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ORIGINAL ARTICLE

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Internal fixation versus revision arthroplasty for Vancouver B2–B3 fractures: mortality and functional outcomes in frail patients. Insights from the PIPPAS study of 485 patients

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Abstract

Background Periprosthetic femoral fractures following hip arthroplasty (FH-PPF) represent a severe complication, especially in elderly patients with compromised health. Traditionally, revision arthroplasty is recommended for B2–B3 FH-PPF, yet internal fixation has emerged as a debated alternative in select patients. The hypothesis was that fixation, in selected patients with B2–B3 FH-PPF, decreases mortality and surgical complication rates with the same functional outcomes as revision arthroplasty.

Materials and methods PIPPAS is a multicenter prospective observational study. This cohort substudy includes 485 patients across 57 hospitals with B2–B3 FH-PPF between January 2021 and May 2023. Management strategy, revision or fixation, was at the attending surgeon's discretion. Propensity score matching, controlled for age, age-adjusted CharIson Comorbidity Index (a-CCI), prefracture mobility, Pfeiffer scale, and ASA score, was done. Mortality risk factors were assessed using univariate and multivariate analysis.

Results Out of 485 patients, 164 received fixation, and 321 underwent revision. Fixation patients were older (88 versus 82 years, $p < 0.001$) and frailer. Fixation was associated with shorter hospital stay (13 versus 15 days, $p = 0.003$) but higher 1-year mortality (25% versus 14.3%, $p = 0.04$). There were no differences in medical or surgical complications ($p = 0.83$ and $p = 0.36$) at any time, but dislocation rate was higher in the revision group ($p = 0.001$). The 1-year mortality rate in patients with no weight-bearing restrictions was higher for the revision group ($p = 0.01$). The propensity score matching showed higher 1-year mortality rate in the fixation group but no differences in functional outcomes, complications, or up to 6-months mortality. In the multivariate analysis a-CCI, cognitive impairment, B3 fractures, and prefracture independent walking impairment were independent mortality risk factors.

Conclusions Revision arthroplasty showed less 1-year mortality rate and weight-bearing restrictions than fixation. However, frail patients with B2–B3 FH-PPF managed with fixation allowing full weight-bearing showed a lower 1-year mortality rate. Fixation in B2–B3 FH-PPF is a treatment option in frail patients, while aiming for stable constructions allowing full weight-bearing.

Level of Evidence II: prospective cohort study.

Trial registration: ClinicalTrials.gov (NCT04663893)

Keywords Periprosthetic fracture, Orthogeriatrics, Vancouver B2 fracture, Vancouver B3, Mortality, Revision, Fixation, Frailty, Weight-bearing, Total hip arthroplasty

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Graphical Abstract

Fix or Replace?

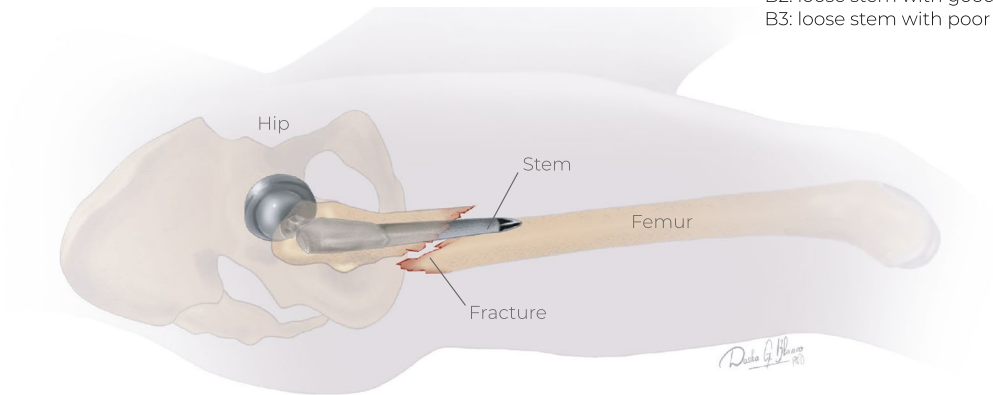
What the PIPPAS study found about B2-B3 femur fractures

Hip replacement surgeries are increasing worldwide as populations age.

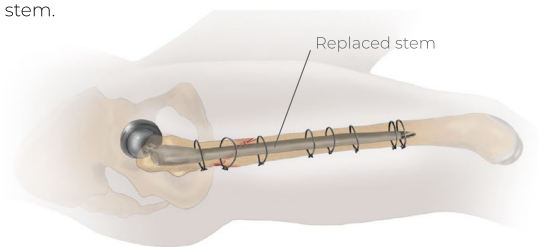
Bone fractures around hip replacements are dangerous, especially in elderly patients.

B fractures occur around the implant stem

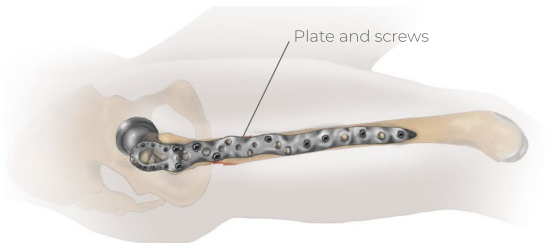
B2: loose stem with good bone.
B3: loose stem with poor bone.



Replacement Treatment
B2-B3 fractures are usually treated by replacing the stem.

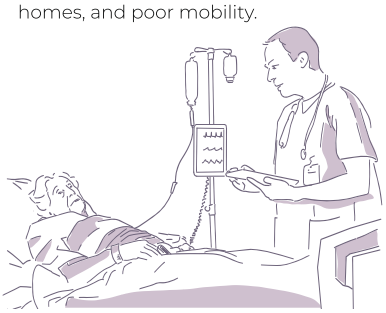


Internal fixation
A promising alternative for specific patient groups.

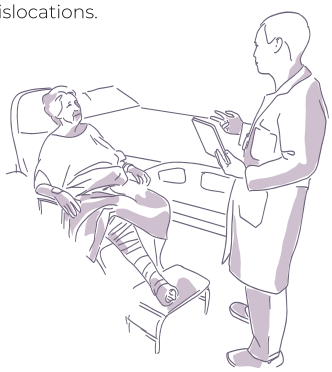


Fixation group

Who Gets Fixation?
Older (88 vs 82), frailer patients with memory problems, living in nursing homes, and poor mobility.



Better Outcomes
Shorter hospital stays and fewer dislocations.



Key Finding
Frail patients treated with fixation had lower death rates when allowed full weight-bearing.

Weight-bearing as tolerated soon after hip fracture surgery reduces complications and death rates.

Illustrations & Infographic: Dasha G. del Blanco

Introduction

Periprosthetic femoral fractures after hip arthroplasty (FH-PPF) are a severe complication. Their incidence is rising worldwide [1] owing to the increase in the global number of hip arthroplasty procedures and the high prevalence of elderly patients carrying a hip arthroplasty. According to the Unified Classification System (UCS), B type fractures sit around or just below the stem and are subdivided into B1 when the stem is fixed, B2 if the stem is loose with adequate bone stock, and B3 when the stem is loose and the bone quality is poor [2]. The management strategy recommended for B2–B3-type FH-PPF is revision arthroplasty of the stem [2–5]. As these fractures occur mainly in elder and frail patients with poor functional status, there is recent controversy about whether this treatment is ideal for all patients. Therefore, there is an ongoing debate whether management with internal fixation can be a valid treatment option in selected cases [6–9]. Recent studies comparing revision versus fixation alone present similar reoperation rates [8–14].

