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ORIGINAL PAPER

Proximal femoral replacement in non-oncologic patients undergoing revision total hip arthroplasty

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Abstract

Purpose Proximal femoral replacements (PFRs) have been recently utilized in complex revision arthroplasties where proximal femoral bone is compromised. The purpose of this study is to evaluate the clinical outcomes, complications, and survivorship of PFRs as a salvage treatment for severe bone loss after non-oncologic revision total hip arthroplasty.

Methods This is a retrospective review of all patients who underwent femoral revision surgery using a single design PFR between 2004 and 2013 at our institution. Forty patients (41 hips) were included with a mean age of 64 years (29–90). According to Paprosky classification, 15 femurs had type IIIB defect, and 26 had type IV defect. Patients were followed for a mean of five years (2–10). The average length of reconstruction was 150 mm (81–261). A Kaplan–Meier analysis was used to determine the survival of the PFR.

Results A total of nine patients (9 PFRs, 22%) were re-operated upon. Three re-operations were for infection, two for dislocation, two for aseptic loosening, and two for periprosthetic fracture. The survivorship at five years was 95.1% for revision of the femoral stem for aseptic loosening. We did not find length of the segmental reconstruction or the indication for revision, to be a risk factor for implant failure or re-revision.

Conclusions Proximal femoral replacements have shown an acceptable survivorship in non-oncologic revision hip arthroplasties for severe proximal femoral bone loss. The frequent use of constrained liners may decrease the risk of dislocation due to the loss of the abductor mechanism encountered in these complex reconstructions.

Keywords Revision total hip arthroplasty · Proximal femoral replacement · Megaprosthesis · Dislocation · Bone loss

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Introduction

Revision total hip arthroplasty (THA) often involves varying degrees of femoral bone loss that presents unique reconstructive challenges. Extensive proximal femoral bone loss can be due to several factors, including aseptic loosening, osteolysis, periprosthetic fracture, and periprosthetic joint infection (PJI) [1]. Major femoral bone defects, classified as Paprosky [2] types IIIB (less than 4 cm of diaphyseal bone available) and IV (widened diaphyseal canal), have been reconstructed using extensively porous coated stems [3], impaction bone grafting [4], modular and monoblock cementless fluted tapered stems [5], allograft prosthetic composite [1, 6], proximal femoral replacement [7–10], and resection arthroplasty [11].

Studies with structural allografts during revision hip arthroplasty have reported encouraging mid-term results, but the high number of complications is a concern. Complications with these techniques include infection, graft resorption, non-union, failure of graft incorporation, concerns regarding disease transmission, aseptic loosening, escape of the greater trochanter and periprosthetic fracture [12, 13], whereas resection arthroplasties have been associated with limited function and walking ability due to the limb shortening with a resulting lifelong need for an assistive device to walk [14].

Proximal femoral replacement, also known as "megaprosthesis," is a well-established limb salvage procedure for reconstruction of bone defects after the oncological resections of malignant bone neoplasms [15]. More recently, due to the encouraging results with the use of PFRs in musculoskeletal oncology [16, 17], the indication of their use was expanded for non-oncologic patients with severe bone loss (Paprosky types IIIB and IV) [2] encountered during complex revision THAs. However, this type implant has inherent disadvantages including increased risk of dislocation, due to the loss of functioning abductors, and infection [13, 18, 19].

The purpose of this study is to evaluate the clinical outcomes, complications, and survivorship of PFRs as a salvage treatment for severe bone loss after hip arthroplasty.

Table 1 The demographic details of the 40 patients (41 hips) in the initial cohort

Variable	Value
Number of hips	41
Number of patients	40
Gender	
Female	26 (65%)
Male	14 (35%)
Side (number)	
Right	22 (54%)
Left	19 (46%)
Indication for the PFR (number of hips)	
Periprosthetic joint infection	17 (42%)
Aspetic loosening	14 (34%)
Periprosthetic fracture	7 (17%)
Nonunion	3 (7%)
Body mass index (kg/m^2) (range)	28 (17 to 37)
Mean age at surgery (range; years)	64 (29 to 90)

