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Proximal Femoral Replacement in Revision Total Hip Arthroplasty: A 20-Year Experience

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ABSTRACT

Background: Proximal femoral replacement (PFR) is a salvage procedure in revision total hip arthroplasty for extensive femoral bone loss. This study aimed to evaluate implant survivorship, complications, patient mortality, and clinical outcomes of PFR for non-oncologic indications at mid-term follow-up (five years).

Methods: We reviewed 61 PFRs for nononcologic indications performed between 2000 and 2022 at a single academic institution. The most common indications were periprosthetic fracture and reimplantation after periprosthetic joint infection (each 33%), followed by aseptic loosening (31%) and dislocation (3%). Femoral bone loss was severe in all patients, with 49% Paprosky type IIIb defects and 51% Paprosky type IV defects. Constrained liners were used in 26 patients (43%), standard head-liner constructs were used in 25 patients (41%), and dual-mobility constructs in 10 patients (16%). The mean patient age was 77 years, with 67% being women. The mean follow-up was five years.

Results: The 5-year cumulative incidence of revision for aseptic loosening was 2%. The 5-year cumulative incidence of any revision of the PFR was 8%. The 5-year cumulative incidence of any revision was 24%. Dislocation was the most common reason for revision (N = 8), followed by periprosthetic joint infection (N = 4), periprosthetic fracture (N = 2), and aseptic loosening (N = 1). Among the 10 patients who dislocated, eight patients (80%) underwent revision to a constrained liner at a mean of two years. The 5-year cumulative incidence of any reoperation was 30%. The mean Harris Hip Score increased from 46 preoperatively to 78 at five years. The 2- and 5-year mortality rates were 15 and 42%, respectively.

Conclusions: In this complex cohort of 61 PFRs for nononcologic revision total hip arthroplasties, aseptic loosening was rare. However, revisions and reoperations for any reason were prominent, with dislocation being the primary failure mode. In addition, the 5-year mortality rate remained high at nearly one in two.

Level of Evidence: III, retrospective cohort study.

Revision total hip arthroplasty (THA), especially in the setting of multiply revised hips, can require complex reconstructions to account for massive bone loss, including proximal femoral replacements (PFRs) [1,2]. Femoral bone loss can result from various etiologies, including implant loosening, periprosthetic fractures, periprosthetic joint infection (PJI), and/or osteolysis [3–8]. Each etiology has its own unique challenges, requiring considerations for bone stock preservation, implant fixation, hip stability, and functional integrity of the joint [9,10].

Recent advances in surgical techniques and implants like modular fluted tapered stems have emerged as effective options for managing femoral bone loss during revision THAs [11–14]. However, in some cases, a modular fluted tapered stem is not possible, and a proximal femoral replacement is needed. Although some have published on the outcomes of PFRs, most of these series

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have been limited by modest cohort sizes or follow-up length [15–26]. For instance, a recent systematic review found a 77% survivorship free of any revision at a mean follow-up of 5 years [27]. In our prior series of 44 PFRs, we found that PFRs served as a valuable salvage option, offering major clinical improvements and a low rate of aseptic loosening [1].

The purpose of this study was to expand our prior series with additional patients with a specific focus on implant survivorship, complications, patient mortality, and clinical outcomes in this large cohort of proximal femoral replacements for severe femoral bone loss [1].

Patients and Methods

After obtaining institutional review board approval, we reviewed all patients undergoing revision THA between January 1, 2000, and May 31, 2022, at a single academic medical center. Patients were identified through a review of our prospectively collected institutional total joint registry [28]. Following revision THA, clinical and radiographic follow-up were completed at one, two, and five years, and every five years thereafter. Patients who were unable to return for follow-up were mailed a questionnaire and were asked to return radiographic images. Patients were included if they were 18 years of age and underwent PFR as part of a revision THA.

During the study period, 8,414 revision THAs were performed, of which 118 included a PFR as a part of the revision THA. Among these, 41 were removed due to treatment with a total femoral replacement, 14 were removed for a PFR due to malignancy, and two had a prior PFR and were therefore removed. Compared to our previous series [1], the final cohort included 17 additional PFRs, resulting in a total of 61 patients who underwent PFR as a part of revision THA. Of these, 42 patients (69%) had previously undergone at least one revision THA, whereas for 19 patients (31%), this was their first revision THA. The mean number of procedures preceding the PFR was three (range, 1 to 13 operations).