Our hypothesis was that fixation, in selected patients with B2–B3 FH-PPF, decreases mortality and surgical complication rates with the same functional outcomes as revision arthroplasty.

Materials and methods

The PIPPAS study is a collaborative multicenter prospective observational case series study (level IV evidence) evaluating PPF and peri-implant fractures in 56 Spanish hospitals and one hospital in Buenos Aires, Argentina [15]. B2–B3 FH-PPF management was the standard of care at each participating site, as determined by the attending surgeon. This cohort substudy, fixation versus revision arthroplasty, included patients aged 18 years or older who presented with a B2- or B3-type FH-PPF between January 2021 and May 2023, with available 1-year follow-up clinical data. We excluded patients managed nonoperatively, patients with intraoperative or pathologic fractures, patients with fractures between a hip stem and any other distal implant, and pregnant patients. Written consent for participation in the study was obtained from all participants or their legal representatives.

The primary outcome was 1-year mortality rate; secondary outcomes were postoperative weight-bearing restrictions, 1-year surgical complication rate (including dislocation, refracture, infection, nonunion, and revision surgery), medical complication rate, worsening of mobility, cognitive impairment or clinical frailty score (CFS), moving to a nursing home, health-related quality of life, and fracture healing.

Prospective data collection included patient demographics, management, and outcomes based on the Fragility Fracture Network's Minimum Common Dataset for hip fracture audits but adapted to the specific nature of FH-PPFs [16] (appendix 1). Cognitive status was assessed with the Pfeiffer Short Portable Mental Status Questionnaire (SPMSQ) [17]. Distinction between B1 and B2–B3 types was at the discretion of the treating team based on clinical, radiological and surgical findings. Previous clinical history of thigh pain was suggestive of loosening. X-rays showing subsidence, progressive lucencies in multiple Gruen zones, pedestal formation, and calcar remodeling were indicative of type B2 fractures or type B3 fractures if there were also sings of osteolysis and poor supportive bone stock [18]. The intraoperative assessment included direct testing with traction, rotation and visual assessment of cement–bone or stem–bone interface. We classified surgeons into two groups of expertise: those performing more than 20 revision arthroplasty procedures and/or more than 20 minimally invasive fixations per year and those performing fewer than 20 procedures in either category. The weight-bearing protocol at hospital discharge was determined by the surgical team at each site according to local practice. However, the prescription of weight-bearing restrictions did not necessarily ensure patient adherence. Several patients may have performed weight-bearing as tolerated after discharge, which was often only identified at the 30-day follow-up visit, at which time the weight-bearing recommendation was usually revised. Health-related quality of life was assessed using the EQ-5D-5L instrument at 6 and 12 months [19]. Fracture healing was defined as the presence of at least three cortical callus bridges on radiographic examination and pain-free full weight-bearing. A comprehensive list of variables is available in the Supplementary Material. Data were collected and managed using REDCap electronic data capture tools hosted at the Instituto de Estudio de Ciencias de la Salud de Castilla y León, Spain [20]. The manuscript was adapted to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [21]. The study was conducted in accordance with the ethical standards laid down in the 1964 Helsinki Declaration and received approval from the institutional review boards of the coordinating center and each participating hospital. This study is registered at ClinicalTrials.gov (NCT04663893).

Statistical analysis

Descriptive statistics summarized group epidemiological data and outcomes between "fixation" and "revision arthroplasty" groups. Continuous variables were

Table 1 Demographic, baseline data for patients presenting a type B2 or B3 femoral hip periprosthetic fracture (FHPPF), management and hospital outcomes: Qualitative variables are summarized using counts and percentages (%)

	Total	Fixation	Revision	*p*-Value
n	485	164	321	
Baseline:				
Age (years)*	84 [14]	88 (8)	82 (15)	< 0.001
Sex, *n* (%):				
Female	306 (63.09%)	112 (68.29%)	194 (60.44%)	0.110
Male	179 (36.91%)	52 (31.71%)	127 (39.56%)	
Place of residence, *n* (%):				
Community	415 (85.57%)	129 (78.66%)	286 (89.1%)	0.003
Health institution	70 (14.43%)	35 (21.34%)	35 (10.9%)	
Prefracture mobility*, *n* (%):				
Independent outdoors	354 (73.14%)	106 (64.63%)	248 (77.5%)	0.009
Independent indoors	86 (17.77%)	37 (22.56%)	49 (15.31%)	
Dependent	44 (9.09%)	21 (12.8%)	23 (7.19%)	
Pfeiffer's SPMSQ*	2 (5)	3 (4)	2 (4)	< 0.001
CFS*	4 (3)	5 (2)	4 (3)	0.001
ASA*	3 (1)	3 (1)	3 (1)	0.037
CCI age-adjusted*	5 (2)	5 (2)	5 (2)	0.001
Osteoprotective treatment, *n* (%):				
Yes	136 (28.04%)	53 (32.32%)	83 (25.86%)	0.164
No	349 (71.96%)	111 (67.68%)	238 (74.14%)	
Antiaggregant or anticoagulant medication, *n* (%):				
Yes	190 (39.18%)	75 (45.73%)	115 (35.83%)	0.038
No	295 (60.82%)	89 (54.27%)	206 (64.17%)	
Hb at admission (gr/dL)^	12.08 (1.87)	11.87 (1.98)	12.19 (1.81)	0.119
Fracture features:				
UCS type:				
B2	389 (80.21%)	137 (83.54%)	252 (78.5%)	0.541
B3	96 (19.79%)	27 (16.46%)	69 (21.5%)	
Cemented or uncemented stem				
Cemented	142 (29.28%)	55 (33.54%)	87 (27.1%)	0.171
Uncemented	343 (70.72%)	109 (66.46%)	234 (72.9%)	
Time since stem implantation (months)*	120 (131.75)	130 (126.5)	115 (141)	0.023
Dysfunctional prosthesis				
Yes	225 (46.49%)	66 (40.24%)	159 (49.69%)	0.061
No	259 (53.51%)	98 (59.76%)	161 (50.31%)	
Management				
Surgical delay (h)*	154.71 (593.26)	128.69 (105.29)	168 (795.39)	0.007
Anesthesia				
General	171 (35.33%)	31 (19.02%)	140 (43.61%)	< 0.001
Neuroaxial	313 (64.67%)	132 (80.98%)	181 (56.39%)	
Team expertise:				
< 20 procedures per year	157 (32.37%)	57 (34.76%)	100 (31.15%)	0.484
> 20 procedures per year	328 (67.63%)	107 (65.24%)	221 (68.85%)	
Surgical approach:				
Less invasive	34 (7.01%)	34 (20.73%)	0	< 0.001
Open	451 (92.99%)	130 (79.27%)	321 (100%)	
Was the stability of the stem checked?				
Yes	444 (91.55%)	123 (75%)	321 (100%)	< 0.001

Table 1 (continued)