Materials and methods

After obtaining institutional review board approval, we retrospectively evaluated the records of 40 consecutive patients (41 hips) who underwent revision THA for non-neoplastic indications using the Global Modular Restoration System (GMRS) Proximal Femoral Replacement System (Stryker, Mahwah, NJ, USA) at a single institution from January 2004 to March 2013. The patients were identified from our institutional joint replacement database, ensuring a minimum follow-up of two years. We included all patients treated with revision hip arthroplasty in which the GMRS PFRs were implanted. We excluded patients with any oncologic diagnoses and those who received total femoral replacements. Clinical and radiological data were recorded for a minimum of two years. There were 26 women (65%) and 14 men (35%) with a mean age of 64 years (range, 29–90 years) at the time of surgery. The mean body mass index was 28 kg/m^2 (range 17 to 37 kg/m^2). The demographic details of the patients are shown in Table 1. A posterolateral approach was performed in all patients by experienced arthroplasty trained surgeons at a single institution. Patients had a mean of 3.6 (range, 1–11) previous hip surgery before the revision procedure that required the PFR. The indications for the revision with the use of PFR included second-stage reimplantation for periprosthetic joint infection (PJI) after antibiotic spacer placement (17 hips; 42%), aseptic loosening (14 hips; 34%), periprosthetic fracture (7 hips, 17%), and nonunion (3 hips; 7%). In the PJIs the duration between the stages was no less than five weeks [36]. The surgical technique for implantation of PFRs has been described [23]. Femoral bone defects were carefully assessed using pre-operative radiographs and intra-operative findings using the Paprosky classification system [2] and rated as Type IIIB in 15 femurs (32%) and Type IV in 26 femurs (63%) (Fig. 1). The acetabular component was revised in 27 hips; in the remaining, 14 hips the liner was exchanged. To reduce the risk of dislocation a constrained liner was used in 30 hips (73%) and a dual mobility liner in one hip (2%). When a constrained liner or a dual mobility liner were not used (10 hips, 25%), the diameter of the femoral heads used were 28 mm in three hips, 32 mm two hips, 36 mm in three hips, and 40 mm in two hips. The mean length of the construct was 150 mm (range 81–261 cm). Stems were cemented in 37 hips (90%) and press-fit in four hips (10%). The mean length of the stem was 127 mm (range, 100–200 mm). The greater trochanter was reattached to the implant with sutures in ten hips, with polyethylene wires in eight hips, and metal wires in four hips. Radiographic review was performed by two orthopaedic surgeons (IDM and RDA) not involved in the surgery.

Statistical analysis

Kaplan–Meier survival analysis was used to generate survivorship curves with 95% confidence intervals (CIs) with the end points implant revision for aseptic loosening, and revision of any component (implant and/or cup and/or liner and/or head) for any reason. A worst-case curve was also performed as recommended by Murray [20], where all those lost to follow-up were considered as failures. All statistical analyses were performed completed using the SPSS software version 23.0 (SPSS Inc., Chicago, IL, USA).

