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Management and outcomes of femoral periprosthetic fractures at the hip

DATA FROM THE CHARACTERISTICS, OUTCOMES AND MANAGEMENT OF PERIPROSTHETIC FRACTURE SERVICE EVALUATION (COMPOSE) COHORT STUDY

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Aims
The aim of this study was to describe the management and associated outcomes of patients sustaining a femoral hip periprosthetic fracture (PPF) in the UK population.

Methods
This was a multicentre retrospective cohort study including adult patients who presented to 27 NHS hospitals with 539 new PPFs between 1 January 2018 and 31 December 2018. Data collected included: management strategy (operative and nonoperative), length of stay, discharge destination, and details of post-treatment outcomes (reoperation, re-admission, and 30-day and 12-month mortality). Descriptive analysis by fracture type was performed, and predictors of PPF management and outcomes were assessed using mixed-effects logistic regression.

Results
In all, 417 fractures (77%) were managed operatively and 122 (23%) conservatively. The median time to surgery was four days (interquartile range (IQR) 2 to 7). Of those undergoing surgery, 246 (59%) underwent revision and/or fixation and 169 (41%) fixation alone. The surgical strategy used differed by Unified Classification System for PPF type, with the highest rate of revision in B2/B3 fractures (both 77%, 176/228 and 24/31, respectively) and the highest rate of fixation alone in B1- (55/78; 71%) and C-type (49/65; 75%) fractures. Cemented stem fixation (odds ratio (OR) 2.66 (95% confidence interval (CI) 1.42 to 4.99); p = 0.002) and B2/B3 fracture type (OR 7.56 (95% CI 4.14 to 13.78); p < 0.001) were predictors of operative management. The median length of stay was 15 days (IQR 9 to 23), 12-month reoperation rate was 5.6% (n = 30), and 30-day readmission rate was 8.4% (n = 45). The 30-day and 12-month mortality rates were 5.2% (n = 28) and 21.0% (n = 113). Nonoperative treatment, older age, male sex, admission from residential or nursing care, and sustaining the PPF around a revision prosthesis were significant predictors of an increased 12-month mortality.

Conclusion
Femoral hip PPFs have mortality, reoperation, and readmission rates comparable with hip fracture patients. However, they have a longer wait for surgery, and surgical treatment is more complex. There is a need to create a national framework for data collection for this heterogeneous group of patients in order to understand the outcomes of different approaches to treatment.

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Introduction
The management of femoral periprosthetic fractures (PPFs) associated with a hip arthroplasty presents a challenge due to the presence of an implant, reduced bone stock, and the presence of osteoporosis. These cases are complex, requiring high levels of surgical planning and skill, and are associated with increased procedural costs,

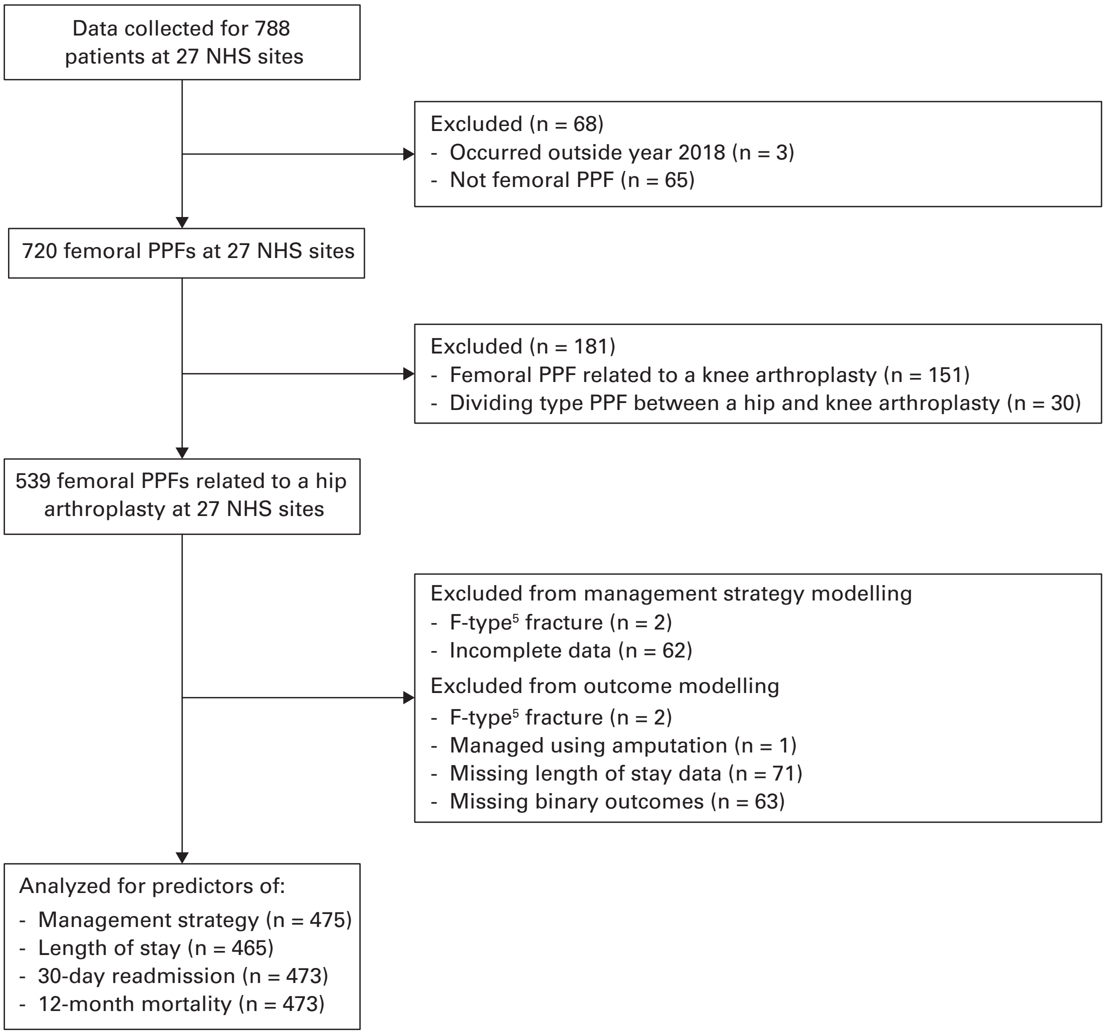

Fig. 1

Flowchart of participants within the Characteristics, Outcomes and Management of PeriprOsthetic fractures: Service Evaluation (COMPOSE) study analysis. PPF, periprosthetic fracture.

morbidity, and risk of mortality.[1] The incidence of these complex injuries is forecast to increase over the next decade, placing a burden on modern healthcare systems, as well as the patients who sustain these injuries and the surgeons treating them.[2] Improved understanding of their management and the associated outcomes is essential to direct clinical decision-making.