	Total	Fixation	Revision	*p*-Value
No	41 (8.45%)	41 (25%)	0	
Cerclage for reduction				
Yes	430 (88.66%)	138 (84.15%)	292 (90.97%)	0.037
No	55 (11.34%)	26 (15.85%)	29 (9.03%)	
Type of fixation:				
Plate	242 (49.90%)	152 (92.68%)	90 (28.04%)	< 0.001
Cerclage wiring	144 (29.69%)	12 (7.32%)	132 (41.12%)	
Medical staff involved⋄				
Geriatrics	190 (39.18%)	76 (46.34%)	114 (35.51%)	0.025
Internal Medicine or others	196 (40.41%)	64 (39.02%)	132 (41.12%)	
No	99 (20.41%)	24 (14.63%)	75 (23.36%)	
Hospital outcomes:				
Length of hospital stay* (days)	14 (11)	13 (10.25)	15 (11)	0.003
Need of transfusion				
Yes	338 (69.98%)	105 (64.42%)	233 (72.81%)	0.0721
No	145 (30.02%)	58 (35.58%)	87 (27.19%)	
Initial postoperative mobilization out of bed				
< 48 h	330 (68.46%)	118 (71.95%)	212 (66.67%)	0.280
> 48 h	152 (31.54%)	46 (28.05%)	106 (33.33%)	
Weight-bearing permission				
Full weight-bearing	186 (38.51%)	34 (20.86%)	152 (47.5%)	< 0.001
Not allowed or with restrictions	297 (61.49%)	129 (79.14%)	168 (52.5%)	
Change of residence at hospital discharge				
Same	316 (69.15%)	95 (61.69%)	221 (72.94%)	0.010
Community to health institution	137 (29.98%)	59 (38.31%)	78 (25.74%)	
Health institution to community	4 (0.88%)	0	4 (1.32%)	

Continuous variables were summarized as mean and standard deviation (SD)^, or median and interquartile range (IQR)*. Categorical variables were summarized by absolute frequencies and percentages. Prefracture mobility scale: registered as 1: complete independent gait, 2: outdoors independent gait with one technical aid, 3: outdoors independent gait with two technical aids, 4: only indoors independent gait with or without aids, 5: no mobility at all or with the help of two other people, and grouped as independent outdoors (nos. 1, 2, and 3), independent indoors (no. 4), and dependent (no. 5). ^Osteoprotective treatment: percentages of each individual treatment are referred to the total number of patients receiving osteoprotective treatment

⋄ Medical staff involved in the patient's care (other than trauma and anesthesia)

Surgeon experience: more or less than 20 less invasive fixation procedures or revisions for PPF per year

IQR interquartile range, *Pfeiffer's SPMSQ* Pfeiffer's Short Portable Mental Status Questionnaire, *CFS* clinical frailty scale, *ASA* American Society of Anesthesiologists (ASA) physical status classification system, *Hb* Hemoglobin

summarized as mean and standard deviation (SD) or median and interquartile range (IQR) as appropriate ($p < 0.05$ Shapiro–Wilk test). Categorical variables were summarized by absolute frequencies and percentages. Pearson's chi-squared test analyzed the association between qualitative variables, the Kruskal–Wallis test for quantitative variables, or the analysis of variance (ANOVA) test for quantitative variables with normal distribution. Fisher's exact test or the likelihood ratio test was used for variables with more than two categories.

Risk factors for 1-year mortality and clinical outcomes were assessed with univariate logistic regression analysis. Variables with a p-value < 0.05 were selected for a multivariate logistic regression analysis. A predictive equation was obtained to predict mortality. A receiver-operating characteristic (ROC) curve represented the discriminative capacity of the model. Propensity score matching techniques were used to minimize risks of bias between both groups in age, prefracture mobility, prefracture place of residency, age-adjusted Charlson Comorbidity Index (a-CCI), Pfeiffer, and presence of a dysfunctional prosthesis with a 1:1 ratio. Uni- and multivariate regression analysis were performed afterwards.

Kaplan–Meier estimators were used to estimate survival functions, and comparisons were made using the log-rank test. p-values < 0.05 were considered statistically

Table 2 30-day, 6-month, and 1-year follow-up outcomes and mortality for patients presenting a type B2 or B3 femoral hip periprosthetic fracture (FHPPF): Qualitative variables are summarized using counts and percentages (%)

	Total	Fixation	Revision	*p*-Value
n	485	164	321	
30-day follow-up				
Weight-bearing permission at 30 days:				
Full weight-bearing	206 (48.47%)	44 (31.43%)	162 (56.84%)	< 0.001
Not allowed or with restrictions	219 (51.53%)	96 (68.57%)	123 (43.16%)	
Change of mobility at 30 days:				
Same	154 (36.32%)	37 (26.43%)	117 (41.2%)	0.002
Worse	14 (3.3%)	2 (1.43%)	12 (4.23%)	
Better	256 (60.38%)	101 (72.14%)	155 (54.58%)	
Place of residence at 30 days:				
Community	243 (57.18%)	62 (44.29%)	181 (63.51%)	< 0.001
Health institution	182 (42.82%)	78 (55.71%)	104 (36.49%)	
6-month follow-up				
EQ-5D*	0.65 (0.32)	0.62 (0.37)	0.66 (0.28)	0.003
Is the fracture healed?				
Yes	229 (69.18%)	95 (90.48%)	134 (59.29%)	
No	43 (13.0%)	10 (9.52%)	33 (14.6%)	< 0.001
Does not apply	59 (17.82%)	0	59 (26.11%)	
1-year follow-up				
EQ-5D*	0.64 (0.41)	0.61 (0.43)	0.66 (0.31)	0.014
Is the fracture healed?				
Yes	202 (75.38%)	73 (92.41%)	129 (68.25%)	
No	20 (7.47%)	6 (7.59%)	14 (7.41%)	0.895
Does not apply	46 (17.25%)		46 (24.34%)	
Change of EQ-5D from 6-month follow-up				
Same	51 (19.54%)	15 (19.48%)	36 (19.57%)	0.766
Better	103 (39.46%)	28 (36.36%)	75 (40.76%)	
Worse	107 (41%)	34 (44.16%)	73 (39.67%)	
Pfeiffer's SPMSQ	2 (4.75)	3 (4.5)	2 (4.75)	0.002
Change of Pfeiffer's SPMSQ from baseline				
Same	83 (34.73%)	25 (31.65%)	63 (37.28%)	0.423
Better	57 (23.85%)	11 (13.92%)	38 (22.49%)	
Worse	99 (41.42%)	43 (54.43%)	68 (40.24%)	
CFS*	5 (2)	6 (2.25)	5 (3)	0.008
Change of CFS from baseline				
Same	72 (27.59%)	20 (28.57%)	47 (25.82%)	0.348
Better	49 (18.77%)	19 (27.14%)	38 (20.88%)	
Worse	140 (53.64%)	31 (44.29%)	97 (53.3%)	
Change of residence from baseline				
Same	229 (84.81%)	65 (81.25%)	164 (86.32%)	0.202
Community to health institution	38 (14.07%)	15 (18.75%)	23 (12.11%)	
Health institution to community	3 (1.11%)	0	3 (1.58%)	
Change of mobility from baseline				
Same	181 (67.29%)	47 (58.75%)	134 (70.9%)	0.090
Better	12 (4.46%)	6 (7.5%)	6 (3.17%)	
Worse	76 (28.25%)	27 (33.75%)	49 (25.93%)	
Cumulative mortality				
In-hospital	28 (5.77%)	10 (6.1%)	18 (5.61%)	0.990