The indications for the use of a PFR were periprosthetic fracture (N = 20), reimplantation after PJI (N = 20), aseptic loosening (N = 19), and dislocation (N = 2; Table 1). Bone loss was classified using the method of Paprosky et al. [6] based on preoperative radiographs and the intraoperative findings (Figure 1). Among the 61 hips, 30 were classified as type IIIB (49%) and 31 as type IV (51%). The mean age at the time of surgery was 77 years (range, 50 to 97), 67% were women, and the mean body mass index) was 28 (range, 19 to 45). Among the 61 PFRs, 12 were revised within two years, eight died within two years, and 13 had less than two years of follow-up. Of the remaining 28 who were alive and unrevised at two years, the mean follow-up was five years (range, two to 10).

Table 1
Demographic and Operative Factors.

No. of hips	61
Age at revision surgery (years)	
Mean	77
Range	50 to 97
Sex[b] (%)	
Men	20 (33)
Women	41 (67)
Body mass index	
Mean[a]	28 ± 6
Range	19 to 45
Indications for index revision THA[b] (%)	
Periprosthetic fracture	20 (33)
Periprosthetic joint infection	20 (33)
Aseptic loosening	19 (31)
Dislocation	2 (3)
Operative approach[b] (%)	
Direct lateral	39 (64)
Osteotomy-based	11 (18)
Paprosky extended trochanteric osteotomy	9 (15)
Wagner extended trochanteric osteotomy	2 (3)
Posterior	9 (15)
Anterolateral	2 (3)
Components revised at index revision THA[b] (%)	
Femoral and acetabular components revised	46 (75)
Femoral component revised with bearing surface exchange	15 (25)
Paprosky bone loss classification[b] (%)	
IIIb	30 (49)
IV	31 (51)
PFR design[b] (%)	
Stryker Global Modular Restoration System	55 (90)
Depuy Synthes Limb Preservation System	4 (7)
Biomet Orthopedic Salvage System	2 (3)
Body length (mm)	
Median	120
Range	60 to 280
Stem diameter (mm)	
Median	13
Range	9 to 18
Stem length (mm)	
Median	127
Range	102 to 203
Bearing type[b] (%)	
Constrained liner	26 (43)
Standard head-liner construct	25 (41)
Dual-mobility construct	10 (16)
Femoral head diameter[b] (%)	
22 mm	1 (4)
28 mm	7 (28)
32 mm	6 (24)
36 mm	4 (16)
40 mm	6 (24)
44 mm	1 (4)
Femoral head composition[b] (%)	
Cobalt-chromium	54 (89)
Ceramic	7 (11)
Operative time (minutes)	
Mean[a]	256 ± 107
Range	90 to 640

THA, total hip arthroplasty; PFR, proximal femoral replacement.
[a] The values are given as the mean and the standard deviation.
[b] The values are given as the number of cases, with the percentage of cases with data in parentheses.

Implants

The implants used in this series were the Global Modular Restoration System (Stryker, Kalamazoo, Michigan) in 55 hips (90%), followed by the Limb Preservation System (DePuy Synthes, Warsaw, Indiana) in four hips (7%), and the Orthopedic Salvage System (Biomet, Warsaw, Indiana) in two hips (3%). In 46 hips (75%), the acetabular component was also revised. In the remaining cases, only the acetabular liner was exchanged. A constrained liner was used in 26 hips (43%), a dual-mobility construct in 10 hips (16%), and a standard femoral head and liner construct in the remaining 25 hips (Table 1). The femoral head component was cobalt-chromium in 54 hips (89%) and ceramic in the remaining seven hips (11%). Cemented stems were used for femoral fixation in 60 PFRs (98%), whereas an uncemented stem was used in one case (Biomet Compress, Warsaw, Indiana).

