Arthroplasty Today 18 (2022) 57–62

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

Evaluating the Functional and Psychological Outcomes Following Periprosthetic Femoral Fracture After Total Hip Arthroplasty

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A R T I C L E I N F O

Article history:
Received 9 August 2021
Received in revised form
29 June 2022
Accepted 10 August 2022
Available online xxx

Keywords:
Periprosthetic femoral fracture
Total hip arthroplasty
Outcome
Mortality rate
Older adults

A B S T R A C T

Background: A fall after total hip arthroplasty (THA) that results in a periprosthetic femoral fracture (PPF) can have devastating functional and psychological consequences in older adults. There are few studies that have evaluated both functional and psychological outcomes of PPF post-THA in the same cohort.
Methods: This is a retrospective study of 130 people who underwent revision THA between 2005 and 2019 due to PPF. The Western Ontario and McMaster Universities Osteoarthritis (WOMAC), Harris Hip Score (HHS), and Short Form-12 (SF-12) assessed physical function, hip joint function, and psychological well-being, respectively. Descriptive statistics using means and standard deviation or frequencies and percentages were used to define the sample. The association between baseline demographic, clinical, and surgical factors on WOMAC, HHS, and SF-12 scores at 1-year post-PPF surgery was modelled using multivariable linear regression. The mean age (n = 130) was 80.6 ± 9.0 years, and 55.4% (n = 72) were female. The mortality rate was 15.4% (n = 20) at 1-year post-PPF surgery. One-year follow-up data were available for 35.4% (n = 46) of patients.
Results: The WOMAC (n = 37), HHS (n = 32), and SF-12 mental component summary (n = 46) scores at 1-year post-PPF surgery were 67.9 ± 20.3, 78.3 ± 15.0, and 52.7 ± 9.1, respectively. No significant association was found among age, gender, previous history of lower extremity surgery, Vancouver classification, and femoral bone grafting on WOMAC, HHS, and SF-12 scores.
Conclusions: Our study found that patients with PPF have fair hip joint function, poor physical function and psychological well-being, and a high mortality rate at 1-year post-PPF surgery.

Introduction

Periprosthetic femoral fracture (PPF) after total hip arthroplasty (THA) is a rare and serious complication in older adults. [1,2] The reported incidence of older adults that have a PPF after THA ranges widely from 0.07% to 18% [3–6]; however, it is predicted there will be a 4.6% rise in the number of PPF cases every 10 years over the next 30 years. [7] The combination of an aging population and the higher occurrence of falls among older adults is seen as the driving force behind the expected increase in PPF. [5,7] Therefore, a better understanding of the outcomes of older adults with PPF is warranted to help guide clinical care.

Very few studies report functional [1,8–12] and psychological outcomes [10,11] following the surgical treatment for this fracture. Only 1 study by Young et al. [12] assessed the short-term (eg, at 6 months) functional outcomes, and 5 other studies have reported the long-term (mean follow-up periods 33.6-64.9 months) functional outcomes. Young et al. [12] found poorer short-term functional outcomes at 6 months after surgery when compared with a control group of people with a revision THA (rTHA) for aseptic loosening. Zheng et al. [1] reported worse ambulatory status and poor hip function (mean postoperative follow-up period of 24-60 months) in patients with PPF after THA when compared with their pre-PPF surgery functional status. The functional outcome scores

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https://doi.org/10.1016/j.artd.2022.08.012

were averaged in this study, and they did not evaluate the functional outcomes over discrete time frames (eg, yearly). [1] In addition, only 2 studies have evaluated both functional and psychological outcomes in the same cohort of patients, and the findings were variable. [10,11] In a study by Märdian et al. [10], patients with PPF after THA demonstrated significant long-term functional and psychological deficits at a mean follow-up of 45 months after PPF surgery. On the other hand, Kinov et al. [11] found 78.6% of the patients with PPF after THA had satisfactory functional and psychological outcomes at a mean follow-up of 5 years after PPF surgery.

Previous research identifying factors predictive of functional and psychological outcomes after PPF surgery is limited. Only the study by Märdian et al. [10] evaluated factors that are associated with functional and psychological outcomes. This study reported comorbidities, measured using the American Society of Anesthesiologists (ASA) score, as a negative predictor. However, the ASA has poor reliability [13], and they did not mention the specific ASA score that is associated with worse functional outcomes and what other patient or surgical factors were assessed. It is important for health-care professionals to understand the patient- and surgery-related factors that can impact the expectations in outcomes of the PPF surgery.

