	No	No	Within 5 years	N/A
87	F	Fx	Stanmore	10 1/12	min	Type C	ORIF	Fem C	Yes	>5 years	N/A
84	F	Fx	Stanmore	7 1/4	min	Type C	ORIF	Fem C	Yes	Within 2 years	N/A
57	F	OA	Mallory-Head	1/12	min	Type A l	Revision + ORIF	No	No	Within 5 years	N/A
50	F	OA	Mallory-Head	1/12	min	Type B2	ORIF	No	No	Alive	18
69	M	OA	SP	13 3/4	min	Type B3	Revision + ORIF	Min C	Yes	Alive	25
47	F	AVN	Harris Monoblock	11 1/12	min	Type B2	Revision	Maj C	Yes	Alive	34
59	M	OA	SHP	2 1/4	maj	Type B2	ORIF	Maj C	No	Alive	17
48	F	AVN	Mallory-Head	1/12	maj	Type B1	ORIF	No	No	Alive	12

OA = primary osteoarthritis, RA = rheumatoid arthritis, Fx = fracture, AVN = avascular necrosis of the femoral head, min = minor trauma, maj = major trauma, no = no obvious trauma, Min C = minor complication, Maj C = major complication, Fem C = femoral related complication.

* Not available.

Table 2

Patients with periprosthetic fractures after revision surgery.

Age	Sex	Indication	Implant type	Implant years	Trauma	Vancouver	Treatment	Complication	Re-operation	Patient deceased	Oxford
82	Man	OA	Stanmore	8 3/5	no	Type B3	Revision	No	No	>5 years	N/A
69	Woman	SA	Mallory-Head	2/3	no	Type B1	Nail	Fem C	Yes	>5 years	N/A
92	Woman	Fx	Stanmore	12 5/6	no	Type B3	Nail	Fem C	No	Within 5 years	N/A
57	Woman	OA	Stanmore	13 3/5	Min	Type B1	ORIF	Min C	No	Within 5 years	N/A
87	Woman	OA	Stanmore	8 1/3	Min	Type B1	Cons	No	No	6 mnd	N/A
63	Woman	OA	exeter	7	Min	Type B2	ORIF	Fem C	Yes	Alive	26
82	Man	OA	Stanmore	10 5/6	Min	Type B2	ORIF	Min C	No	Alive	34
81	Woman	OA	Stanmore	6 2/3	Min	Type B2	Revision	Maj C	No	3 mnd	N/A
81	Woman	OA	SHP	3/5	Min	Type B2	ORIF	No	No	Alive	N/A
76	Man	OA	exeter	0	Min	Type C	ORIF	Min C	Yes	Within 2 years	N/A
74	Woman	OA	SHP	2	Min	Type C	ORIF	Fem C	Yes	Alive	54
74	Woman	OA	exeter	1/3	Min	Type C	ORIF	No	No	Alive	18
79	Woman	OA	Stanmore	0	Min	Type C	Nail	No	No	>5 years	N/A
82	Woman	OA	Stanmore	3	Min	Type C	ORIF	Maj C	Yes	Alive	44
67	Woman	OA	exeter	1/3	Min	Type C	ORIF	Min C	No	Alive	29
38	Woman	SA	exeter	1/2	Min	Type C	ORIF	No	Yes	Alive	N/A
39	Woman	AVN	Mallory-Head	0	Min	Type A g	Cons	No	Yes	Alive	48
77	Woman	Fx	calcar	1/4	Min	Type B1	Cons	Fem C	No	>5 years	N/A
87	Woman	Fx	Muller	1 1/6	Min	Type B1	ORIF	No	No	Alive	25
69	Woman	Fx	SP	5	Min	Type B2	Revision	Min C	Yes	Alive	20
74	Woman	Fx	Stanmore	9 1/6	Min	Type B2	Revision	No	No	>5 years	N/A
71	Woman	Fx	charnley	4 2/3	Min	Type C	ORIF	No	No	Alive	22
89	Woman	OA	SHP	7 1/6	Min	Type B2	Revision	No	No	Alive	31
86	Woman	OA	exeter	0	Min	Type C	ORIF	No	No	Within 5 years	N/A
91	Man	OA	exeter	0	Min	Type C	ORIF	Maj C	Yes	Alive	31
56	Woman	SA	exeter	1	Min	Type B1	ORIF	Fem C	Yes	Alive	57
64	Man	AVN	SP	1/2	Maj	Type B1	Revision	Maj C	No	3 mnd	N/A