There is currently a lack of high-quality evidence in the literature to guide the management of femoral PPFs at the hip. Recent systematic reviews are inconclusive, lacking a controlled comparator, and are largely insufficiently powered.[3] Femoral hip PPFs are a highly heterogeneous group of fractures with multiple subtypes described within both the Vancouver classification system[4] and Unified Classification System (UCS) for PPFs.[5] This makes it difficult to report outcomes and gather sufficient numbers to draw robust conclusions. In practice, a range of factors dictate treatment, including patients' comorbidities, functional status, surgical expertise, and fracture morphology.

The Characteristics, Outcomes and Management of PeriprOsthetic fractures: Service Evaluation (COMPOSE) study was undertaken with the aim of providing information about the population of patients who sustain PPFs in the UK. The analysis presented in this paper focuses on the management of a subset of femoral hip PPFs and their associated outcomes. It supplements our associated paper,[6] which reports the epidemiology, patient and fracture characteristics, and predictors of fracture type of a broader cohort of all femoral PPFs collected as part of the COMPOSE study.

Methods

COMPOSE was a multicentre retrospective cohort study that followed a prospective study protocol and analysis plan. Data were collected from a consecutive series of patients who presented to participating hospitals in the UK with a new PPF between 1 January 2018 and 31 December 2018. Further details on the sampling strategy, study inclusions/

Table I. Operative treatment by hip femoral periprosthetic fracture type using the Unified Classification system for Periprosthetic Fractures classification (percentages calculated based on number of patients with non-missing data). Data on the one F type fracture managed operatively is not presented as a separate column.

Variable	A (n = 14)	B1 (n = 78)	B2 (n = 228)	B3 (n = 31)	C (n = 65)	Overall (n = 417)
Time between PPF and surgery, days						
Patients for whom data were available, n (%)	11 (78.6)	77 (98.7)	213 (93.4)	28 (90.3)	60 (92.3)	389 (93.3)
Mean (SD)	3.8 (3.3)	5.5 (5.3)	6.0 (6.1)	6.4 (5.0)	4.0 (4.5)	5.6 (5.6)
Median (IQR)	3 (2 to 5)	4 (3 to 6)	4 (3 to 7)	4.5 (2.5 to 10)	3 (1 to 5)	4 (2 to 7)
Range	1 to 10	0 to 28	0 to 37	0 to 19	0 to 22	0 to 37
Overall surgical strategy, n (%)						
Revision and/or fixation	6 (46.2)	23 (29.5)	176 (77.2)	24 (77.4)	16 (24.6)	246 (59.1)
Fixation alone	7 (53.8)	55 (70.5)	51 (22.4)	7 (22.6)	49 (75.4)	169 (40.6)
Amputation	0 (0)	0 (0)	1 (0.4)	0 (0)	0 (0)	1 (0.2)
Surgical strategy (multiple strategies possible), n (%)						
Fixation with single plate	5 (35.7)	48 (61.5)	71 (31.1)	6 (19.4)	48 (73.8)	178 (42.7)
Fixation with 2 or more plates	0 (0)	1 (1.3)	7 (3.1)	1 (3.2)	0 (0)	9 (2.2)
Cerclage cables	8 (57.1)	58 (74.4)	131 (57.5)	13 (41.9)	33 (50.8)	243 (58.3)
Strut graft	0 (0)	1 (1.3)	0 (0)	0 (0)	1 (1.5)	2 (0.5)
Bone graft/bone biocomposite augmentation	0 (0)	0 (0)	3 (1.3)	3 (9.7)	0 (0)	6 (1.4)
Cement augmentation	1 (7.1)	1 (1.3)	3 (1.3)	0 (0)	2 (3.1)	7 (1.7)
Cement revision of component related to fractured bone	3 (21.4)	12 (15.4)	72 (31.6)	11 (35.5)	9 (13.8)	108 (25.9)
Uncemented revision of component related to the fractured bone	3 (21.4)	9 (11.5)	104 (45.6)	12 (38.7)	4 (6.2)	132 (31.7)
Nail	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.5)	1 (0.2)
Endoprosthetic arthroplasty	0 (0)	0 (0)	1 (0.4)	1 (3.2)	2 (3.1)	4 (1.0)
Excision arthroplasty	0 (0)	0 (0)	1 (0.4)	0 (0)	0 (0)	1 (0.2)
Surgical strategies used, n (%)						
1	7 (53.8)	28 (35.9)	86 (37.7)	19 (61.3)	31 (47.7)	172 (41.3)
2	5 (38.9)	46 (59.0)	118 (51.8)	8 (25.8)	32 (49.2)	209 (50.2)
3	1 (7.7)	4 (5.1)	24 (10.5)	4 (12.9)	2 (3.1)	35 (8.4)
Reciprocal component also revised, n (% of those who underwent revision and/or fixation)						
Yes	2 (33.3)	11 (50.0)	61 (34.7)	14 (60.9)	11 (68.8)	99 (40.7)
No	4 (66.7)	11 (50.0)	115 (65.3)	9 (39.1)	5 (31.2)	144 (59.3)
Duration of operation, mins						
Patients for whom data were available, n (%)	6 (42.9)	34 (43.6)	98 (43.0)	12 (38.7)	20 (30.8)	170 (40.8)
Mean (SD)	106.2 (42.3)	132.8 (33.6)	167.4 (62.2)	196.8 (100.1)	150.8 (44.7)	158.4 (61.3)
Median (IQR)	97.5 (90 to 143)	126 (113 to 150)	150 (120 to 189)	167 (141 to 246.5)	129.5 (120 to 186)	150 (120 to 180)
Range	45 to 164	84 to 242	62 to 360	39 to 388	70 to 238	39 to 388
Intraoperative complications, n (%)						
Intraoperative fracture	0 (0)	1 (0.8)	1 (0.4)	0 (0)	1 (1.4)	3 (0.7)
Nerve injury	0 (0)	0 (0)	1 (0.4)	0 (0)	0 (0)	1 (0.2)
Blood vessel injury	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.4)	1 (0.2)
Other	0 (0)	0 (0)	1 (0.4)	1 (2.6)	0 (0)	2 (0.5)
Admission to HDU/ITU postoperatively, n (%)						
Yes	1 (7.1)	9 (11.8)	38 (16.9)	8 (26.7)	6 (9.7)	62 (15.2)
No	13 (92.9)	67 (88.2)	187 (83.1)	22 (73.3)	56 (90.3)	346 (84.8)