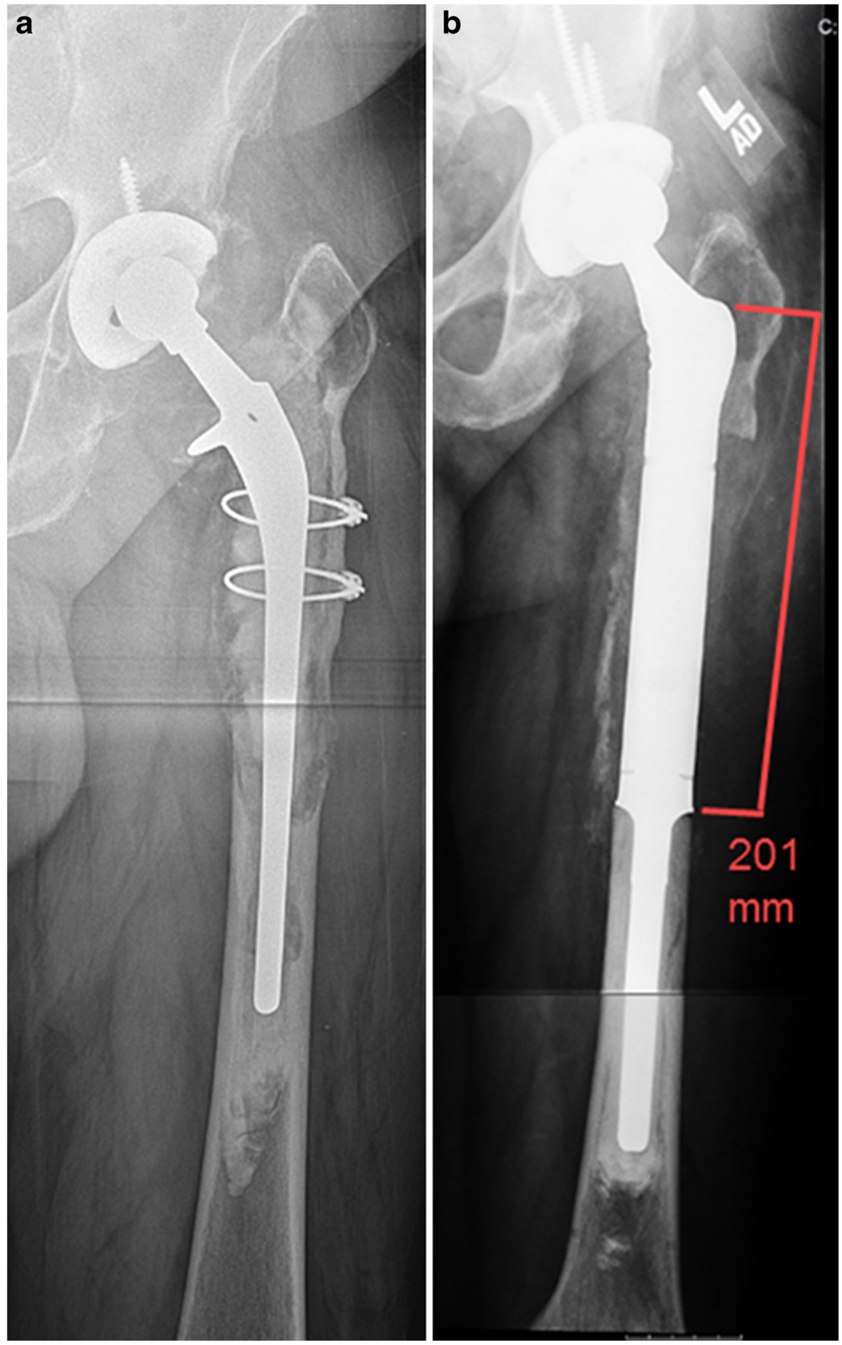

Fig. 1 Radiograph showing (**a**) massive proximal femoral bone defect (Paprosky IIIB) and loosening of a cemented stem in a 81-year-old male and (**b**) after cemented proximal femoral replacement with the greater trochanter reattached

Results

Four patients (4 hips) died (9.7%) for causes unrelated to the index arthroplasty and six patients (6 hips) were lost to follow-up (14.6%) leaving 30 patients (31 hips) available for analysis (85.7%). The prostheses in these ten patients (10 hips) were known to be functioning well at the time of the most recent follow-up. Thus, 30 patients (31 hips) were available for clinical and radiographic analysis (75.6%). The mean follow-up was five years (range 2–10 years). A total of nine patients (9 PFRs, 22%) were re-operated upon. The reason for re-operation included infection (3 patients, 7%), dislocation (2 patients 5%), aseptic loosening (2 patients 5%), and periprosthetic fracture (2 patients 5%). Two of the three infections were for recurrent infection in the second-stage reimplantation subgroup and were treated with irrigation and debridement. The third infection was treated with a two-stage revision. The eradication of infection was achieved in 12 (86%) of the 14 patients in the second-stage reimplantation subgroup. The patients revised for aseptic loosening were both in the aseptic loosening subgroup and were converted to a total femoral replacement (Fig. 2). One of the two patients revised for dislocation had