The current study aimed to reduce the knowledge gap regarding the functional and psychological outcomes associated with PPF surgery after THA. We hypothesized that there will be patient- and surgery-related factors that are associated with the adverse outcomes of PPF surgery. The objectives of this study were (1) to define the clinical and surgical characteristics of people who underwent rTHA after PPF, (2) to determine the mortality rate at 1-year after rTHA due to PPF, (3) to evaluate the impact of the fall status on the outcome scores at 1-year after PPF surgery, and (4) to evaluate the factors associated with functional and psychological outcomes at 1-year after the rTHA for PPF.

Material and methods

Study design and participants

This retrospective study was approved by the Health Sciences Research Ethics Board at the University of Western Ontario and the Clinical Resources Impact Committee of Lawson Health Research Institute. Using an electronic clinical database and billing code reports, we identified all patients who had an rTHA with or without open reduction and internal fixation (ORIF) due to a PPF between 2005 and 2019 at our institution. Patients' baseline demographics and surgical characteristics were collected from the surgical admission note, and then people were followed up forward in time to collect data from subsequent postsurgical follow-up clinic visits at 1-year in the outpatient orthopaedic clinics. In total, 764 hip procedures of any kind were screened to identify eligible patients. Chart reviews were completed between April 29, 2019, and February 29, 2020. Inclusion criteria were age 60 years or older and had rTHA with or without ORIF for PPF after THA or hemiarthroplasty (HA) regardless of the mechanism of the PPF and if the surgery was performed between 2005 and 2019. Patients were excluded if they sustained a PPF during THA (intraoperative PPF), the fracture was managed conservatively, had a periprosthetic acetabular fracture after THA, PPF occurred around antibiotic spacer or pathologic lesion, or if the PPF after HA was revised to HA or Girdlestone resection arthroplasty. Additionally, we excluded patients who underwent ORIF without rTHA for PPF. We also excluded a small group of people who had a PPF after Birmingham hip resurfacing to reduce the heterogeneity of the sample.

Baseline demographic information extracted from the clinical charts was age, sex, the mechanism of injury, any previous lower extremity surgeries performed at our institution, and the index surgical procedure of the hip. The Vancouver Classification (VC) System was used to classify the fractures. This classification system, developed by Duncan and Masri in 1995, is based on the anatomic location and pattern of the fracture, the amount of bone loss, and prosthesis stability. [14] Surgical information extracted was operative diagnosis, surgical approach, type of the fracture fixation (eg, cable, wire, plate), bone grafting (eg, femoral or acetabular), special surgical techniques (eg, extended trochanteric osteotomy), and intraoperative events (eg, trochanteric fracture). If the fracture type was not mentioned in the clinical charts, an investigator (B.L.) reviewed the radiographs or computed tomography scans to identify and classify the fractures. The Harris Hip Score (HHS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) evaluated hip joint and physical function, while the Short Form-12 Survey (SF-12) assessed psychological well-being. Death was confirmed by reviewing the clinical charts and searching through online obituary records in the public domain.

Outcome measures

The Harris Hip Score

The HHS is an outcome measure that is collected by the clinician and covers 4 domains of pain, function, range of motion, and absence of deformity of the hip joint. [15] The overall score has a maximum of 100 points; a higher score represents better hip function. The minimal clinically important difference, which is the minimal change in scores that are perceived as beneficial to health, for the HHS ranges from 15.9 to 18 points. [16] In THA patients, the HHS has demonstrated excellent reliability [17].

The Western Ontario and McMaster Osteoarthritis Index

The WOMAC is comprised of 24 questions divided into 3 domains: pain, stiffness, and physical function. [18] A weighted and inverted conversion of scores was used such that the score of each domain is out of 100, and higher scores are indicative of better overall health status. The minimal clinically important difference for the original version of WOMAC ranges from 9.4 to 25 points. [19,20] In patients with THA, the instrument has demonstrated good to excellent test-retest reliability across the different subdomains [18].

The Short Form-12 survey

The SF-12 is divided into 2 components: the mental component summary (MCS) and the physical component summary (PCS) scores. [21] Both components are scored on a population-normalized scale, with higher scores indicating better health outcomes. The reported minimal clinically important difference is 5 points for both components. [22] The SF-12 has shown to be reliable and valid in older adults [23].

Data analysis

Objective #1

Descriptive statistics using means and standard deviations or frequencies and percentages were used, as appropriate, to summarize the baseline demographics, clinical, and surgical characteristics.