The median length of the body was 120 mm (range, 60 to 280; Table 1). The most commonly used body was 70 mm in 20 hips. The length of the most commonly used femoral stem component was 127 mm in 27 hips, followed by 203 mm in 26 hips, 125 mm in three hips, and 102, 175, and 200 mm in one hip each, respectively. For two hips, the component length was not available. The femoral

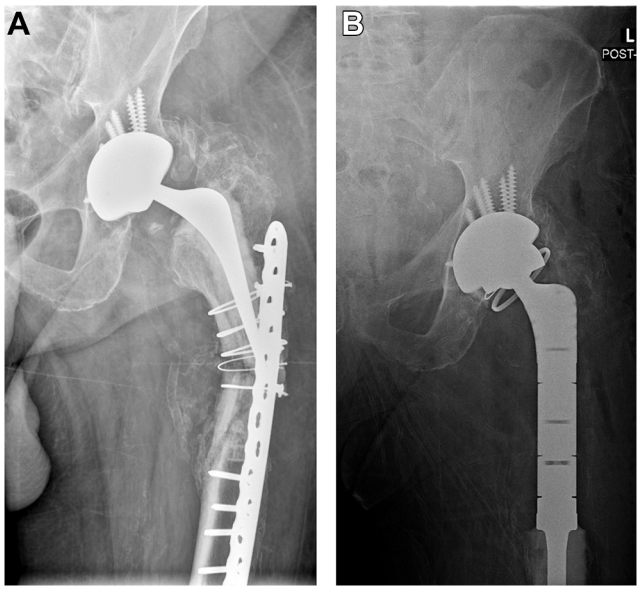

Figure 1. Radiographs showing (A) a periprosthetic fracture resulting in femoral bone loss (Paprosky IV) in a 97-year-old man (B) who then underwent a cemented proximal femoral replacement with a constrained liner.

component stem diameter was 13 mm in 20 hips, 15 mm in 13 hips, 11 mm in 12 hips, 17 mm in nine hips, and nine, 10, 12, 14, and 18 mm in one hip each, respectively. The diameter was not available in two hips.

Surgical Technique

The PFR was performed according to the technique previously described by Viste et al. [1]. When residual abductor musculature was present, it was reattached to the lateral aspect of the proximal femoral component using heavy nonabsorbable sutures. Implant positioning and hip stability were assessed intraoperatively using trial components. Fluoroscopy and/or intraoperative radiographs were routinely used to confirm stability, restoration of leg length, and optimal implant positioning. All revision THAs were performed by fellowship-trained orthopaedic surgeons. The surgical approach was a direct lateral approach in 39 patients (64%), through an osteotomy in 11 patients (18%), by a posterior approach in nine patients (15%), and via an anterolateral approach in two patients (3%). The mean operative time was 255 minutes (range, 90 to 640).

Study end points included cumulative incidences of revision for aseptic loosening of the femoral component, any revision of the femoral component, revision for dislocation, any revision, and any reoperation, accounting for death as a competing risk. In addition, we analyzed complications, mortality rates, and clinical outcomes using the Harris Hip Scores (HHS) [29]. Revision was defined as a surgical intervention that involved the revision of at least one component, including the acetabular component liner. Reoperation was defined as any subsequent surgical intervention on the operative joint, with or without revision of the implants. Dislocation was defined as an event requiring closed or open reduction. Complications were defined as any complications that were not revisions or reoperations.

Data Analyses

Demographic variables were summarized utilizing descriptive statistics, with continuous variables reported as means and standard deviations and categorical variables reported by counts and percentages, unless otherwise noted. Revisions, reoperations, dislocations, and aseptic failures were considered as time-to-event outcomes and were analyzed using the cumulative incidence function, accounting for the competing risk of death. The association of implant bearing type with the risk of dislocation was evaluated using Cox regressions. Mortality was assessed using the Kaplan–Meier estimation. All statistical tests were two-sided, and statistical significance was set at $P < 0.05$. All analyses were conducted using Statistical Analysis System (version 9.4M8; SAS Institute, Inc, Cary, North Carolina) and R (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria).