HDU/ITU, high-dependency/intensive treatment unit; IQR, interquartile range; PPF, periprosthetic fracture; SD, standard deviation.

exclusions, method of data collection, ethics, and study regulations can be found in our associated paper reporting the epidemiology and characteristics of femoral PPFs within the COMPOSE cohort.[6]

Overall, data on 720 femoral PPFs (539 hip, 151 knee, and 30 dividing type) were collected as part of the broader COMPOSE study. This paper presents a focused analysis of the management and outcomes of the 539 femoral fractures related to a hip arthroplasty. The COMPOSE study flowchart, describing overall patient distribution and the available data for analysis, is presented in Figure 1.

Data collection. Data collected relating to the management and outcomes of femoral hip PPFs included: management strategy (operative versus nonoperative), details of nonoperative management, details of operative management (revision and/or fixation versus fixation alone) including surgical strategy

Table II. Outcomes in patients with femoral hip periprosthetic fractures summarized by fracture classification (two fractures classified as F not presented as a separate column).

Variable	Hips (n = 537)					
	A (n = 61)	B1 (n = 118)	B2 (n = 250)	B3 (n = 39)	C (n = 69)	Overall (n = 537)
Length of hospital stay, days						
n (%)	58 (95.0)	117 (97.5)	249 (99.2)	38 (97.4)	69 (100)	533 (98.3)
Mean (SD)	13.4 (11.8)	18.6 (15.5)	20.2 (17.6)	19.5 (12.7)	21.1 (19.3)	19.1 (16.6)
Median (IQR)	10 (5 to 18)	14 (8 to 23)	15 (10 to 24)	15 (11 to 24)	16 (10 to 23)	15 (9 to 23)
Range	1 to 64	1 to 90	1 to 120	3 to 65	2 to 137	1 to 137
Readmitted within 30 days, n (%)						
Yes	7 (11.5)	7 (5.9)	19 (7.6)	1 (2.6)	11 (15.9)	45 (8.4)
No	54 (88.5)	111 (94.1)	230 (92.0)	38 (97.4)	58 (84.1)	491 (91.4)
Information unavailable	0 (0)	0 (0)	1 (0.4)	0 (0)	0 (0)	1 (0)
30-day mortality, n (%)						
Yes	1 (1.6)	5 (4.2)	15 (6.0)	7 (17.9)	0 (0)	28 (5.2)
No	60 (98.4)	113 (95.8)	235 (94.0)	32 (82.1)	69 (100)	511 (94.8)
Information unavailable	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12-month mortality, n (%)						
Yes	17 (27.9)	23 (19.5)	48 (19.2)	15 (38.5)	10 (14.5)	113 (21.0)
No	44 (72.1)	95 (80.5)	201 (80.4)	24 (61.5)	59 (85.5)	425 (79.0)
Information unavailable	0 (0)	0 (0)	1 (0.4)	0 (0)	0 (0)	1 (0)

IQR, interquartile range; SD, standard deviation.

Table III. Reoperation rates for those with periprosthetic hip fractures managed using either revision and/or fixation or fixation alone.

Variable	Revision and/or fixation (n = 246)	Fixation alone (n = 169)	Overall (n = 415)
Had operation post-discharge within 30 days, n (%)			
Yes	7 (2.8)	3 (1.8)	10 (2.4)
No	239 (97.2)	165 (98.2)	404 (97.6)
Had operation post-discharge within 12 months, n (%)			
Yes	25 (10.2)	11 (6.5)	36 (8.7)
No	220 (89.8)	157 (93.5)	377 (91.3)

employed, length of stay (LOS), discharge destination, and details of post-treatment outcomes (reoperation, readmission, and 30-day and 12-month mortality). All fractures were classified via the UCS classification system for PPFs.[5] A full list of data fields collected can be found in the Supplementary Material.

Statistical analysis. Management and outcome data were summarized descriptively using counts and percentages for categorical data and mean, standard deviation (SD), median, interquartile range (IQR), and minimum and maximum values for continuous data. A p-value < 0.05 was deemed statistically significant.

The femoral hip PPFs were grouped into two categories based on whether the underlying arthroplasty remained fixed to the bone or was loose. Category 1 comprised type A, B1, and C fractures (implant fixed to bone following PPF and therefore potentially suitable for fixation), while category 2 comprised B2 and B3 fractures (implant not fixed to bone following PPF and therefore likely to require revision). Candidate predictors of fracture management in femoral hip PPFs were summarized descriptively by whether the fracture was A/B1/C or B2/B3. A mixed-effects logistic regression model with fracture type as the dependent variable was implemented, controlling for the candidate predictors as fixed effects and site as a random effect. The candidate predictors were age, sex, residence type (own home, supported living, residential care, nursing care), whether the fracture was around a primary or revision implant, implant fixation (cemented or uncemented), and time between arthroplasty and PPF (< one year, one to ten years, or > ten years). Candidate predictors of management strategy were chosen using prior clinical knowledge. The impact of sparse data bias on the model estimates for binary outcomes was assessed using Firth logistic regression.

The impact of patient and fracture characteristics on each of the collected outcomes was assessed. Binary outcomes were analyzed using a mixed-effects logistic regression model including type of surgery (fixation alone, revision and/or fixation), age, sex, residence type (own home, supported living, residential care, nursing care), whether the fracture was around a primary or revision implant, time between arthroplasty and PPF (< one year, one to ten years, or > ten years) as fixed effects, and site as a random effect. LOS was analyzed using a mixed-effects Poisson regression model using the same fixed and random effects. Candidate predictors of outcomes were chosen using prior clinical knowledge.