OA=primary OA, SA=secondary osteoarthritis, RA=rheumatoid arthritis, Fx=fracture, AVN=avascular necrosis of the femoral head, min=Minor trauma, maj=Major trauma, no= no obvious trauma, Cons=conservative, Min C=Minor Complication, Maj C=Major complication, Fem C=femoral related complication.

outcome of total hip replacement (THR) surgery (each item is scored from 1 to 5, from least to most difficult or severe).^{3,5} A high score represents an impaired function. Clinical notes from medical records concerning mobility 1 year after surgery were obtained for deceased patients at the time of follow-up.

Statistical analysis was performed on a personal computer using SPSS for Windows XP (version 14.0). A $p < 0.05$ was considered significant.

Results

Patient, fracture and implant characteristics

A total of 79 patients were identified with 80 PPFs. Due to radiographs destroyed by the hospital administration, only in 71 cases of PPF were radiographs available for Vancouver classification. These patients (52 females (72%)) had a mean age of 73.4 years (range: 38–95 years). Mean implant survival at the time of fracture was 6.3 years. At the time of final follow-up, 32 (45%) patients had deceased, one had migrated and two were unable to answer the questionnaire because of impaired mental status. The mean radiological follow-up was 3 years (3 months to 12.8 years).

Reasons for initial THR surgery were osteoarthritis (70%), fracture (16%), secondary arthritis (9%) and avascular necrosis of the femoral head (5%). Fifty-eight percent of the patients had one or more co-morbidities. Twenty-seven (38%) fractures occurred in patients with at least one revision arthroplasty and 44 (62%) after a primary THR. The majority of the PPFs were caused by minor trauma (87%), followed by spontaneous fractures (9%) and major trauma (4%). As many as 62 patients (87%) had a cemented implant and nine patients (13%) an uncemented hip stem prior to fracture (Tables 1 and 2).

Primary versus revision treatment

A total of 27 cases of PPF occurred in patients who had a history of revision arthroplasty. Of the 44 patients with PPF after primary

THA, 70.5% ($n = 31$) had a type-B fracture and 25% ($n = 11$) a type-C. The revision group ($n = 27$) showed a type-B fracture in 59.2% ($n = 16$) and a type-C fracture in 37% ($n = 10$). This difference was not significant ($p > 0.05$).

The primary group had their prostheses significantly longer *in situ* than the revision group – 7.8 years versus 3.9 years ($p < 0.05$). The mean age in the primary group was not significantly different from the revision group – 73.3 years (44 patients) versus 73.6 years (27 patients) ($p = 0 > 0.05$).

Clinical results

From both groups (the primary and the revision group), 35 patients (49%) were able to fill out a complete Oxford hip score after a mean period of 64.9 months (range: 16–157 months). The average Oxford hip score outcome was 27.8 points (range: 12–57 points). A high score implies an impaired function. A significant difference was found between the mean Oxford score of the patients with a primary THR (24.3 points) and the patients with multiple implants before fracture (33.8 points) ($p = 0.02$). Patients suffering from a femur-related complication scored significantly worse on the hip score at long-term follow-up ($p = 0.02$). No significant difference in hip score outcome was found between various operative techniques. Of the patients who had no Oxford score (deceased 45%, mentally impaired 4%), 50% of them returned to preoperative mobilisation levels, according to the medical records.

Fracture treatment

The various treatments used for the fractures are shown in Table 3.

Vancouver B2 and B3 fractures underwent revision arthroplasty with or without the use of additional internal fixation in 76% (25 out of 33) of the cases. One patient received an intramedullary osteosynthesis and one patient was considered not fit for operation and therefore treated conservatively. The rest were treated with

Table 3

The overview of various treatments in relation to the Vancouver fracture type.

	ORIF	Revision arthroplasty	Revision arthroplasty and ORIF	Other	Total
Vancouver A	0	0	2	1	3
Vancouver B1	10	1	0	3	14
Vancouver B2	6	10	10	0	26
Vancouver B3	0	3	2	2	7
Vancouver C	20	0	0	1	21
Total	36	14	14	7	71

ORIF (18%). Vancouver type-C fractures were treated with ORIF in 95% (20) of the cases.