Objective #2

The mortality rate was reported using percentages.

Objective #3

The scores on WOMAC, HHS, and SF-12 PCS and MCS at 1-year were summarized as means and standard deviations. The scores on the HHS were graded as poor (<70), fair (70-79), good (80-89), or excellent (90-100). [15] For the WOMAC and SF-12 PCS and MCS, scores were compared with normative data (WOMAC [24]: 2.4 [0-100 scale, 0 being best outcome and 100 being the worst outcome] and PCS [25]: 42.0 and MCS [25]: 54.5).

People with 1-year follow-up data were stratified into fallers and nonfallers based on the mechanism of the PPF as recorded in the clinical charts, and outcome measure scores were summarized with median and interquartile range. Mann-Whitney U tests were performed to compare the outcome scores at 1-year after the PPF surgery between fallers and nonfallers.

In addition, comparison of the baseline demographics and surgical information was done between the patients that had at least 1 outcome measure score over the follow-up period and the patients with no available outcome measures data during the period. Another comparison of the baseline demographics and surgical characteristics was made between the patients that died within the first postoperative period and those who were alive and had 1-year outcome measures data. Independent t-tests were used for the comparison on continuous data. Chi-square tests of homogeneity and Fisher's Exact test were used for comparison among nominal variables as appropriate. The normality of continuous data was determined by Shapiro-Wilk tests and the visual inspection of the normal Q-Q plots. Statistical significance corrected for multiple comparisons was set at $P < .008$ for the first comparison and $P < .01$ for the second comparison using the Holm-Bonferroni method.

Objective #4

The association between baseline demographic, clinical, and surgical factors and each of the 1-year post-PPF surgery outcome measures of SF-12 MCS and PCS, HHS, and WOMAC was modelled using linear regression. The initial analysis involved separate univariate linear regression models for each independent variable. If statistically significant in the univariate analysis, variables were included in a multivariable linear regression model. Statistical significance corrected for multiple comparisons was set at $P < .01$ using the Holm-Bonferroni method. Independent variables of interest were selected based on previous literature and clinical significance. The following independent variables were assessed for inclusion in the regression models: age (continuous), sex (male/female), previous lower extremity surgeries performed at our institution (yes/no), femoral bone grafting (yes/no), and the VC. For the VC variable, the fracture types were categorized into 2 groups based on the presence of inadequate bone stock surrounding the implant. The 4 fracture types (greater trochanter [AG]; lesser trochanter [AL]; well-fixed stem [B1]; loose stem [B2]) were combined to form 1 category, and fracture type B3 (loose stem with inadequate bone stock) as another category.

SPSS version 26 (IBM Corporation, Armonk, NY) was used to analyze the data.

Results

Baseline demographics, clinical and surgical characteristics

A total of 130 eligible patients were included in the analysis. The average age at baseline was 80.6 ± 9.0 years, 55.4% (n = 72) were female, and 98.5% (n = 128) of patients had rTHA and ORIF to fix the fracture (Table 1). A trochanteric fracture occurred during the PPF surgery in 1.5% (n = 2) of patients, and wires were used to fix this intraoperative fracture. The femoral head and stem were revised during the rTHA for 98.5% (n = 128) of patients. The acetabular liner was exchanged for 51.5% (n = 86) of patients, and 14.6% (n = 19) had revision of both the acetabular liner and cup. In total, 26.9% (n = 35) of patients had femoral bone grafting, 3.8% (n = 5) had acetabular bone grafting, and 3.1% (n = 4) had both femoral and acetabular bone grafting.

Table 1
Demographic, clinical, and surgical characteristics of the patients who had revision total hip arthroplasty with or without open reduction and internal fixation for a periprosthetic femoral fracture (n = 130).

Variable	Mean ± SD, [range] or n (%)
Age (y)	80.6 ± 9.0, [60.3-99.7]
Sex, female	72 (55.4)
Mechanism of the periprosthetic femoral fracture:	
Fall	101 (77.7)
Nontraumatic	10 (7.7)
Missing information	19 (14.6)
VC of periprosthetic femoral fracture:	
AG	2 (1.5)
AG and AL	1 (0.8)
B1	5 (3.8)
B2	75 (57.7)
B3	47 (36.2)
Previous lower extremity surgeries, yes	32 (24.6)
Surgical approach:	
Direct lateral	119 (91.5)
Posterior	11 (8.5)
Index surgical procedure of hip:	
Primary total hip arthroplasty	86 (66.2)
Revision total hip arthroplasty	12 (9.2)
Hemiarthroplasty	20 (15.4)
Missing information	12 (9.2)
Periprosthetic femoral fracture fixation:	
Cable	52 (40.0)
Wire	33 (25.4)
Cable and wire	34 (26.2)
Accord cable plate	6 (4.6)
Plate-screw and cable	3 (2.3)
No fixation	2 (1.5)

AG, greater trochanter; AL, lesser trochanter; B1, well-fixed stem; B2, loose stem; B3, loose stem with inadequate bone stock; ORIF, open reduction and internal fixation; SD, standard deviation; VC, Vancouver classification.

