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Proximal Femoral Replacement in the Management of Acute Periprosthetic Fractures of the Hip: A Competing Risks Survival Analysis

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ABSTRACT

To examine the mortality and implant survivorship of proximal femoral replacement (PFR), revision total hip arthroplasty (REV) and open reduction internal fixation (ORIF) in the treatment of acute periprosthetic fractures of the proximal femur, we retrospectively reviewed 97 consecutive acute periprosthetic proximal femoral fractures from 2000 to 2010. Three groups were defined: PFR (n = 21), REV (n = 19), and ORIF (n = 57). Outcome measures were all-cause mortality, implant failure, and reoperation. Competing Risks survival analysis of overall mortality during the mean 35-month follow-up showed no statistical difference between the three groups ($P = 0.65$; 12 and 60 month mortality for PFR: 37%, 45%; REV: 16%, 46%; ORIF: 14%, 100%). Implant survival was worse for the PFR group ($P = 0.03$, 12 and 60-month implant failure rate for PFR: 5%, 39%; REV: 7%, 7%; ORIF 2%, 2%). We conclude that PFR as compared with REV or ORIF may have worse medium-term implant survival, primarily due to instability and dislocation.

Periprosthetic fracture around proximal femoral implants is a difficult complication of hip arthroplasty. A rising incidence of this complication has been observed and is likely a result of increasing volume of primary and revision procedures, longer average patient lifespan, and increasing number of arthroplasty procedures in older patients [1–4]. It is estimated to occur after 1% of primary total hip arthroplasty (THA) and 4% of revision total hip arthroplasty (RTHA) procedures [1]. Recent analysis from the Swedish Hip Registry has documented markedly increased perioperative and long-term mortality following periprosthetic proximal femur fracture compared with primary THA controls [5]. The severity of periprosthetic fracture is determined by host and surgical factors. Although most commonly low energy [6], these injuries frequently occur in an aging population with osteoporotic bone, advanced osteolytic defects, and multiple prior hip operations. In addition, while modern implants have improved survivorship, their predominantly cementless design may have higher early rates of periprosthetic fracture [7]. Revision stems may also be prone to stress shielding and proximal bone resorption [3,8].

Treatment paradigms for periprosthetic fracture around proximal femoral implants should be individualized based on patient functional demand, comorbidities, and patient expectations. However, the principles of obtaining a stable implant and achieving early mobilization are paramount in developing treatment strategy and improving outcomes [5]. Important considerations in achieving these goals include fracture location, implant stability, and quality of the surrounding bone [8,9]. Treatment options include most commonly, but are not limited to, open reduction with internal fixation and implant retention (ORIF), revision arthroplasty with supplemental fixation for fractures (REV), and modular endoprosthetic proximal femoral replacement (PFR). Although not a new implant technology, PFR in particular has emerged as an attractive treatment option for difficult fractures because it is technically straightforward, can be performed in an expeditious manner, and allows for immediate mobilization of the patient. There have been few reports on non-oncologic use of this implant, but in the existing studies there have been concerns regarding implant failure, especially due to instability [10–13].

The purpose of this study was to examine the outcomes of PFR compared to the other most common treatment strategies for periprosthetic fractures of the proximal femur. Specifically, we sought to examine the implant survivorship, mortality, and complication profiles of PFR as compared with conventional revision surgery and ORIF in the treatment of this difficult problem. Based on our experience and existing reports [10–13], we hypothesized that PFR is a viable, durable reconstructive option for difficult periprosthetic fractures around the proximal femur and may confer mortality benefit due to early mobilization and short operative times.

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Patients and Methods

Study Design and Statistics

After obtaining approval from our institutional review board, we performed a retrospective analysis of 97 consecutive periprosthetic hip fractures treated at our center from 2000 to 2010. Inclusion criteria for the study included Vancouver grade A, B, or C periprosthetic fracture of the proximal femur around a primary or revision total or hemiarthroplasty femoral implant [14]. In addition, the index operation for periprosthetic fracture took place at our institution without exception. Exclusion criteria in this study included antecedent surgical treatment prior to arrival at our institution and polytrauma including concomitant acetabular fracture.

Three treatment groups were identified depending on the index operation: Proximal femoral arthroplasty (PFR, n = 21), Revision arthroplasty (REV n = 19), and open reduction internal fixation (ORIF n = 57). The three groups were analyzed in all cases with an intention-to-treat methodology despite occasional cases of crossover, for example failed ORIF which later went on to PFR. We recorded patient demographics and comorbidities (Table 1), original implant type, fracture grade according to the Vancouver classification of periprosthetic fracture of the proximal femur (Table 2) [14], surgical treatment profiles, complication profiles (Tables 3, 4), and mortality. The principle outcome measure was implant failure, which was defined as need for reoperation and revision or resection of femoral or acetabular components for any reason. This definition referred to arthroplasty implants only, and not, for instance, revision of plates or screws. In addition, operations which retained the original implants such as polyethylene exchange or irrigation and debridement were not counted as implant failures but were recorded as re-operation events. A secondary outcome measure was death from all causes.