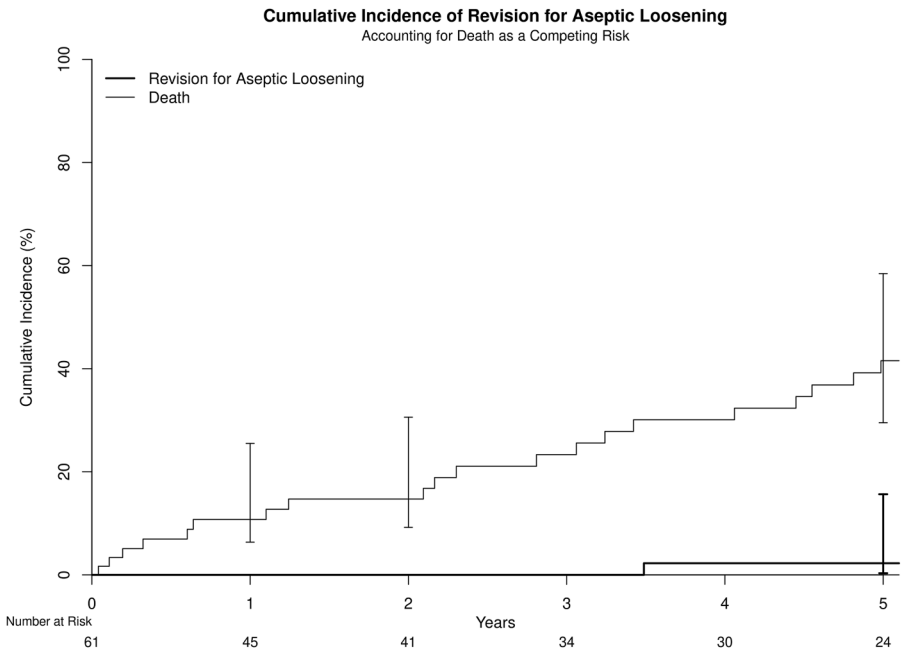

Figure 2. Cumulative incidence of revision for aseptic loosening with death as a competing risk.

Table 2
Cumulative Incidences of Revision for Aseptic Loosening, Any Revision of the Femoral Component, Revision for Dislocation, Any Revision and Any Reoperation.

Event	Time point (Year)	Cumulative Incidence (%)	95% CI[a]
Revision for aseptic loosening	1	0	N/A, N/A[b]
	2	0	N/A, N/A[b]
	5	2.3	0.3, 15.6
Any revision of the femoral component	1	3.8	1.0, 14.6
	2	5.8	1.9, 17.3
	5	7.9	3.1, 20.3
Revision for dislocation	1	7.1	2.7, 18.2
	2	14.9	7.8, 28.2
	5	14.9	7.8, 28.2
Any revision	1	12.4	6.2, 24.9
	2	21.8	13.2, 36.0
	5	23.9	14.8, 38.5
Any reoperation	1	20.8	12.5, 34.5
	2	28.2	18.6, 42.8
	5	30.3	20.3, 45.1

CI, confidence interval.
[a] The values representing the lower and upper bounds of the 95% confidence interval.
[b] No data available due to the absence of events.

Results

Implant Survivorship

The cumulative incidences of femoral revision for aseptic loosening were 0% at one year and two years and 2% at five years (Figure 2). Only one femoral component was revised for aseptic loosening at 41 months postoperatively, and that was converted to a total femoral replacement. The 1-, 2-, and 5-year cumulative incidences of any revision of the femoral component were 4, 6, and 8%, respectively (Table 2).

The 1-, 2-, and 5-year cumulative incidences of revision for dislocation were 7, 15, and 15%, respectively (Figure 3). Among the eight patients revised for dislocation, seven patients initially received a standard bearing (three had a 44, two had a 32, and one each had a 28 and a 22 mm head). In addition, one dislocation occurred in a patient who had a constrained liner. No revisions were required for hips that initially received a dual-mobility construct. There was no significant difference in survivorship for dislocation between standard bearing, constrained liners (hazard ratio 0.19; 95% confidence interval [CI] 0.03 to 1.26; $P = 0.085$), and dual-mobility constructs (hazard ratio 0.12; 95% CI 0.01 to 2.68; $P = 0.18$). Before the PFR procedure, four of the eight patients who were revised for dislocation had undergone two or more previous surgeries (mean four, range, 1 to 11). All these patients were revised to a constrained liner at a mean of 11 months postoperatively (range, 0 to 20), with one patient requiring an additional acetabular component revision.