Table 2 (continued)

	Total	Fixation	Revision	*p*-Value
30-day follow-up	36 (7.42%)	15 (9.14%)	21 (6.54%)	0.395
6-month follow-up	69 (14.23%)	31 (18.90%)	38 (11.84%)	0.056
1-year follow-up	87 (17.94%)	41 (25.0%)	46 (14.33%)	0.004
Medical complications				
In-hospital	225 (46.39%)	82 (50%)	143 (44.55%)	0.297
30-day follow-up	102 (21.03%)	37 (22.56%)	65 (20.25%)	0.636
6-month follow-up	189 (38.97%)	69 (42.07%)	120 (37.38%)	0.366
1-year follow-up	248 (51.13%)	92 (56.1%)	156 (48.6%)	0.142
At any moment	412 (84.95%)	138 (84.15%)	274 (85.36%)	0.827
Surgical complications				
30-day follow-up	116 (23.92%)	32 (18.29%)	84 (26.79%)	0.050
6-month follow-up	167 (34.43%)	55 (33.54%)	112 (34.89%)	0.845
1-year follow-up	222 (45.77%)	79 (48.17%)	143 (44.55%)	0.509
At any moment	266 (54.85%)	87 (53.05%)	179 (55.76%)	0.364

Continuous variables were summarized as median and interquartile range (IQR)*. Categorical variables were summarized by absolute frequencies and percentages.
IQR interquartile range, *Pfeiffer's SPMSQ* Pfeiffer's Short Portable Mental Status Questionnaire, *CFS* clinical frailty scale

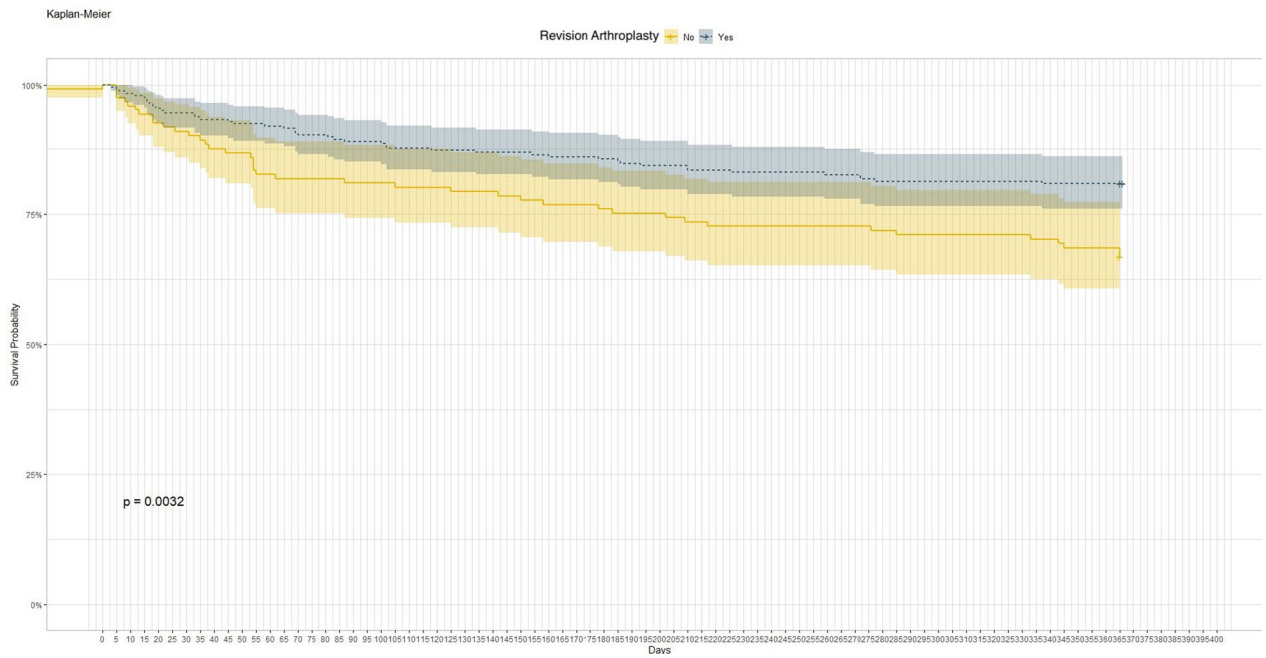


Fig. 1 Kaplan–Meier analysis for 1-year survival rate between fixation and revision arthroplasty groups

significant. Statistical analysis was conducted using RStudio (v.4.3.2; R Foundation for Statistical Computing, Vienna, Austria).

Results

The study involved 485 patients meeting the inclusion criteria, with two groups: 164 patients managed with internal fixation and 321 patients with revision arthroplasty. Patients managed with fixation were older (88 versus 82 years, $p < 0.001$), frailer according to the CFS, the American Society of Anesthesiologists physical status classification system (ASA), and the a-CCI, presented higher cognitive impairment (Pfeiffer 3 versus 2, $p < 0.001$), living at nursing healthcare facilities (21.3% versus 10.9%, $p < 0.001$), and presented worse mobility

Table 3 Surgical complications at 30-days, at 12-month follow-up, and cumulative. * $p < 0.05$

	30-day follow-up			12-month follow-up			Cumulative (1 year)		
	Fixation	Revision	*p*	Fixation	Revision	*p*	Fixation	Revision	*p*
Fracture	0	9 (2.81%)	0.070	2 (1.23%)	5 (1.56%)	1	3 (1.83%)	15 (4.67%)	0.1690
Dislocation	1 (0.61%)	24 (7.5%)	< 0.001*	2 (1.23%)	18 (5.62%)	0.040*	3 (1.83%)	45 (14.02%)	0.0013*
Infection	7 (4.29%)	22 (6.88%)	0.354	6 (3.68%)	15 (4.69%)	0.782	17 (10.37%)	50 (15.58%)	0.2284
Fixation failure	0	1 (0.31%)	1	0	0		1 (0.61%)	1 (0.31%)	1
Loosening	3 (1.84%)	2 (0.62%)	0.440	4 (2.45%)	2 (0.62%)	0.2	7 (4.27%)	6 (1.87%)	0.4192
Nonunion				0	1 (0.31%)	1	0	4 (1.25%)	0.4636

($p = 0.009$). The fixation group had shorter surgical delay (128 versus 168 h, $p = 0.007$), more patients operated under spinal anesthesia (80.98% versus 56.39%, $p < 0.001$) and received a higher proportion of comanagement with geriatricians (46.34% versus 35.51%, $p = 0.025$) (Table 1).

Outcomes are presented in Table 2. Patients managed with fixation showed higher rates of 1-year mortality (25% versus 14.33%, $p = 0.04$), with no differences in mortality up to the 6-month follow-up. Patients with fixation had more weight-bearing restrictions (20.86% versus 47.5%, $p < 0.001$ after surgery, and 31.43% versus 56.84%, $p < 0.001$ at 30-day follow-up) and worse EQ5D at 6- and 12-month follow-up (0.62 versus 0.66, $p = 0.003$ and 0.61 versus 0.66, $p = 0.014$) but shorter hospital stay (13 versus 15 days, $p = 0.003$). The Kaplan–Meier analysis demonstrated a significantly higher 1-year survival rate for the revision arthroplasty group compared with the fixation group ($p = 0.032$) (Fig. 1). There were no differences in medical or surgical complication rates at any time point, although the dislocation rate was higher for the revision group ($p = 0.001$) (Table 3). Patients with no weight-bearing restrictions at hospital discharge showed lower 1-year mortality rates in the fixation group than those in the revision group ($p = 0.014$). Patients with no weight-bearing restrictions at 30-day follow-up showed no differences in 1-year mortality rates ($p = 0.14$) between both groups.