The number of femoral hip PPFs at each of the 27 study sites were summarized dependent upon the management approach (operative vs nonoperative) using counts and percentages. For the most complex B2/B3 fracture group the patient's outcomes for those undergoing surgery were also reported based on surgical volume (low volume: ≤ one B2/B3 hip femoral PPF

Fig. 2

Association of patient characteristics with whether the femoral periprosthetic hip fracture (PPF) was managed operatively or nonoperatively. *Reference category males; †Reference category living in own home; ‡Reference category A/B1/C; §Reference category PPF around primary implant; ¶Reference category original implant uncemented; **Reference category early PPF. Descriptive comparison of candidate predictors for the operative and nonoperative PPFs groups are presented in Supplementary Table ii. CI, confidence interval.

operation/month; high volume: > one B2/B3 hip femoral PPF operation/month).

Results

PPF management. Descriptive summary of the 539 femoral hip PPFs analyzed, 417 (77.4%) were managed operatively with 122 (22.6%) managed nonoperatively. The proportion of patients treated nonoperatively was similar in patients with < two comorbidities (33 of 163 patients (20.1%) treated nonoperatively) compared to those with ≥ two comorbidities (89 of 375 patients (23.7%) treated nonoperatively.

In the nonoperative group, 20 (17.5%) patients were instructed to be ‘non-weightbearing’, 31 (27.2%) were ‘restricted weightbearing’, and 51 (44.7%) were ‘unrestricted weightbearing’. The remaining ten patients (8.1%) were treated palliatively and restricted to bed. The use of adjunctive immobilization with casts or splints was rarely seen (n = 2; 1.6%).

A detailed analysis of the operative management of hip femoral PPFs dependent upon the UCS fracture type is presented in Table I. The median time between admission and surgery for the 417 patients treated operatively was four days (IQR 2 to 7) and varied between three and 4.5 days, depending on the fracture type.

Overall, 246 (59.1%) of the surgical cases involved component revision and/or additional fixation, and 169 (40.6%) involved fixation alone, with one patient (0.2%) undergoing amputation. Most surgical cases (244; 58.6%) used multiple surgical strategies (Table I). The proportion of patients undergoing a revision procedure varied by fracture type (Table I). Revision occurred in only 25% (n = 16) and 30% (n = 23) of C and B1 type fractures, respectively, but was more frequently observed in B2/B3 fractures (n = 176 and n = 24, respectively, both 77%). For B1 fractures, single-plate fixation (n = 48; 61.5%) and cerclage cables (n = 58; 74.4%) were the most used surgical strategies. For B2 fractures, cerclage cables (n = 131; 57.5%), uncemented revision (n = 104; 45.6%), and cemented revision (n = 72; 31.6%) were the most used surgical strategies. For B3 fractures, cerclage cables (n = 13; 41.9%), uncemented revision (n = 12; 38.7%), and cemented revision (n = 11; 35.5%) were the most used surgical strategies. For C fractures, single plate fixation (n = 48; 73.8%) and cerclage cables (n = 33; 50.8%) were the most used surgical strategies (Table I). Augments to fixation such as strut graft (n = 2; 0.5%), bone graft/biocomposite augmentation (n = 6; 1.4%), and cement augmentation (n = 7; 1.7%) were rarely employed. Where a hip prosthesis was revised, revision of the reciprocal (acetabular) component was reported in 99 patients (40.7%) (Table I).

Operating time reflected operative complexity with B3 fractures requiring the longest time in theatre (median 167 minutes (IQR 141 to 246.5)) (Table I). While rates of intraoperative complications were low (n = 7; 1.6%) a significant proportion of patients required high-dependency/intensive treatment unit (HDU/ITU) admission in the postoperative phase (n = 62; 15.2%). Complexity was also reflected in rates of HDU/ITU admission, with the highest rates again seen in the most complex B3 fractures (n = 8; 26.7%) (Table I).

Site variation in PPF management. Data for the number of femoral hip PPFs treated at each of the 27 study sites are presented in Supplementary Table i, which also provides details of

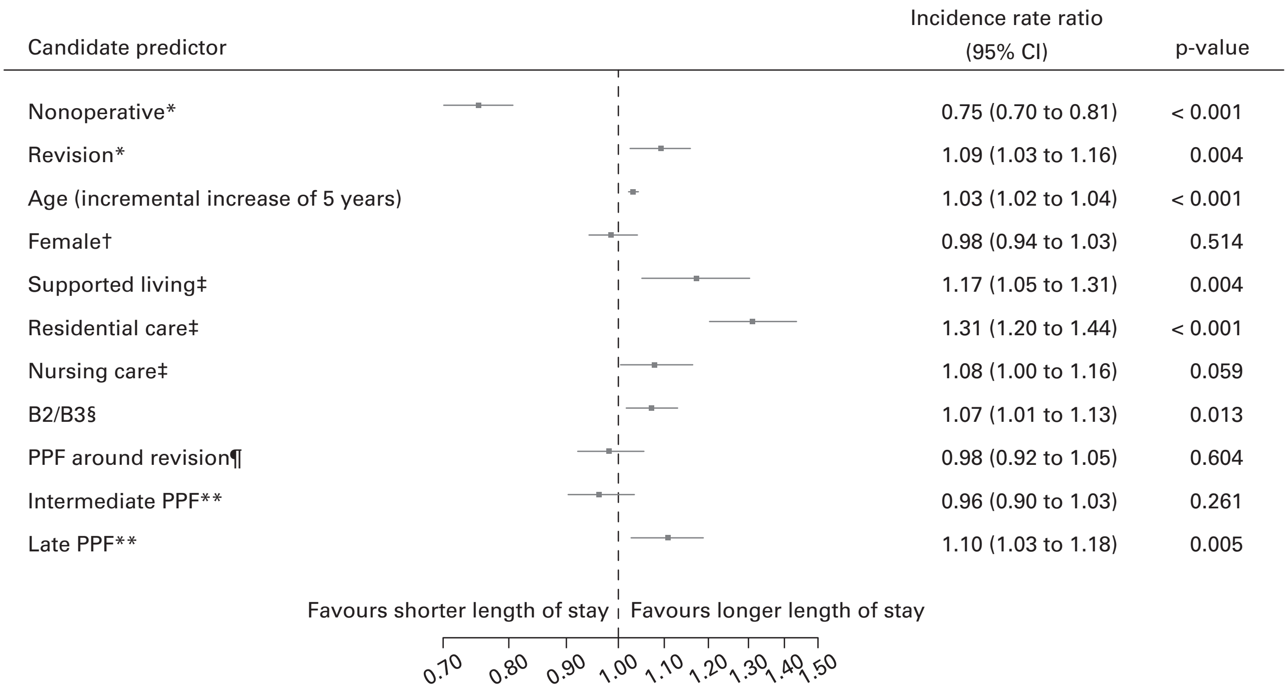

Fig. 3

Forest plot displaying predictors of length of stay for patients with femoral periprosthetic hip fracture (PPF). *Reference category fixation; †Reference category male; ‡Reference category living in own home; §Reference category A/B1/C; ¶Reference category PPF around primary; **Reference category early PPF. Descriptive comparison of candidate predictor variables based on the median length of stay (15 days) is presented in Supplementary Table iii. CI, confidence interval.

the management strategy used at each site (nonoperative; operative revision and/or fixation; operative fixation alone). There was wide variation in the use of nonoperative management (range 0% to 64% of cases) and the surgical techniques employed (revision and/or fixation range 0% to 94% of cases; fixation alone range 0% to 100% of cases) across the study sites.