Of the eight patients who were revised for chronic dislocation, four required additional revision procedures. There was one patient who underwent two further revisions. Another patient developed acetabular component loosening and underwent a revision of the acetabular component before ultimately requiring a total femoral replacement. There were two additional patients who underwent revisions for PJI, with each requiring a two-stage exchange arthroplasty culminating in a total femoral replacement.

The 1-, 2-, and 5-year cumulative incidences of any revision were 12, 22, and 24%, respectively (Figure 4). There were 15 patients (25%) who underwent a subsequent revision, with seven of these patients requiring multiple revisions (range, one to five operations) during the study period. The leading cause of revision was dislocation in eight patients (53%), followed by PJI in four patients (27%), periprosthetic femoral fracture in two patients (13%), and aseptic loosening in one patient (7%; Table 3). The four revisions for PJI included two chronic PJIs (one treated with a PFR revision and one treated with implant removal), one acute hematogenous PJI treated with implant removal, and one acute postoperative PJI managed with debridement, antibiotics, and implant retention. Furthermore, the two revisions for periprosthetic fracture were both revised to a total femoral replacement at four and nine months, respectively.

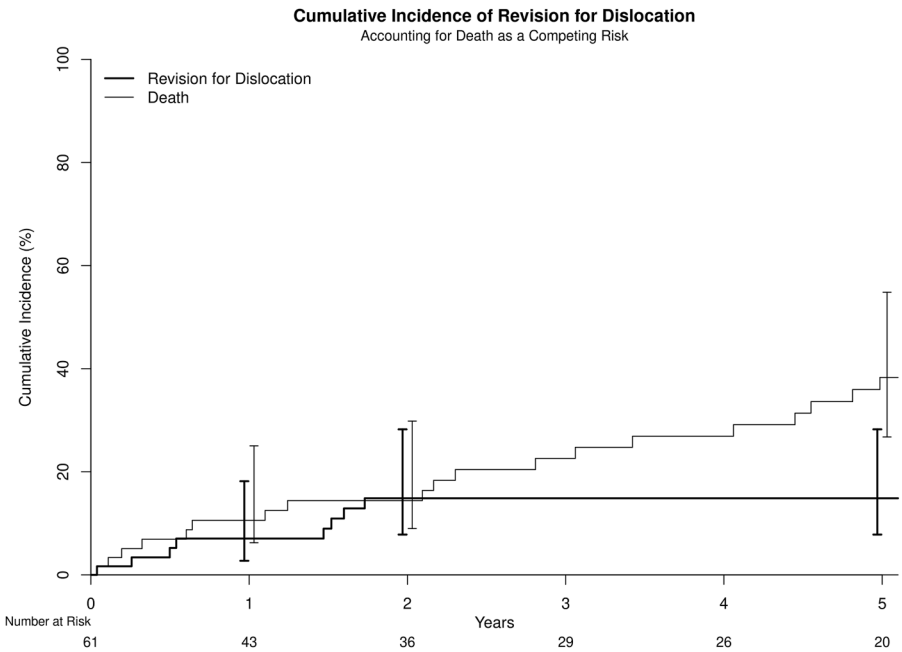

Figure 3. Cumulative incidence of revision for dislocation with death as a competing risk.