The PFR, REV, and ORIF groups were compared using analysis of variance for quantitative data, two-tailed chi-squared with Fisher exact test for categorical data, and Kaplan–Meier survival analysis incorporating log-rank statistic to compare survival curves (SPSS, IBM, Inc, Armonk, NY). Given the high incidences of two interacting outcome measures, death and implant failure, we also used competing risks survival analysis with the Gray test to compare cumulative incidence curves [15,16]. This method accounts for interactions between outcome variables and analyzes their survivorship separately, thus overcoming bias and misleading overestimation effect sometimes present with Kaplan–Meier.

Table 1
Study Group Demographics and Medical Comorbidities.

	PFR	REV	ORIF	*P* Value
Male	43%	42%	40%	0.36
Female	57%	58%	60%	0.36
Age at Fracture[a]	75	72	76	0.53
Cardiac Disease	43%	37%	44%	0.80
Chronic Pulmonary Disease	38%	16%	16%	0.05
Chronic Steroid Use	19%	5%	7%	0.26
Prior Unrelated Oncologic History	29%	26%	14%	0.19
Peripheral Vascular Disease	19%	5%	11%	0.42
Renal Disease	19%	5%	5%	0.16
Diabetes	19%	21%	21%	0.94
Chronic Bisphosphonate Use	10%	11%	4%	0.46
Dementia	19%	5%	18%	0.38
Immunosuppression	5%	5%	0%	0.25
Smoking	19%	16%	9%	0.49
BMI[b]	26.9	27.8	27.6	0.90

[a] Means reported. Standard deviations: PFR, 15.8, REV, 14.5, ORIF, 13.1.
[b] Means reported. Standard Deviations: PFR, 7.6, REV, 6.1, ORIF, 6.1.

Table 2
Vancouver Classification of Periprosthetic Fractures by Treatment Group.

Vancouver Periprosthetic Fracture Grade	Description	PFR	REV	ORIF	*P* Value
Ag	Greater trochanteric fracture, stable stem	10%	0%	5%	0.42
B1	Fracture around or just below stem; stable implant	10%	0%	81%	<0.0001
B2	Fracture around or just below stem; unstable implant	57%	100%	7%	<0.0001
B3	Fracture around or just below stem, unstable implant and poor surrounding bone stock	24%	0%	0%	<0.0001
C	Fracture well below tip of stem	0%	0%	7%	0.21

Operative Protocols

Indications for performing PFR included all fractures with a loose implant and poor surrounding proximal femoral bone stock (Vancouver B3, Table 2, 24%). In addition, PFR was commonly performed for fractures with adequate bone stock and a loose implant (Vancouver B2, Table 2, 57%) in cases where a subjective surgeon assessment of the risk/benefit profile for PFR was more favorable than that of revision arthroplasty based on reasons such as fracture difficulty or comminution, deconditioning and comorbidities of the host, or need for immediate mobilization with full weight bearing. Rarely, PFR was performed for A or B1 type fractures (Table 2, 10% and 10%, respectively) in the face of a stable-appearing implant if there was extensive osteolysis, osteopenia, or if the host characteristics seemed to preclude healing based in the treating surgeon opinion. Indications for revision arthroplasty included those periprosthetic fractures with a loose stem (Vancouver type B2, Table 2, 100%). Indications for ORIF included fractures with a stable stem either at the greater trochanter, around the stem, or well below it (Vancouver Ag, B1, and C, Table 2, 5%, 81%, and 7%, respectively). 7% of the fractures treated with ORIF had a prosthetic stem loosen in the postoperative period and thus were classified retrospectively as Vancouver B2 variants although this was not recognized at the time of surgery.

Although this study involved three attending surgeons with different operative protocols, there are some generalizations which can be made. All surgeons contributing to this study use a direct lateral or anterolateral approach to the femur. At our institution specialized laboratory or aspiration studies to investigate occult infection are not routinely performed preoperatively in periprosthetic fracture patients unless the patient shows signs of sepsis on presentation or there is some other sign which lowers the threshold of suspicion such as late spontaneous dislocation. We do however routinely send gram stain and intraoperative frozen section studies prior to implantation in any case where there is a question of infection or purulence discovered intraoperatively.

For PFR reconstructions specifically, two different techniques were used for abductor reconstruction: trochanteric slide with maintenance

Table 3
Summary Non-Death Complications: Entire Study Group.

Entire Series: Summary Non Death Complications	34%
Pulmonary Embolus	1%
Deep Venous Thrombosis	3%
Myocardial Infarction	1%
Infection Requiring Debridement	9%
Hematoma Requiring Debridement	3%
Re-fracture	6%
Non-Union	7%
Knee or Hip Contracture	2%
Dislocation	7%
Nerve Palsy	2%