Predictors of management strategy. Complete data were available for 475 PPFs (88.5%), which were included in the models for candidate predictors of management strategy (Supplementary Table ii). Patients whose PPF was type B2/B3 (OR 7.56 (95% CI 4.14 to 13.78); $p < 0.001$, mixed-effects logistic regression) and whose original implant was cemented (OR 2.66 (95% CI 1.42 to 4.99); $p = 0.002$, mixed-effects logistic regression) were more likely to have their PPF managed operatively (Figure 2). There was a trend towards patients living in supported living (OR 0.33 (95% CI 0.09 to 1.16); $p = 0.084$, mixed-effects logistic regression) or being in residential care (OR 0.38 (95% CI 0.13 to 1.07); $p = 0.067$, mixed-effects logistic regression) being more likely to have their PPF managed nonoperatively, although this was not significant.

PPF outcomes: descriptive summary. The rates of complications, length of stay, 30-day and 12-month reoperation rates, 30-day readmission rate, and 30-day and 12 month mortality rates following hip, knee, and dividing femoral PPFs are presented in Table II. The median length of stay was 15 days (IQR 9 to 23).

The overall 30-day and 12-month reoperation rates were 2.8% (n = 15) and 8.0% (n = 43), respectively. For the subset that were managed operatively (n = 417) the 30-day and 12-month reoperation rates were 2.4% (n = 10) and 8.7% (n = 36) with a higher 12-month reoperation rates observed in patients treated with revision and/or fixation (n = 25; 10.2%) compared to fixation alone (n = 11; 6.5%) (Table III).

The 30-day readmission rate was 8.4% (n = 45). The overall 12-month mortality rate was 21.0% (n = 113). The 30-day and 12-month mortality rates varied by UCS fracture type, with B3 hip PPFs having the highest 12-month mortality (38.5%) (Table II).

Predictors of outcome. Complete data were available for 465 (LOS), 473 (30-day readmission), and 473 (12-month mortality) PPFs which were included in the models for candidate predictors of management strategy (Supplementary Table iii). Formal analyses could not be carried out for 30-day mortality due to sparse data. For the remaining outcomes, results are displayed in Figures 3 to 5.

In the model examining LOS, nonoperative treatment was associated with a shorter LOS when compared to patients operated on using fixation alone (incidence rate ratio (IRR) 0.75 (95% CI 0.70 to 0.81); $p < 0.001$, mixed-effects logistic regression). In contrast, undergoing a revision procedure was associated with a longer length of stay when compared to patients operated on using fixation alone (IRR 1.09 (95% CI 1.03 to 1.16); $p = 0.004$, mixed-effects logistic regression). Additional factors found to be associated with a longer length of stay included older age (IRR 1.03 (95% CI 1.02 to 1.04); $p < 0.001$, mixed-effects logistic regression), being admitted from supported living (IRR 1.17 (95% CI 1.05 to 1.31); $p = 0.004$,

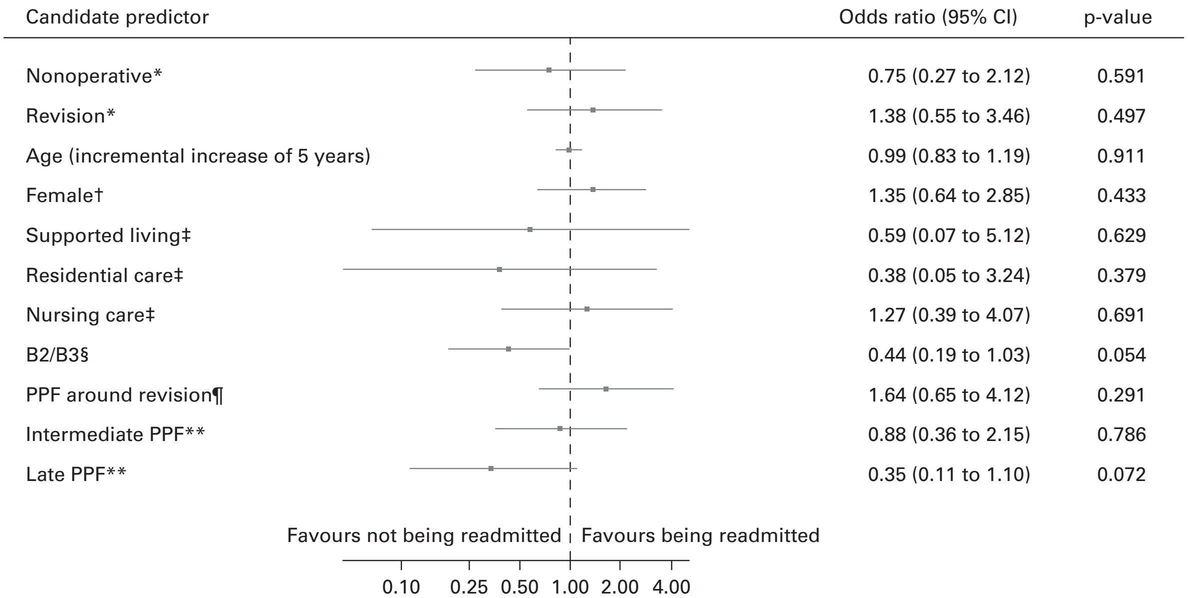

Fig. 4

Forest plot displaying predictors of hospital readmission within 30 days of discharge for patients with femoral periprosthetic hip fracture (PPF). *Reference category fixation; †Reference category male; ‡Reference category living in own home; §Reference category A/B1/C; ¶Reference category PPF around primary; **Reference category early PPF. Descriptive comparison of candidate predictor variables based on readmission (Yes/No) is presented in Supplementary Table iii. CI, confidence interval.