In the Vancouver type-C cases, standard AO dynamic compression plate (DCP) osteosynthesis was used in 12 patients. Five cases were treated with standard AO plates (non-locking) and additional cerclage wires. Three fractures were treated with a dynamic condylar screw (DCS) plate osteosynthesis.

At 6 months postoperatively, fracture consolidation was evaluated for the surviving patients ($n = 66$). A total of 35 fractures showed consolidation, and 20 patients lacked signs of fracture union. In 11 patients, no reliable judgement could be made due to implant overlay.

Complications

As many as 11 patients (15.5%) suffered from major systemic complications. Four patients (5.6%) died within 3 months after treatment. In addition, seven patients (9.8%) died within 1 year after treatment. Minor systemic complications were noted in 11 patients (15.5%).

As many as 32% of all patients ($n = 23$) were re-operated one or more times after fracture treatment, 21% ($n = 21$) within 1 year. Table 4 shows re-operations in relation to primary treatment. Nine patients needed more than one intervention. The most common indication for re-operation was re-fracture or implant failure (44%), followed by infection of the prosthesis (26%), nonunion (17%), dislocation (9%) and aseptic loosening of the stem (4%).

Eight out of the initial 26 patients (31%) with a Vancouver type-B2 fracture were re-operated for pseudarthrosis, plate breakage or infection. A total of 55% of the patients with a Vancouver type-C fracture underwent a re-operation after ORIF (11 of 20). Of this group, seven patients with conventional AO plates and another two patients with additional cerclage wires needed to have an additional surgical procedure. Two of three patients with the DCS plate had a revision as well. Open reduction and internal fixation resulted in a significantly higher rate of re-operations than revision surgery with or without the open reduction and internal fixation ($p = 0.02$) in the Vancouver type-B fractures. Patients with a complication had a significantly longer duration of hospitalisation ($p = 0.02$).

Table 4

Number of re-operations in relation to the number of treated periprosthetic fractures.

Vancouver classification	A ($n = 3$)	B1 ($n = 12$)	B2 ($n = 26$)	B3 ($n = 6$)	C ($n = 21$)	Total
Revision	0/0	0/0	2/10	0/3	0/0	2
Revision and ORIF	0/2	0/1	4/10	1/2	0/0	5
ORIF	0/1	1/10	2/6	0/0	11/20	14
Femoral nail	0/0	1/1	0/0	0/2	1/1	2
Total per fracture type	0	2	8	1	12	23

Discussion

The treatment of PPFs after a THA is complex and high complication rates are reported in the literature. In our series, we encountered a considerable number of serious complications. Considering the variety of treatment modalities used, we were not able to establish differences between these forms of treatment due to the formation of small groups after stratification. More re-operations were observed in patients treated with an osteosynthesis than in patients with a revision arthroplasty. More complications were observed in the Vancouver type-C group.

The re-operation rate is very high, in concordance with literature reports.⁹ Not many treatment protocols in fracture surgery show similarly high re-operation rates. Particularly in this elderly aged, compromised patient group, re-operations are very needless and threatening to the patient's health. This makes the treatment of PPF both difficult and challenging.

One of the major reasons for re-operation is implant failure. Plate breakage is often a result of delayed or nonunion and progressive load bearing. In our study, only 36 of 67 patients showed clear signs of radiological union at 6 months. In 11 patients, no reliable judgement could be made. Implants (e.g., meshes) hindered our (retrospective) radiographic judgement of fracture healing. Of this small group, 4 out of 11 (36%) patients were re-operated afterwards. Of the 36 patients with consolidated fractures, only six (16.6%) patients were re-operated. This difference is 20% and is not significant, $p = 0.15$ (Fisher's exact test mid p). The implant failure may have been caused by the assumption of fracture consolidation by the treating physician. The clinical decision of progressive mobilisation and weight bearing might have caused the implant failure. To prevent misjudgement or underestimation of fracture union, we suggest the use of additional radiographs in other directions or prolonged protective weight bearing.