After propensity score matching, 99 patients were included in each group, showing no differences in patient and fracture features between both groups. The revision group showed longer surgical delay (6 versus 4 days, $p < 0.001$) and received general anesthesia more frequently (54.55% versus 17.35%, $p < 0.001$) (Table 4). Mortality was higher for the fixation group only at 1-year follow-up, with no differences before that time point. The fixation group presented higher rates of weight-bearing restrictions after surgery and at 30-day follow-up (17.35% versus 42.42%, $p < 0.001$) (Table 5).

Table 6 shows risk factors for mortality in the univariate and multivariate analysis. The predictive model for mortality presented a ROC curve with an area under the curve of 0.7784 (Fig. 2). The equation predicting mortality obtained from this model is presented in Table 6. Mortality risk predictive cutoff values in the multivariate regression analysis could be established for Pfeiffer > 2 (odds ratio, OR: 2.52; 95% CI (1.438,4.492), $p = 0.001$) and a-CCI > 5 (OR: 2.35; 95% CI (1.373,4.064), $p = 0.002$). Table 7 shows risk factors for mortality after the propensity score matching.

Discussion

According to previous research recommendations [2–5], B2–B3 FH-PPF should be managed with stem revision. Recent literature, however, has questioned whether all patients should adhere to these recommendations, particularly frail and elderly individuals with low functional demands and certain fracture patterns [22, 23]. A systematic review published in 2017 with 22 studies reported that internal fixation for B2–B3 FH-PPF was associated with a higher reoperation rate [24]. By contrast, a 2022 systematic review found no significant difference in surgical complication rates between fixation alone (24%) and revision arthroplasty (18%), with fixation being superior preventing dislocation [25]. A 2023 meta-analysis further revealed that fixation was associated with reduced blood loss, shorter operative time, decreased need for transfusions, fewer complications, lower reoperation rates, and shorter hospital stays [26]. Mortality rates and overall outcomes were comparable between the groups. Additional studies have suggested that B2 and B3 can be effectively managed with fracture fixation, without stem revision, yielding favorable and, in several cases, superior results compared with revision in select patient populations [8–14, 27].

B2–B3 FH-PPF represent a severe complication because they commonly affect frail and elderly patients.

Table 4 Demographic, baseline data, management, and hospital outcomes for patients presenting a type B2 or B3 femoral hip periprosthetic fracture (FHPPF), included in the propensity matching score. Qualitative variables are summarized using counts and percentages (%)^

	Total	Fixation	Revision	*p*-Value
n	198	99	99	
Baseline:				
Age (years)*	87 (9)	87 (8.5)	86 (8.5)	0.456
Sex, *n* (%):				
Female	130 (65.66%)	64 (64.65%)	66 (66.67%)	0.881
Male	68 (34.34%)	35 (35.35%)	33 (33.33%)	
Place of residence, *n* (%):				
Community	165 (83.33%)	81 (81.82%)	84 (84.85%)	0.703
Health institution	33 (16.67%)	18 (18.18%)	15 (15.15%)	
Prefracture mobility*, *n* (%):				
Independent outdoors	139 (70.2%)	69 (69.7%)	70 (70.71%)	0.188
Independent indoors	39 (19.7%)	20 (20.2%)	19 (19.19%)	
Dependent	20 (10.1%)	10 (10.1%)	10 (10.1%)	
Pfeiffer's SPMSQ*	3 (4)	3 (4)	3 (4)	0.781
CFS*	5 (2)	5 (2)	5 (2)	0.963
ASA*	3 (1)	3 (1)	3 (1)	0.519
CCI age-adjusted*	6 (1.75)	6 (1.5)	6 (2)	0.992
Osteoprotective treatment, *n* (%):				
Yes	104 (52.53%)	55 (55.56%)	49 (49.49%)	0.477
No	94 (47.47%)	44 (44.44%)	50 (50.51%)	
Antiaggregant or anticoagulant medication, *n* (%):				
Yes	85 (42.93%)	43 (43.43%)	42 (42.42%)	0.600
No	113 (57.07%)	56 (56.57%)	57 (57.58%)	
Hb at admission (gr/dL)^	12 (1.79)	12.13 (1.46)	11.88 (2.09)	0.695
Fracture features:				
UCS type:				
B2	160 (80.81%)	82 (82.83%)	78 (78.79%)	0.588
B3	38 (19.19%)	17 (17.17%)	21 (21.21%)	
Cemented or uncemented stem				
Cemented	64 (32.32%)	36 (36.36%)	28 (28.28%)	0.288
Uncemented	134 (67.68%)	63 (63.64%)	71 (71.72%)	
Time since stem implantation (months)	123 (135)	123 (123)	121 (151.25)	0.676
Dysfunctional prosthesis				
Yes	93 (46.97%)	48 (48.48%)	45 (45.45%)	0.776
No	105 (53.03%)	51 (51.52%)	54 (54.55%)	
Management:				
Surgical delay (h)*	120 (119)	96 (108)	143.5 (120)	< 0.001
Anesthesia				
General	71 (36.04%)	17 (17.35%)	54 (54.55%)	< 0.001
Neuroaxial	126 (63.96%)	81 (82.65%)	45 (45.45%)	
Team expertise:				
< 20 procedures per year	63 (31.82%)	34 (34.34%)	29 (29.29%)	0.542
> 20 procedures per year	135 (68.18%)	65 (65.66%)	70 (70.71%)	
Surgical approach:				
Less invasive	21 (10.61%)	21 (21.21%)	0	< 0.001
Open	177 (89.39%)	78 (78.79%)	99 (100%)	
Was the stability of the stem checked?				
Yes	174 (87.88%)	75 (75.76%)	99 (100%)	< 0.001

Table 4 (continued)

	Total	Fixation	Revision	*p*-Value
No	24 (12.12%)	24 (24.24%)	0	
Cerclage for reduction				
Yes	170 (85.86%)	81 (81.82%)	89 (89.9%)	0.153
No	28 (14.14%)	18 (18.18%)	10 (10.1%)	
Type of fixation:				
Plate	118 (59.6%)	94 (94.95%)	24 (24.24%)	
Cerclage wiring	48 (24.24%)	4 (5.05%)	44 (44.44%)	
Medical staff involved⋄				
Geriatrics	85 (42.93%)	43 (43.43%)	42 (42.42%)	0.955
Internal Medicine or others	78 (39.39%)	38 (38.38%)	40 (40.4%)	
No	35 (17.68%)	18 (18.18%)	17 (17.17%)	
Hospital outcomes:				
Length of hospital stay (days)*	14.5 (13)	13 (12.75)	17 (13.75)	0.015
Initial postoperative mobilization out of bed				
< 48 h	132 (67.01%)	75 (75.76%)	57 (58.16%)	0.013
> 48 h	65 (32.99%)	24 (24.24%)	41 (41.84%)	
Weight-bearing permission				
Full weight-bearing	59 (29.95%)	17 (17.35%)	42 (42.42%)	< 0.001
Not allowed or with restrictions	138 (70.05%)	81 (82.65%)	57 (57.58%)	
Change of residence at hospital discharge				
Same	111 (60.66%)	50 (54.95%)	61 (66.3%)	0.076
Community to health institution	70 (38.25%)	41 (45.05%)	29 (31.52%)	
Health institution to community	2 (1.09%)		2 (2.17%)	

Continuous variables are expressed as median and interquartile range (IQR)*. Prefracture mobility scale: registered as 1: complete independent gait, 2: outdoors independent gait with one technical aid, 3: outdoors independent gait with two technical aids, 4: only indoors independent gait with or without aids, 5: no mobility at all or with the help of two other people, and grouped as independent outdoors (nos. 1, 2, and 3), independent indoors (no. 4), and dependent (no. 5). ^Osteoprotective treatment: percentages of each individual treatment are referred to the total number of patients receiving osteoprotective treatment.