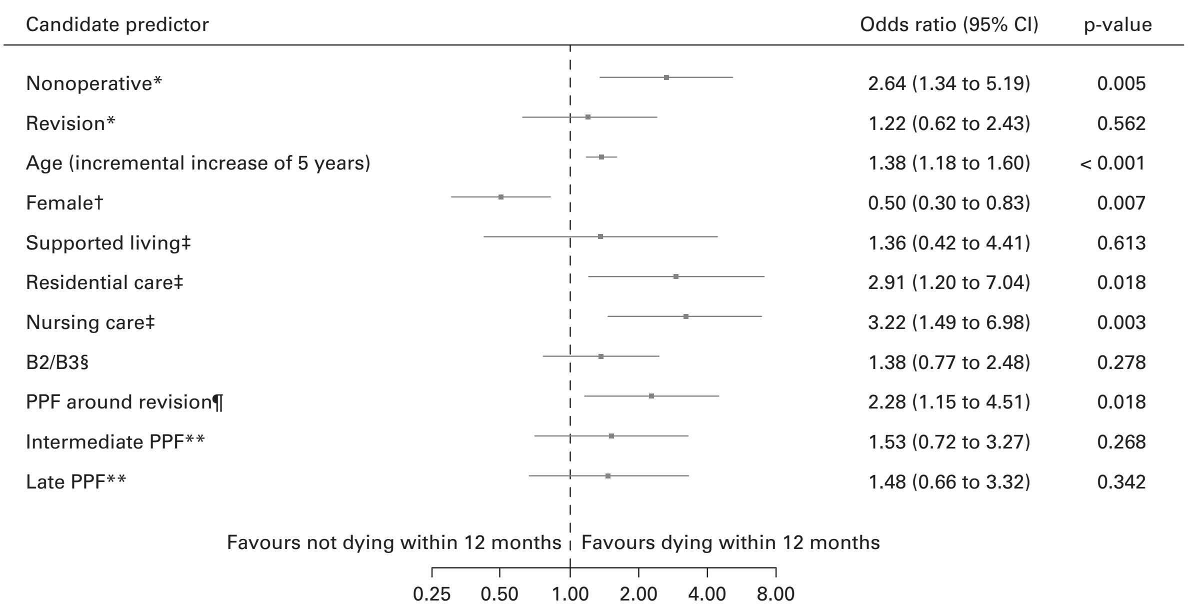

Fig. 5

Forest plot displaying predictors of 12-month mortality for patients with femoral periprosthetic hip fracture (PPF). *Reference category fixation; †Reference category male; ‡Reference category living in own home; §Reference category A/B1/C; ¶Reference category PPF around primary; **Reference category early PPF. Descriptive comparison of candidate predictor variables based on 12-month mortality (Yes/No) is presented in Supplementary Table iii. CI, confidence interval.

Table IV. Outcomes for those with B2/B3 periprosthetic hip fractures managed using either revision and/or fixation, or fixation alone.

Outcome	Revision and/or fixation (n = 200)	Fixation alone (n = 58)	Overall (n = 258)
Complications prior to discharge, n (%)			
Yes	46 (23.2)	16 (28.1)	62 (24.3)
No	152 (76.8)	41 (71.9)	193 (75.7)
Length of hospital stay, days			
n (%)	200 (100)	57 (98.3)	257 (99.6)
Mean (SD)	20.7 (16.6)	17.6 (14.6)	20.0 (16.2)
Median (IQR)	16 (10 to 24)	13 (10 to 22)	15 (10 to 24)
Range	3 to 119	4 to 105	3 to 119
Had operation post-discharge within 30 days, n (%)			
Yes	7 (3.5)	0 (0)	7 (2.7)
No	193 (96.5)	57 (100)	250 (97.3)
Had operation post-discharge within 12 months, n (%)			
Yes	20 (10.1)	2 (3.5)	22 (8.6)
No	179 (89.9)	55 (96.5)	234 (91.4)
Readmitted within 30 days, n (%)			
Yes	15 (7.5)	4 (7.0)	19 (7.4)
No	185 (92.5)	53 (93.0)	238 (92.6)
30-day mortality, n (%)			
Yes	11 (5.5)	2 (3.4)	13 (5.0)
No	189 (94.5)	56 (96.6)	245 (95.0)
12-month mortality, n (%)			
Yes	34 (17.0)	12 (21.1)	46 (19.9)
No	166 (83.0)	45 (78.9)	211 (82.1)

IQR, interquartile range; SD, standard deviation.

Table V. Outcomes for those with B2/B3 periprosthetic hip fractures managed using either revision and/or fixation or fixation alone, presented by whether the study site was low-volume (usually less than or equal to one operation per month) or high-volume (generally more than one operation per month).

Outcome	Operated on at low-volume site (n = 117)	Operated on at high-volume site (n = 141)	Overall (n = 258)
Complications prior to discharge, n (%)			
Yes	29 (25.2)	33 (23.6)	62 (24.3)
No	86 (74.8)	107 (76.4)	193 (75.7)
Length of hospital stay, days			
n (%)	116 (100)	141 (100)	257 (100)
Mean (SD)	23.2 (18.9)	17.3 (13.1)	20.0 (16.2)
Median (IQR)	18 (11 to 28.5)	14 (10 to 21)	15 (10 to 24)
Range	3 to 119	3 to 95	3 to 119
Had operation post-discharge within 30 days, n (%)			
Yes	5 (4.3)	2 (1.4)	7 (2.7)
No	111 (95.7)	139 (98.6)	250 (97.3)
Had operation post-discharge within 12 months, n (%)			
Yes	16 (13.9)	6 (4.3)	22 (8.6)
No	99 (86.1)	135 (95.7)	234 (91.4)
Readmitted within 30 days, n (%)			
Yes	14 (12.1)	5 (3.5)	19 (7.4)
No	102 (87.9)	136 (96.5)	238 (92.6)
30-day mortality, n (%)			
Yes	6 (5.1)	7 (5.0)	13 (5.0)
No	111 (94.9)	134 (95.0)	245 (95.0)
12-month mortality, n (%)			
Yes	26 (22.4)	20 (14.2)	46 (17.9)
No	90 (77.6)	121 (85.8)	211 (82.1)

IQR, interquartile range; SD, standard deviation.