The relatively large percentage of failure of osteosynthesis raises suspicion of slower fracture consolidation. Fracture healing depends on biological, biomechanical or force-loading factors. All of these factors are altered in the case of a PPF when compared to a femur without prior hip prosthesis surgery. Primarily, the local biological environment might be influenced by a pre-existent intramedullary implant. Second, tissue damage and disturbed blood supply caused by prior surgery might contribute to a slower healing process of a PPF. Finally, the biomechanical properties of a femur with an implant *in situ* and the consequences on PPF healing are not known. The beneficial effect of load bearing on fracture healing is well established by research. In PPF treatment, only revision stems or retrograde nails bridging the stem can offer sufficient stability and weight-bearing possibility. Other implants might fail due to insufficient stability. Long protective weight bearing is commonly practised in patients with these forms of treatment. However, compliance of the patient to obey non-weight-bearing instructions is a major concern in the geriatric population. It is possible that these patients load their extremity regardless of the instructions. Whether partial weight bearing is possible at all in this patient group has to be further investigated.

PPFs in patients with THR for proximal femoral fracture showed a higher complication rate following their PPF treatment. Hypothetically, the outcome and complications could have been influenced by the bone quality of these patients. Osteoporosis is at least a major contributing factor to hip fracture. Screening for osteoporosis in older patients and treatment is important to prevent fractures. Many patients with osteoporotic fractures are not treated with bisphosphonates or calcium; thus, many patients have diminished bone mineral density around the prosthesis, leaving them prone to PPF. The same reasoning can be true for patients with a revision arthroplasty performed in the past.

Patients with multiple implants before developing a PPF had shorter implant survival than primary hip stems with a fracture, possibly as a result of this previously mentioned poor bone quality. Unfortunately, in our series, no bone quality measurement was made. Nevertheless, bone strength should be the subject of further research in PPF prevention and treatment.

In our series, several patients with radiographic signs of loosening were treated with osteosynthesis. Recently, Parvizi et al. proposed an algorithm for PPF treatment.¹⁴ Revision arthroplasty is advised for type-B2 and -B3 fractures. In our series, six patients with Vancouver B2 fractures were treated using internal fixation. Two of these patients were re-operated. Therefore, if the proposed algorithm had been applied, better results might have been obtained.

Furthermore, a remarkable result is the high occurrence of re-operations in the Vancouver type-C group treated with ORIF (55%). Unfortunately, because of the retrospective nature of our study, we were not able to analyse the newer locking compression plates, which could provide more stability. In our series, possibly the initial stability, the influence of the ORIF on fracture healing or the rehabilitation schedule (especially the load bearing) might be among the reasons for failure. Many clinicians might use the (after) treatment for the normal femoral fracture; however, this regime might not be favourable in periprosthetic femoral fractures. Biomechanical factors could play a role in failure scenarios as hinging of the fracture site or significantly altered off-loading fracture level is quite possible in the area well below the tip of the stem.

This study combines retrospective results and a prospective hip questionnaire. The mean Oxford hip score in our series was 27.8 after a mean period of 64.9 months. This is worse than the reported 20.6–22.6 for primary and revision hip surgery by Field et al.⁴ It is expected that people who were able to complete the questionnaire were likely to have superior scores compared with the patients who were not. Our patients who underwent a revision arthroplasty prior to their PPF had a significant higher Oxford score, implicating a worse functional outcome. These scores were worse than results reported for regular elective revision arthroplasty.

Patients who suffered from a complication had a higher Oxford score at long-term follow-up. This emphasises the importance of preventing complications and re-operations. The Oxford score is a test validated for hip function in primary hip arthroplasty. Patients with general physical impairment have a higher score as well. This could have affected the results, delivering a worse overall score. This study, however, describes long-term results of a patient group with a specific diagnosis and treatment. Few reports in the literature provide these clinical follow-up data. The need for prospective follow-up studies is imminent for a better

understanding of fracture healing of periprosthetic femurs. Treatment algorithms can be adjusted to improve results, especially if patient-based and clinician-based outcome scores are used to define patient groups more accurately than just the fracture classification.

In conclusion, this study shows a high complication rate and high re-operation numbers in patients treated for periprosthetic femoral fractures. In addition to the generally recognised complexity of the treatment of type-B fractures, the treatment of Vancouver type-C fractures deserves more attention both in the literature as well as in clinical practice to prevent re-operations.

Conflict of interest

Hereby the authors state that there are no conflicts of interest.

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