⋄ Medical staff involved in the patient's care (other than trauma and anesthesia)

Surgeon experience: more or less than 20 less invasive fixation procedures or revisions for PPF per year

IQR interquartile range, *Pfeiffer's SPMSQ* Pfeiffer's Short Portable Mental Status Questionnaire, *CFS* clinical frailty scale, *ASA* American Society of Anesthesiologists (ASA) physical status classification system, *Hb* hemoglobin

The mean age from previous reviews was around 75 years old [25, 28]. Other studies have observed that fixation is more frequently performed in older patients, with the mean age in the fixation group ranging from 78.8 to 80 years old to and from 77 to 84 years in the revision group [12, 29, 30]. In the present study, patients were notably older, potentially influencing the prognosis. However, age is not always an accurate indicator of a patient's medical status. Several studies have reported worse medical status and higher proportion of patients with ASA ≥ 3 and a-CCI, > 5, particularly among those treated with fixation [29, 30]. González-Martín et al. [31] proposed a treatment algorithm suggesting that patients with a-CCI ≥ 5, ASA ≥ 3, and low functional demand can be treated with fixation, provided that the anatomical reduction of the fracture can be achieved. Preoperative gait ability is another critical factor influencing the choice between fixation and revision. Previous studies suggest that fracture fixation maybe suitable for patients with low functional demand [29–31]. In the current study, the percentage of patients without autonomous ambulation was higher in the fixation group (12.8% versus 7.19%). Prefracture mobility has been identified as a mortality risk factor and should be carefully considered during the decision-making process.

Table 5 30-days, 6-month, and 1-year follow-up outcomes and mortality for patients presenting a type B2 or B3 femoral hip periprosthetic fracture (FHPPF) included in the propensity matching score. Qualitative variables are summarized using counts and percentages (%).

	Total	Fixation	Revision	*p*-Value
n	198	99	99	
30-day follow-up				
Weight-bearing permission at 30 days:				
Full weight-bearing	69 (38.98%)	24 (27.91%)	45 (49.45%)	0.005
Not allowed or with restrictions	108 (61.02%)	62 (72.09%)	46 (50.55%)	
Change of mobility at 30 days:				
Same	37 (20.9%)	13 (15.12%)	24 (26.37%)	0.184
Worse	27 (15.25%)	14 (16.28%)	13 (14.29%)	
Better	113 (63.84%)	59 (68.6%)	54 (59.34%)	
Place of residence at 30 days:				
Community	91 (51.41%)	39 (45.35%)	52 (57.14%)	0.156
Health institution	86 (48.59%)	47 (54.65%)	39 (42.86%)	
6-month follow-up				
EQ-5D*	0.62 (0.34)	0.62 (0.34)	0.64 (0.29)	< 0.001
Is the fracture healed?				
Yes	106 (71.14%)	62 (88.57%)	44 (55.7%)	< 0.001
No	22 (14.77%)	8 (11.43%)	14 (17.72%)	
Does not apply	21 (14.09%)	0	21 (26.58%)	
1-year follow-up				
EQ-5D*	0.62 (0.42)	0.62 (0.38)	0.6 (0.45)	0.416
Is the fracture healed?				
Yes	113 (79.58%)	57 (90.48%)	54 (70.13%)	0.004
No	12 (8.45%)	6 (9.52%)	6 (7.79%)	
Does not apply	17 (11.97%)		17 (22.08%)	
Change of EQ-5D from 6-month follow-up				
Same	25 (18.12%)	12 (19.35%)	13 (17.11%)	0.943
Better	54 (39.13%)	24 (38.71%)	30 (39.47%)	
Worse	59 (42.75%)	26 (41.94%)	33 (43.42%)	
Pfeiffer's SPMSQ*	3 (5)	3 (5)	3 (5)	0.929
Change of Pfeiffer's SPMSQ from baseline				
Same	40 (29.63%)	18 (29.03%)	22 (30.14%)	0.4294
Better	34 (25.19%)	13 (20.97%)	21 (28.77%)	
Worse	61 (45.19%)	31 (50%)	30 (41.1%)	
CFS*	6 (3)	6 (2.25)	5 (3)	0.794
Change of CFS from baseline				
Same	44 (31.21%)	19 (29.69%)	25 (32.47%)	0.230
Better	25 (17.73%)	8 (12.5%)	17 (22.08%)	
Worse	72 (51.06%)	37 (57.81%)	35 (45.45%)	
Change of residence from baseline				
Same	116 (81.69%)	53 (82.81%)	63 (80.77%)	0.654
Community to health institution	25 (17.61%)	11 (17.19%)	14 (17.95%)	
Health institution to community	1 (0.7%)	0	1 (1.28%)	
Change of mobility from baseline				
Same	87 (61.27%)	37 (57.81%)	50 (64.1%)	0.745
Better	6 (4.23%)	3 (4.69%)	3 (3.85%)	
Worse	49 (34.51%)	24 (37.5%)	25 (32.05%)	
Cumulative mortality				
In-hospital	15 (7.58%)	8 (8.08%)	7 (7.07%)	1

Table 5 (continued)

	Total	Fixation	Revision	*p*-Value
30-day follow-up	20 (10.1%)	12 (12.12%)	8 (8.08%)	0.479
6-month follow-up	43 (21.72%)	26 (26.26%)	17 (17.17%)	0.168
1-year follow-up	56 (28.28%)	35 (35.35%)	21 (21.21%)	0.040
Medical complications				
In-hospital	101 (51.01%)	48 (48.48%)	53 (53.54%)	0.570
30-day follow-up	36 (18.18%)	17 (17.17%)	19 (19.19%)	0.854
6-month follow-up	58 (29.29%)	32 (32.32%)	26 (26.26%)	0.435
1-year follow-up	67 (33.84%)	38 (38.38%)	29 (29.29%)	0.230
At any moment	154 (77.78%)	77 (77.78%)	77 (77.78%)	1
Surgical complications				
30-day follow-up	39 (19.7%)	15 (15.15%)	24 (24.24%)	0.153
6-month follow-up	44 (22.22%)	21 (21.21%)	23 (23.23%)	0.864
1-year follow-up	54 (27.27%)	29 (29.29%)	25 (25.25%)	0.632
At any moment	72 (36.36%)	33 (33.33%)	39 (39.39%)	0.460

Continuous variables are expressed as median and interquartile range (IQR)*. *IQR* interquartile range, *Pfeiffer's SPMSQ* Pfeiffer's Short Portable Mental Status Questionnaire, *CFS* clinical frailty scale

Surgical delay was longer in the revision group (128 versus 168 h), as well as hospital stay (13 versus 15 days). Across both cohorts, 46.39% of patients experienced medical complications during hospitalization. Although an economic analysis was not conducted, the longer hospital stay likely incurs higher costs. A recent study reported that the average cost for patients undergoing fixation was €14,239.07 compared with €21,498.45 for those treated with revision [30]. Only 20.86% of patients treated with fixation were permitted full weight-bearing at hospital discharge, compared with 47.5% in the revision group. This situation may explain the higher proportion of patients managed with fixation being discharged to a nursing home (38.31% versus 25.74%, $p = 0.010$).