Table VI. Information on residence type pre-fracture and post-fracture, presented by fracture location.

Variable	Hips (n = 539)
Residence type pre-PPF, n (%)	
Own home	431 (80.0)
Supported living	20 (3.7)
Residential care	30 (5.6)
Nursing care	56 (10.4)
Information unavailable	2 (0.4)
Discharge destination, n (%)	
Own home	270 (50.1)
Supported living	18 (3.4)
Respite care	0 (0)
Residential care	44 (8.2)
Nursing care	103 (19.1)
Another hospital	72 (13.4)
Died	23 (4.3)
Information unavailable	9 (1.7)

PPF, periprosthetic fracture.

mixed-effects logistic regression) or a residential accommodation (IRR 1.31 (95% CI 1.20 to 1.44); p < 0.001, mixed-effects logistic regression), sustaining a B2/B3 fracture (IRR 1.07 (95% CI 1.01 to 1.13); p = 0.013, mixed-effects logistic regression) and sustaining the PPF > ten years after initial implantation (IRR 1.10 (95% CI 1.03 to 1.18); p = 0.005, mixed-effects logistic regression) and (Figure 3).

No variables were found to be associated with the likelihood of being readmitted to hospital within 30 days, although the fracture being B2/B3 was of borderline significance (OR 0.44 (95% CI 0.19 to 1.01); p = 0.054, mixed-effects logistic regression) (Figure 4).

Patients treated nonoperatively were more likely to die within 12 months compared to those treated operatively using fixation alone (OR 2.64 (95% CI 1.34 to 5.19); p = 0.005, mixed-effects logistic regression). However, there was no observed difference between patients operated using a 'fixation alone' approach and those undergoing a revision procedure. Additional factors found to be associated with an increased likelihood of dying within 12 months of injury included older age (OR 1.38 (95% CI 1.18 to 1.60); p < 0.001, mixed-effects logistic regression), being in residential care (OR 2.91 (95% CI 1.20 to 7.04); p = 0.018, mixed-effects logistic regression), or nursing care (OR 3.22 (95% CI 1.49 to 6.98); p = 0.003, mixed-effects logistic regression), and sustaining the PPF around a revision rather than a primary prosthesis (OR 2.28 (95% CI 1.15 to 4.51); p = 0.018, mixed-effects logistic regression) (Figure 5). Being female was found to be associated with a decreased likelihood of dying within 12 months of injury (OR 0.50 (95% CI 0.30 to 0.83); p = 0.007, mixed-effects logistic regression).

Outcomes for B2/3 fractures. In total, there were 289 B2/B3 fractures, of which 200 (69.2%) were managed using revision and/or fixation, 58 (20.1%) were managed using fixation alone, and one was managed using amputation. Outcomes dependent upon the surgical management are presented in Table IV. Other than observing a higher 12-month reoperation rate in the revision and/or fixation group (10.1% vs 3.5% in the fixation alone group), the outcomes for these two groups were similar (Table IV).

Of the 258 B2/B3 PPFs managed operatively, 117 (45.3%) were managed at low-volume sites (less than or equal to one B2/B3 operation per month) and 141 (54.7%) were managed at high-volume sites (more than one B2/B3 operation per month) (Table V). There was a tendency for longer LOS (median 18 days vs 14 days), a higher 12-month reoperation rate (16 cases (13.9%) versus six cases (4.3%)), and a higher 12-month mortality rate (26 cases (22.4%) versus 20 cases (14.2%) in the low-volume centres based on the unadjusted descriptive data (Table V).

Discharge destination. Information on the patients place of residence pre- and post-fracture dependent upon the fracture location is presented in Table VI. Of the 431 femoral hip PPFs admitted from their own home, only 264 (61.3%) were discharged back to their own home post-discharge.

Discussion

The COMPOSE study demonstrates variation in fracture management both within and between UCS fracture types, and also on the treating site. Multiple operative and nonoperative strategies were reported reflecting the heterogeneity in the fractures that present to hospital and the complexity of management. Surgical waiting times were typically > four days, and the overall 12-month mortality rates were > 20%.

The study was designed to be a descriptive analysis of the characteristics, management, and outcomes of PPFs. We have therefore been careful not to over-interpret unadjusted data and draw strong inferences from observed differences, except in the instances that we have performed adjusted statistical comparisons. However, despite this caveat, there are a number of interesting observations that merit further investigation and should be the focus of future research. First, there was wide variation in the management approaches used across the 27 study sites. This is possibly due to the availability of surgeons, their training background, and their surgical skillsets, as differences in the management of distal femoral PPFs have been reported depending on whether the surgeon comes from a trauma or arthroplasty background.[7] Second, we observed differences in outcomes between high- and low-volume centres for the most complex B2/3 fractures. The impact of surgical volume is increasingly recognized in orthopaedic surgery,[8] and this finding provides further evidence to support the cohorting of these cases in high-volume centres. Third, we observed higher reoperation rates in cases undergoing revision and/or fixation compared to fixation alone, both for all surgically treated fractures and for the B2/B3 subset. While these differences were small, and we have been careful not to ascribe statistical significance to them due to a lack of adjustment, comparison of different strategies to management could be an area for future research. Finally, in our adjusted models, the nonoperative patients had the highest mortality but the shortest LOS. Possible explanations for this finding are that a proportion of the nonoperative patients died early after fracture, or that having made the decision to treat nonoperatively, patients were discharged back to care facilities or intermediate care beds to reduce the pressure on acute trauma services.

The majority of patients in our study underwent operative intervention (77%), similar to the 73% reported by Bottle et al[2] in their analysis of UK HES data. Other series reporting on specific subsets of hip PPFs have reported higher operative rates of 84% to 94%.[9,10] In their analysis, Bottle et al[2] reported that both males and females over the age of 84 years were less likely to undergo surgery in comparison to younger patients, as well as those with increasing socioeconomic deprivation, chronic obstructive pulmonary disease, or a pre-existing neurological disorder. COMPOSE observed similar rates on nonoperative treatment in patients with comorbidities compared to those without comorbidities. It also found that the method of stem fixation and fracture type were predictors of the decision to treat operatively. These variables would not have been available from HES, and this represents new information about the decision-making process used by surgeons to treat femoral hip PPFs.