Mortality rate

The mortality rate was 3.8% (n = 5) at 30 days and 15.4% (n = 20) at 1-year after the PPF surgery. The comparison between the patients that died within the first year of the postoperative period and the patients who were alive with 1-year outcome measures data showed a significant difference for older patients ($P < .001$) and no significant difference ($P > .01$) for sex, mechanism of PPF, VC of PPF, index surgical procedure of hip, and previous history of the lower extremity surgery.

Functional and psychological outcomes after surgery for PPF

Only 54.6% (n = 71) of patients returned to the outpatient clinic 1-year after the PPF surgery. Of these patients, 35.4% (n = 46) had total score data for at least 1 of the outcome measures of interest at a mean follow-up period of 12 months and 6 days after the PPF surgery. Comparison between the patients with available follow-up outcome measures data and those with no available values for the outcome measures at 1-year after PPF surgery demonstrated no significant differences on baseline age ($P > .01$), gender ($P > .01$), mechanism of PPF ($P > .01$), VC of PPF ($P > .01$), index surgical procedure of hip ($P > .01$), and previous history of the lower extremity surgery ($P > .01$).

Table 2
Patient's average scores on the functional and psychological outcome measures at 1-year after the revision total hip arthroplasty for a periprosthetic femoral fracture.

Domain	Mean ± SD Year one
WOMAC scores	
Pain	76.0 ± 22.0 n = 39
Stiffness	62.5 ± 24.7 n = 39
Function	62.4 ± 24.0 n = 37
Total score	67.9 ± 20.3 n = 37
Harris Hip scores	
Pain	39.0 ± 8.2 n = 37
Function	30.6 ± 10.4 n = 34
Total score	78.3 ± 15.0 n = 32
Short Form-12 scores	
PCS	34.6 ± 10.8 n = 46
MCS	52.7 ± 9.1 n = 46

MCS, Mental Component Summary Scale; PCS, Physical Component Summary Scale; SD, standard deviation; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Functional and psychological outcomes

The mean total scores of the WOMAC and HHS were 67.9 ± 20.3 (n = 37) and 78.3 ± 15.0 (n = 32) at 1-year after the PPF surgery (Table 2). For SF-12 (n = 46) PCS and MCS, the mean scores at 1-year after a PPF surgery were 34.6 ± 10.8 and 52.7 ± 9.1, respectively. No statistically significant differences were found between fallers and nonfallers for the WOMAC ($P = .29$), HHS ($P = .18$), SF-12 PCS ($P = .40$), and SF-12 MCS ($P = .29$) total scores (Fig. 1). For the nonfallers group, clinical charts indicated only a nontraumatic origin of the fracture, and specific details of the etiology of the fracture were not available in the charts.

Factors associated with functional and psychological outcomes at 1-year after the PPF surgery

In the univariate regression analyses, no significant association was found between age, gender, previous history of lower extremity surgery, the VC, and femoral bone grafting and the outcomes of the WOMAC (n = 37, $P \geq .01$), HHS (n = 32, $P \geq .01$), SF-12 (n = 46) PCS ($P \geq .01$), and SF-12 MCS ($P \geq .01$) total scores. The multivariable linear regression analyses were not performed as none of the independent variables were significantly associated with the outcomes.

Discussion

Patients who underwent rTHA due to a PPF had fair hip joint function and poor overall physical function and psychological well-being. The 1-year postoperative mortality rate for our sample was 15.4%. The mechanism of the PPF (fall or nontrauma) was not associated with the functional and psychological outcomes at 1-year after the PPF surgery. Additionally, no baseline clinical or surgical characteristics were associated with any of the outcomes of interest at 1-year following the PPF surgery. Our findings in this study are novel and expand the current knowledge of the adverse effects of PPF surgery on the functional and psychological well-being in older adults. In addition, this is the first study to have evaluated the impact of the mechanism of PPF (falls or nontrauma)