Like hip fractures, FH-PPF are associated with high mortality rates. Comorbidities play a critical role in determining the optimal treatment strategy for each patient. Some studies correlated a-CCI ≥ 5 with increased mortality risk [9, 32, 33]. One study reported a 1-year mortality rate of 22.3%, associated with poorer prefracture walking ability and a-CCI ≥ 3 [32]. In our study, an a-CCI > 5 was associated with 1-year mortality. Additionally, patients in the fixation group were older and had more comorbidities compared with those in the revision group, likely influencing the choice of management strategy. To account for potential selection bias, propensity score matching was performed. This analysis identified male gender, a-CCI, and cognitive impairment as independent risk factors for 1-year mortality.

Early weight-bearing is a well-established protective factor following hip fractures, decreasing morbidity and mortality rates [34]. In the PIPPAS study, weight-bearing restriction was common practice in the fixation group (42.42% versus 17.35%) and was identified as an independent risk factors for mortality. Among patients treated with fixation, full weight-bearing within the first 30 days was associated with reduced risk of mortality. A review by Haider et al. [27] reported similar rates of full weight-bearing between revision and fixation groups. While a higher rate of stem subsidence was observed in the fixation group, there was no statistically significant difference in radiological loosening during the first year of follow-up, even though pain referred to the thigh was not evaluated. This finding suggests that full weight-bearing may be safely achieved after stable fixation, highlighting the relevance of the fixation technique. Minimally invasive plating osteosynthesis has been shown to reduce blood loss and local complications [35, 36]. A recent retrospective study comparing a mini-invasive approach with an open approach demonstrated shorter operative times, reduced intraoperative bleeding, and earlier fracture consolidation by 2 months [37]. In our study, less invasive approaches were used in 20.73% of the cases of

Table 6 Univariate and multivariate regression analysis for mortality.

	Univariate			Multivariate				Multivariate significant values (p-value < 0.1)			
	OR	CI	p-Value	OR	CI	p-Value	Coefficients	OR	CI	p-Value	Coefficients
Patient related at admission							−5.48716				−5.79221*
Age	1.070	(1.038, 1.106)	< 0.001								
Sex: female	1.391	(0.843, 2.285)	0.194								
Place of residency: healthcare facility	1.881	(0.984, 3.507)	0.050	1.029	(0.451, 2.256)	0.944	0.02259				
Prefracture mobility:											
Independent indoors	3.312	(1.820, 5.999)	< 0.001	1.345	(1.175, 1.551)	< 0.001	0.74303	1.913	(0.958, 3.768)	0.062	0.64876
Dependent	2.850	(1.062, 7.518)	0.034	1.924	(0.959, 3.81)	0.062	0.98863	2.729	(1.121, 6.617)	0.026	1.00404
Pfeiffer's SPMSQ	1.223	(1.130, 1.326)	< 0.001	2.636	(1.047, 6.628)	0.038	0.14651	1.155	(1.052, 1.268)	0.003	0.14371
CFS	1.562	(1.334, 1.850)	< 0.001								
ASA	2.214	(1.585, 3.181)	< 0.001								
age-adjusted CCI	13.71	(1.213, 1.562)	< 0.001	1.345	(1.175, 1.551)	< 0.001	0.28859	1.324	(1.158, 1.524)	< 0.001	0.28064
Prefracture osteoprotective treatment	0.823	(0.467, 1.411)	0.489								
Antiaggregant or anticoagulant medication	1.818	(1.111, 2.979)	0.017								
Hb at admission	0.817	(0.713, 0.933)	0.003								
Fracture related at admission											
B3 type	1.864	(1.065, 3.220)	0.027	1.17	(1.065, 1.293)	0.002	0.50152	1.155	(1.052, 1.268)	0.003	0.14371
Cemented stem	1.502	(0.895, 2.496)	0.119								
Time since stem implantation	0.999	(0.991, 1.009)	0.960								
Dysfunctional prosthesis	0.859	(0.527, 1.399)	0.542								
Treatment related											
Surgical delay	0.999	(0.991, 1.009)	0.960								
Revision	0.477	(0.289, 0.787)	0.004								
Open approach (only fixation)	0.634	(0.282, 1.525)	0.284								
Spinal anesthesia	0.991	(0.601, 1.650)	0.970								
Expert team	0.792	(0.477, 1.329)	0.370								
Medical staff involved:											
Geriatrics	2.530	(1.149, 6.188)	0.029	0.644	(0.354, 1.150)	0.143	−0.38847				
Internal Medicine or others	3.540	(1.641, 8.546)	0.002								
Weight-bearing restrictions	18.563	(1.084, 3.283)	0.028	2.306	(1.967, 3.002)	< 0.001	1.12638	3.004	(1.245, 8.015)	0.019	1.10008

The equation is: $1/(1+e^{-y})$ where $y = -5.79221 + (0.64876 \times$ "Pre-Fracture mobility independent indoors") + $(1.00404 \times$ "Pre-Fracture mobility dependent") + $(0.14371 \times$ Pfeiffer SPMSQ) + $(0.28064 \times$ age-adjusted CCI) + $(0.14371 \times$ "B3 type") + $(1.10008 \times$ "Weight-bearing restriction"). For qualitative variables, values are 0 or 1, depending on the absence or presence of the variable, and for quantitative variables, the value is the numeric value of the variable

CI Confidence Interval, *OR* Odds Ratio

* Intercept for the equation predicting mortality obtained from this model.

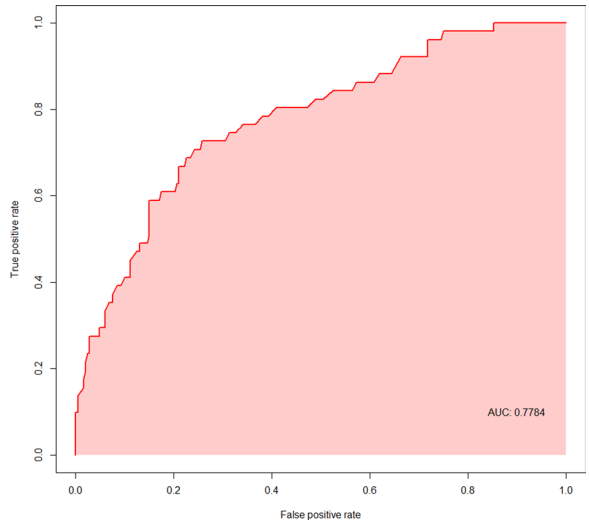


Fig. 2 ROC curve corresponding to the predictive model for mortality

fixation group. However, the surgical approach did not influence weight-bearing restrictions or mortality rates.