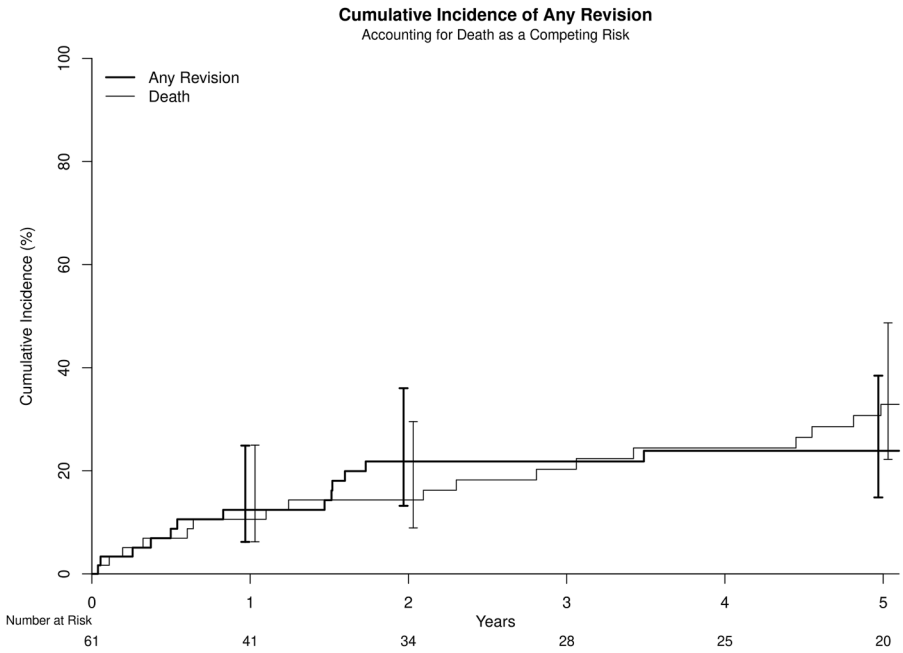

Figure 4. Cumulative incidence of any revision with death as a competing risk.

There were three additional nonrevision reoperations (Table 3), including two patients who required debridement, antibiotics, and implant retention with revision closure due to wound drainage, and one patient underwent hematoma evacuation. The overall 1-, 2-, and 5-year cumulative incidences of any reoperation were 21, 28, and 30%, respectively (Figure 5).

Complications

A total of six patients experienced complications (Table 3). These were deep vein thrombosis, delayed wound healing, and dislocation treated nonoperatively (each occurring in two patients).

Patient Mortality

There were three patients who died within 90 days following PFR. The 1-, 2-, and 5-year mortality rates were 11 (95% CI, 2.2 to 18.5), 14 (95% CI, 4.7 to 23.9), and 42% (95% CI, 25.7 to 54.5), respectively. Among the 38 deceased patients in this cohort, the mean age at the time of death was 81 years (range, 49 to 97), and the mean time from PFR to death was five years (range, 1 month to 14 years).

Table 3
Etiologies of Subsequent Revisions, Reoperations, and Postoperative Complications.

Etiology	Number of Cases
Revisions (15)	
Dislocation	8
Periprosthetic joint infection	4
Periprosthetic femur fracture	2
Aseptic loosening	1
Reoperations (3)	
Wound drainage	2
Hematoma	1
Other complications (6)	
Deep vein thrombosis	2
Delayed wound healing	2
Dislocation	2

Clinical Outcomes

The mean HHS was 46 (range, 22 to 78) preoperatively, improving to a mean of 75 (range, 51 to 97) at two years postoperatively. At five years, the mean HHS was 78 (range, 63 to 89), and at 10 years, it was 65 (range, 54 to 74). Of the nine patients alive and unrevised at the last follow-up, eight patients required a gait aid. However, eight patients reported minimal to no pain. Of these, the majority were able to walk at least one block, with three walking one to three blocks, four walking four to six blocks, and one walking without limitation.

Discussion

Despite advancements in surgical techniques and implants for revision THAs, extensive femoral bone loss in multiply revised patients remains a challenge, which can necessitate proximal femoral replacements as a salvage procedure. Given the complexity of the procedure and the high mortality rate in this patient population, we sought to evaluate implant survivorship, complications, patient mortality, and clinical outcomes. In this extended series of 61 PFRs performed for nononcologic indications, we observed high rates of reoperations and revisions, but this was primarily driven by dislocation.

Femoral revision for aseptic loosening was exceptionally low, with only a single case. Similar rates have been observed in other contemporary series on PFRs [18,20,30–32]. Chandi et al. [30] reported one case of aseptic loosening in a cohort of 50 PFRs, and Grammatopoulos et al. [31] reported 4% at a mean of five years. Previously published studies on older implant designs reported revision rates for aseptic loosening as high as 22% at a mean of 11 years [33]. In addition, our 5-year cumulative incidence of any femoral component revision was notably low at 8%. In contrast, the cumulative incidence of any revision was high at 24%, but this is consistent with existing literature, which reports revision rates