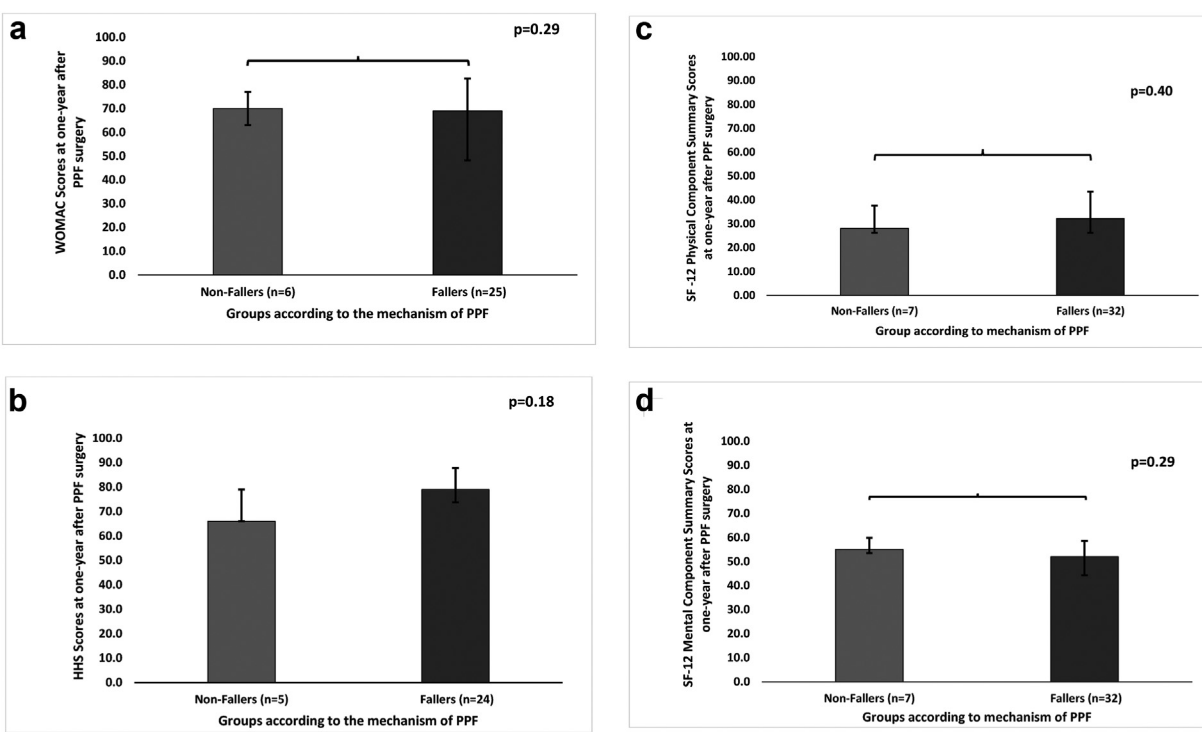

Figure 1. Comparison in the outcome scores at 1-year after periprosthetic femoral fracture (PPF) surgery between fallers and nonfallers. (a) Comparison in the Western Ontario and McMaster Osteoarthritic Index (WOMAC) total scores at 1-year after periprosthetic femoral fracture surgery between fallers and nonfallers. (b) Comparison in the Harris Hip Score (HHS) total scores at 1-year after periprosthetic femoral fracture surgery between fallers and nonfallers. (c) Comparison in the Short Form-12 Survey (SF-12) physical component summary scores at 1-year after periprosthetic femoral fracture surgery between fallers and nonfallers. (d) Comparison in the Short Form-12 Survey mental component summary scores at 1-year after periprosthetic femoral fracture surgery between fallers and nonfallers.

on the functional and psychological outcomes at 1-year following an rTHA.

Previous research that measured functional outcomes [1,8–10,12] with the WOMAC, HHS, or Oxford hip score and psychological outcomes [10] using the Short Form-36 MCS for PPF after THA demonstrated reduced ability in both domains following the surgery, which is comparable with our results. The study by Kinov et al. [11] reported better functional outcome scores after the PPF surgery than the other published studies. The difference between our findings and those of Kinov et al. [11] is likely related to age difference in the studies, our cohort was 13.7 years older, and 30.9% of our patients with 1-year functional data had a history of previous lower extremity surgery compared to a relatively younger and healthier cohort. Our population demonstrated better psychological outcome scores than the Kinov et al. [11] cohort, yet these scores are lower than normative data for age and sex-matched Canadian general population.