Surgical complications should be expected in both treatment groups. In the present study, rates of infection were high in both groups, but the dislocation rate was higher in the revision group, similar to in a recent systematic review [11]. A systematic review by Haider et al. [10] found no significant differences in overall complication rates between fixation and revision arthroplasty. Although nonunion is a concern in fixation cases, nonunion rates in our study were not relevant, and there were no differences in the rate of subsequent surgeries performed for aseptic loosening during the first year of follow-up. The primary objectives for stem revision in B2–B3 FH-PPF are to address loosening and restore function, enabling unrestricted weight-bearing [2–5, 8, 11, 24]. Based on our findings, stem revision did not result in a higher re-revision rate for aseptic loosening at 1-year follow-up. Notably, in the fixation group, full weight-bearing was not associated with fixation failure, suggesting that surgeons may be overly cautious in restricting weight-bearing in certain patients. There is an ongoing debate regarding who should manage periprosthetic fractures: arthroplasty-focused orthopedic surgeons, orthopedic trauma surgeons specialized in fracture fixation, or perhaps a combined team. Pohl et al. did not find differences in outcomes based on surgeon subspecialty training [38]. In our study, the level of expertise was not a risk factor for mortality, although it may influence treatment indication, complication rates and weight-bearing indications. The impact of expertise and subspecialty focus on the management of periprosthetic fractures deserves further research.

The weaknesses of this study include the fact that the decision to pursue fixation or revision was made by the attending surgeon on the basis of the patient's functional status, comorbidities, and the fracture pattern. Consequently, a selection bias was inherent, although we attempted to mitigate this using propensity score matching. There was variability in the treatment methods that were employed. In addition, the distinction between B1 and B2–B3 types was at the discretion of the treating surgeon based on clinical, radiological, and surgical findings. Although criteria were standardized, several radiographic or intraoperative details might have not been captured uniformly across sites. Surgeon experience might influence the choice of treatment (fixation versus revision), the weight-bearing protocol, as well as the risk of complications, including dislocation. Weight-bearing restrictions prescribed at hospital discharge could only be verified at the 30-day follow-up visit, depending on the patient's actual behavior at home after discharge. Nonetheless, to the best of our knowledge, and excluding meta-analyses, this represents the largest series of B2–B3 FH-PPF cases reported to date.

In conclusion, revision arthroplasty showed a lower 1-year mortality rate and fewer weight-bearing restrictions than fixation with similar functional outcomes; fixation showed reduced dislocation rates, shorter surgical delay, and hospital stay. Frail patients with B2–B3 FH-PPF managed with fixation and without weight-bearing restrictions presented a lower 1-year mortality rate. Age, frailty, and weight-bearing restrictions were identified as mortality risk factors following B2–B3 FH-PPF. Elderly patients treated with a strategy to achieve full weight-bearing, regardless of the treatment selected, fare better than patients who were prescribed weight-bearing restrictions.

Table 7 Univariate and multivariate regression analysis for mortality for the propensity score matching groups

	Univariate			Multivariate				Multivariate significant variables ($p < 0.05$)			
	OR	CI	*p*-Value	OR	CI	*p*-Value	Coefficients	OR	CI	*p*-Value	Coefficients
Patient related at admission							−10.77446				−11.57057*
Age	1.061	(1.020, 1.110)	0.006	1.063	(1.013, 1.121)	0.017	0.06115	1.076	(1.033, 1.128)	0.001	0.07359
Sex: male	2.294	(1.212, 4.356)	0.011	3.178	(1.463, 7.083)	0.004	1.15636	3.336	(1.592, 7.197)	0.002	1.20482
Place of residency: healthcare facility	1.333	(0.581, 2.923)	0.481								
Prefracture mobility:											
Independent indoors	2.424	(1.132, 5.140)	0.021	3.307	(1.423, 7.672)	0.005	1.19602	3.911	(1.769, 8.661)	< 0.001	1.3639
Dependent	2.850	(1.062, 7.518)	0.034	3.764	(1.234, 11.308)	0.018	1.32543	5.421	(1.911, 15.098)	0.001	1.69027
Pfeiffer's SPMSQ	1.187	(1.071, 1.320)	0.001	1.094	(0.971, 1.231)	0.134	0.09024				
CFS	1.447	(1.175, 1.812)	< 0.001								
ASA	2.257	(1.476, 3.641)	< 0.001								
Age-adjusted CCI	1.401	(1.187, 1.682)	< 0.001	1.061	(0.864, 1.292)	0.559	0.05953				
Prefracture osteoprotective treatment	0.740	(0.364, 1.448)	0.389								
Antiaggregant or anticoagulant medication	1.650	(0.885, 3.088)	0.115								
Hb at admission	0.801	(0.481, 1.271)	0.357								
Fracture related at admission											
B3 type	1.639	(0.763, 3.432)	0.195								
Cemented stem	1.237	(0.638, 2.363)	0.522								
Time since stem implantation	0.691	(0.370, 1.285)	0.244								
Dysfunctional prosthesis	1.013	(0.964, 1.061)	0.581								
Treatment related											
Surgical delay	1.013	(0.964, 1.061)	0.581								
Revision	0.492	(0.258, 0.921)	0.029	0.697	(0.343, 1.427)	0.318	-0.36108				
Open approach (only fixation)	0.526	(0.213, 1.350)	0.168								
Spinal anesthesia	0.880	(0.464, 1.691)	0.697								
Expert team	0.782	(0.409, 1.518)	0.460								
Medical staff involved:											
Geriatrics	4.444	(1.418, 19.672)	0.022								
Internal Medicine or others	5.973	(1.912, 26.421)	0.006	1.507	(0.746, 3.050)	0.251	0.41021				
Weight-bearing restrictions 30 days	1.548	(0.773, 3.256)	0.231	2.394	(1.158, 5.171)	0.021	0.87315	2.706	(1.347, 5.701)	0.006	1.2731

The equation is: $1/(1+e^{-y})$ where $y = -5.79221 + (0.64876 \times$ "Pre-Fracture mobility independent indoors") + $(1.00404 \times$ "Pre-Fracture mobility dependent") + $(0.14371 \times$ Pfeiffer SPMSQ) + $(0.28064 \times$ age-adjusted CCI) + $(0.14371 \times$ "B3 type") + $(1.10008 \times$ "Weight-bearing restriction"). For qualitative variables, values are 0 or 1, depending on the absence or presence of the variable, and for quantitative variables, the value is the numeric value of the variable

CI Confidence Interval, *OR* Odds Ratio

* Intercept for the equation predicting mortality obtained from this model

Abbreviations

FH-PPF	Periprosthetic femoral fractures following hip arthroplasty
UCS	Unified classification system
CFS	Clinical frailty score
SPMSQ	Pfeiffer short portable mental status questionnaire
a-CCI	Age-adjusted Charlson Comorbidity Index
ASA	American Society of Anesthesiologists physical status classification system

Supplementary Information

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Additional file 1.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the ethical standards laid down in the 1964 Helsinki Declaration and received approval from the institutional review boards of the coordinating center (Comité de Ética de la Investigación con Medicamentos CEIm Área de Salud de Valladolid) code number PI-20–2041 and each participating hospital. Written consent for participation in the study was obtained from all participants or their legal representatives. This study is registered at ClinicalTrials.gov (NCT04663893).

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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