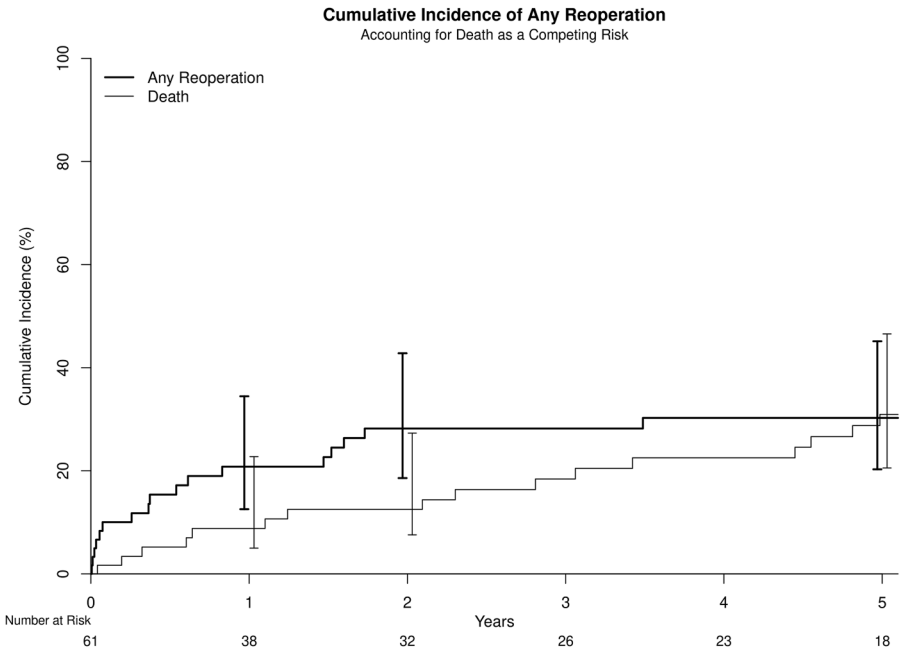

Figure 5. Cumulative incidence of any reoperation with death as a competing risk.

ranging from 5 to 58% across varying follow-up durations [1,15,18,20–26,31,33,34].

The most common reason for revision was dislocation, which can be expected with a no greater trochanter and limited abductor function. Although the surgical approach was selected at the discretion of the operating surgeon, changes in approach, particularly in the setting of multiple prior surgeries, may contribute to the observed dislocation rates. However, the initial approach was often unknown due to surgeries performed at outside institutions, limiting our ability to analyze this factor. An option to mitigate the risk is the utilization of a constrained liner. In the present study, of the 26 constrained liners, only one failed. Although some surgeons remain concerned that using constrained liners at the time of initial PFR surgery could increase the risk of early acetabular component loosening if also revising the cup, current evidence does not support higher aseptic loosening rates when initial rigid fixation occurs with multiple supplemental screws [35]. Notably, six of the eight patients who experienced a dislocation underwent an acetabular component revision at the time of their PFR, but only one of them received a constrained liner. Another strategy to reduce dislocation risk is the use of a dual-mobility construct. Our group and others have published that dual-mobility constructs in revision THAs reduce the risk of dislocation [36–38]. Importantly, none of the 10 dual-mobility constructs in our study experienced dislocation.

The patient mortality observed in this study was notably high. The elevated mortality risk can be attributed to the advanced age of the cohort as well as the cumulative burden of multiple revisions. These findings align with previous studies that have also documented high mortality rates in similar populations. For example, Colman et al. [17] reported a 45% mortality rate at five years in their cohort of patients who had periprosthetic fractures treated with a PFR. Similarly, Fenelon et al. [34] documented an 8% mortality rate at 30 days and a 29% mortality rate at a mean follow-up of two years.

This study has potential limitations. It is a retrospective study without a comparator group, which limits generalizability. In addition, the sample size is relatively small, potentially reducing the power to detect true differences. Also, the study included patients who had varying degrees of femoral bone loss, introducing heterogeneity into the cohort.

In conclusion, PFRs for nononcologic indications have a very low rate of femoral component aseptic loosening, but a high rate of dislocation that often requires a constrained liner. Given the high revision and reoperation rate, its use remains limited to the salvage setting.

CRediT authorship contribution statement

Nils Meissner: Writing – original draft, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Mason F. Carstens:** Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Dirk R. Larson:** Writing – review & editing, Validation, Formal analysis. **Nicholas A. Bedard:** Writing – review & editing, Methodology, Investigation, Data curation. **Charles P. Hannon:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation, Data curation, Conceptualization. **Matthew P. Abdel:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization.

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