The mean follow-up period in existing research [1,8–11] varied between 33.6 and 64.9 months and provided a summary on outcomes rather than a detailed evaluation over discrete time frames, for example, yearly, which our study was able to evaluate. In our study, patients alive at 1-year after the PPF surgery with outcome measures data and those who died within a year of surgery significantly differed on the baseline age. Although these groups did not differ on any other baseline characteristics that we evaluated, it should be considered that we were constrained by the variables that were collected as part of the routine clinical practice. Therefore, we were unable to evaluate other relevant factors such as comorbidities, pre-PPF ambulatory status, and preoperative psychological outcomes scores that could confirm if the patients that were alive and had outcome measures data were healthier. Thus, there is still a potential that we might have seen a healthy survivor effect in our study. Additionally, the change in WOMAC, HHS, and SF-12 PCS and MCS scores was not statistically significant and did not meet a clinically relevant difference.

The 1-year postoperative mortality rate for our study at 15.4% was comparable with the 1-year mortality rate of 17% reported by Moreta et al. [9] The study by Moreta et al. [9] had a similar distribution of sex and mechanism of fracture and used the VC of the fractures as well. In a retrospective study of 291 people with PPFs after THA or total knee arthroplasty, Drew et al. [26] determined advanced age at the time of the surgery as a risk factor for increased mortality at 1-year after the PPF surgery. Consistent with the findings of the study by Drew et al. [26], the highest number of patients died within the first year after surgery, and they were older at the time of surgery than those who survived. The 1-year post-PPF surgery mortality rate found in our sample was similar to the 16.5% in the literature following surgery for the native femoral fracture [2].

In this present study, we found no significant association between age, gender, previous lower extremity surgery, the VC, and femoral bone grafting and the functional and psychological outcomes at 1-year following the surgery. Märdian et al. [10] and Moreta et al. [9] also reported no significant association between the VC and the post-PPF surgery functional outcome in patients with PPF after THA. In contrast to our study, the Moreta et al. [9] study reported functional outcome in terms of recovery of the pre-PPF ambulatory status, and they did not evaluate the association between the VC and the psychological outcomes of the surgery. Similar to the 2 mentioned studies, we had a relatively small sample size and incomplete 1-year postoperative outcome measures data resulting in power issues to find a statistically significant association.

There are limitations in the study which need to be acknowledged. In this study, follow-up data were incomplete after baseline, which impacts the power of the study to detect statistically significant differences. PPFs that were managed conservatively or by ORIF without an rTHA at our institution were not evaluated; thus, our results are not generalizable to all the patients with PPF. Additionally, due to the lack of adequate preoperative values on the patient-reported outcome measures scores, the comparison between preoperative and postoperative outcomes was not possible. In the current study, we were unable to report the cause of death due to lack of specific details of the mortality cause in the clinical charts and online obituary. The patients that died within the first postoperative year were significantly different in baseline age from the cohort of patients with 1-year data that were analyzed. Therefore, our results at 1-year may not be generalizable for all the patients who had PPF surgery in our study and may overestimate functional and psychological outcomes of the population. In addition, the evaluation of outcomes was not possible for 100% (n = 130) of our study population because 45.4% (n = 59) of patients were lost to follow-up. Of 54.6% (n = 71) who had 1-year post-PPF surgery follow-up visit, 3.1% (n = 23) of patients did not complete any of the outcome of interests. However, we were able to determine that of these 45.4% (n = 59) of patients that were lost to follow-up, 33.9% (n = 20) of patients died within 1-year of post-PPF surgery. Additionally, we found no significant difference in baseline characteristics between patients with available 1-year post-PPF surgery follow-up data and patients with no available outcome measures data. Importantly, there are several strengths to the present study. We included all the patients that had undergone a PPF surgery at our institution within the last 14 years, thus providing a representation of the patient profiles that had undergone PPF surgery at our institution performed by experienced arthroplasty surgeons.

Conclusions

Our study found that patients with a PPF have fair hip joint function and poor physical function and psychological well-being at 1-year after an rTHA with or without ORIF. This study also demonstrated a high 1-year mortality rate that is comparable to previous research. We found no significant changes in the functional and psychological recovery between the 1 and 2 years after the PPF surgery.

Conflicts of interest

Brent Lanting is a paid consultant for Stryker, DePuy, and Smith & Nephew; receives research support as a principal investigator from Stryker, DePuy, and Smith & Nephew; and receives institutional support from Stryker, DePuy, Zimmer, and Smith & Nephew. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.08.012.

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