In COMPOSE, the most common strategies used in patients sustaining femoral hip B1 PPFs were single plate fixation and cerclage cables. The proportions undergoing fixation (71%) were similar to the findings of an Italian single-site study, which reported that 77% of patients underwent fixation.[11] There continues to be a lack of consensus in how to manage B2/3 fractures, however, COMPOSE found that 77% of femoral hip B2/B3 PPFs underwent revision, and that sustaining this fracture type around a cemented implant was positively correlated with the patient undergoing surgical intervention. For B2 and B3 fractures, the proportions of patients undergoing revision (B2 77%; B3 77%) were lower than the 87% (B2) and 96% (B3) reported in the Cochrane Review by Khan et al.[12] The difference in the proportion of patients undergoing revision for B1 and B2/B3 PPFs may to be due to the contemporary use of taper-slip cemented femoral stem designs.[13] The taper-slip stem design requires controlled subsidence within an intact cement mantle and therefore, when the cement-implant interface is broken, the implant is by definition loose and may require revision. In uncemented, proximally well-fixed implants, a fixation alone may be appropriate.[9,13]

National standards for the treatment of hip fragility fractures stipulate that these injuries should be operated on within 36 hours of admission.[14] COMPOSE data demonstrated that for all fractures, the median time between admission and surgery across 27 NHS sites was four days. The longest waits were observed in hip B2/3 type PPFs, in which the majority of patients underwent revision. A recent systematic review by Farrow et al[15] reported a mean time to surgery of 2.7 days, and observed that delays in surgery were associated with higher mortality and poorer clinical outcomes, including greater risk of medical complications, longer length of stay, higher transfusion risk, and increased rates of reoperation. Griffiths et al[10] reported that a delay to surgery of greater than 72 hours led to increased risk of postoperative complications, whereas Bliemel et al[16] observed that early surgery had no effect on mortality and patient outcomes at 120 days, but did find that the risk of reoperation was significantly higher in patients whose surgery was delayed. Other studies have failed to find an association between the timing of surgery and hospital length of stay or mortality at one year.[17,18] While timely surgery is likely to reduce the risks to patients, it is important to recognize that these are complex injuries that often require significant planning, surgical experience, and appropriate theatre resources to ensure an optimal surgical result.

A significant proportion of patients who lived in their own homes prior to their PPF did not return to their own home postoperatively (n = 167/431; 39%). This is higher than the 25% reported in a large observational study using HES data including all PPFs,[2] but lower than 65% observed in B type femoral hip PPFs from Sweden.[19] The reported 30-day and 12-month reoperation rates (2.8% and 5.6%) were much lower than the reoperation rate of 13.3% reported by Khan et al,[12] although a timescale for reoperation was not provided within their review, making direct comparison difficult. They observed that B2/B3 fractures treated without revision of the stem were associated with a higher rate of reoperation.[12] Reoperation rates in our cohort may continue to rise beyond 12 months due to late fixation failures.

We observed that the mortality rate for all femoral hip PPFs increased from 5.2% at 30 days to 21.0% at 12 months. This is similar to the 12-month rates previously reported in the literature for people experiencing hip PPFs (21%).[2,10,17,18] However, we observed variation in mortality outcomes dependent upon fracture type, method of surgical reconstruction, and, for B2/3 fracture, the hospital surgical volume. Older age and being in supported/residential care prior to injury predicted the greatest risk of death within 12 months. Our 30-day mortality rate was also similar to the rates for hip fracture reported by the National Hip Fracture Database, but our cohort had higher rates of failing to return to their own home and longer waits between admission and surgery.[20] The median LOS (15 days) observed was similar to the 17 days reported by Bottle et al.[2] Their findings of a longer LOS in older patients and those managed operatively concurred with our data demonstrating a longer LOS in older patients, those requiring a revision, those from residential care or supported living, and those who sustained a PPF > ten years after their original surgery.[2] Approximately one-quarter of our cohort had a complication prior to discharge. Griffiths et al[10] found that generally patients who had complications during their treatment had a delayed discharge and stayed 4.5 days longer.

This study is limited by its retrospective design. Data collection was dependent on individual, independent investigators at each site, and required adequate clinical coding in the participating hospitals to retrospectively identify patients undergoing both operative and nonoperative treatment. Patients who were managed nonoperatively may not have been coded correctly, or may have been assigned a different diagnosis and therefore may not have appeared in the hospital records used to identify patients for this study. This could have resulted in an underestimation of the number of nonoperative patients, particularly if they were managed in an outpatient setting. The sites were also responsible for classifying the fracture type, albeit based on a variety of available data sources including operation notes, clinical notes, and radiographs. Inter-reporter variability in the recording of the UCS type is a known issue with this classification system, particularly with differentiating between B1 and B2 fractures. However, our results have good face validity, which offsets concerns that this may have impacted the findings. Furthermore, we did not collect data about the reasons for delays to surgery, which may have provided valuable information about how care is delivered to this group of patients.

In conclusion, although patients sustaining femoral hip PPFs are broadly similar to those with hip fractures, COMPOSE suggests that they have a more complicated treatment course and wait longer for surgery. There is a need to create a national framework for data collection for this heterogeneous group of patients, to help build an evidence base to support clinical decision-making and management based on patient and fracture characteristics and study their long-term outcomes. Further work should focus on developing strategies to improve the timing and delivery of care, identifying risks factors associated with poor outcomes and defining a core outcome set to allow standardized reporting within clinical studies.

Take home message

- Femoral periprosthetic fractures (PPFs) at the hip have an overall 12-month mortality of 21% with the most complex B3 type having the highest mortality (38.5%).
- PPF patients requiring surgery typically wait for > four days, in contrast to standard hip fracture care where best practice tariff is linked to surgery within 36 hours.
- Variation in PPF management was observed within and between fractures types and also by hospital site, possibly reflecting the heterogenity of these fractures and the associated patient group.

Supplementary material

Tables describing the site variation in the management of femoral periprosthetic hip fractures across the 27 COMPOSE study sites, and details of the patients' characteristics for the four outcomes presented in the figures in the main manuscript (operative vs nonoperative management, length of stay (LOS) (based on median LOS), 30-day readmission, and 12-month mortality).

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Ethical review statement:
The COMPOSE study was performed as a service evaluation as it was collecting retrospective, anonymized information about care that had previously been delivered. All patients received standard care as per their treating centre and their surgeon’s usual practice. There was no requirement for ethical approval or patient consent as checked against the Health Research Authority criteria. The study was registered locally at each site as a service evaluation prior to data collection.

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