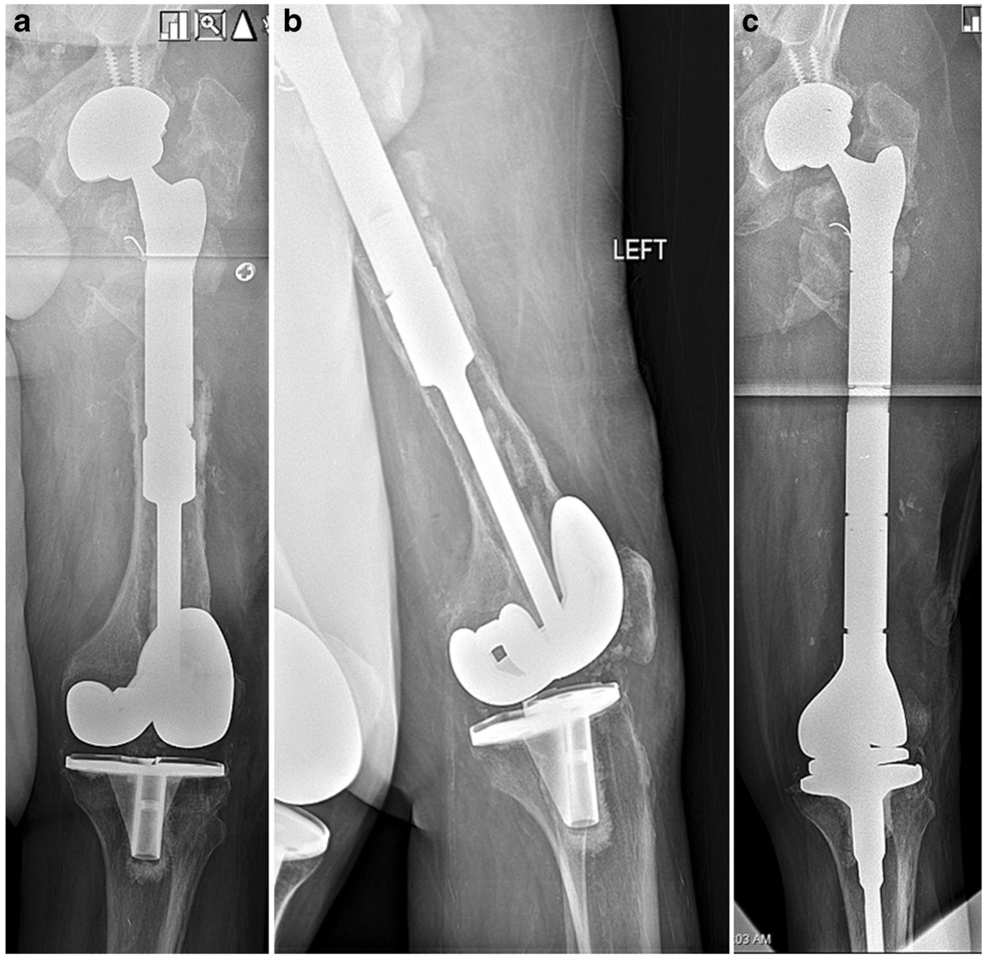

Fig. 2 One of the two patients reoperated upon for aseptic loosening. Radiograph showing (**a** and **b**) failed cemented proximal femoral replacement and (**c**) after conversion to total femoral replacement

a constrained liner and both did not have the greater trochanter reattached when the PFR was implanted. They both underwent closed reduction first, and then required a new constrained liner. There was no relation between the length of the reconstruction, indication for revision and failure rate.

The Kaplan–Meier survivorship at five years was 95.1% (95% CI 82 to 100) for revision of the femoral stem for aseptic loosening (Fig. 3), and 78% (95% CI 62 to 97) for revision of any component for any reason (Fig. 4). The worst-case scenario femoral stem survivorship, in which all those lost to follow-up or died were considered as failures, was 53.6% (95% CI 37% to 79%).

Discussion

In this cohort, nine of 41 PFRs were revised (22%). Our overall re-operation rate at a mean of five years was similar to the reoperation frequency reported by Grammatopoulos et al. [10] (22%), but was higher than reported by Viste et al. [9] (18%) using a contemporary modular PFR. Similar re-operation rate (24%) was reported by Korim et al. [21] in a recent meta-analysis of 14 studies including a total of 356 PFR with an average follow-up of 3.8 years (range 0–14 years). When we take into consideration only the re-operations for aseptic loosening, our revision frequency (2 of 41) was superior to the re-operation frequencies reported by Viste et al. [9] (1 of 44) and Grammatopoulos et al. [10] (2 of 80). However, our patients had a mean age of 64 years and were younger than the patients in their cohorts (79 years and 69 years respectively) reflecting a possible different functional status with a concurrent different risk of aseptic loosening.

The results of our patients may be compared with those of patients treated with allograft prosthesis composite during revision hip arthroplasty, Haddad et al. [22], and Maury et al. [23] reported reoperation rates of 22% (11 of 51), and 16% (4 of 25) in their series of 51 and 25 hips at a mean follow-up of nine and five years respectively. Our revision rate is similar to the re-operation rate reported by Maury et al. [23], and is slightly higher than the rate reported by Haddad et al. [22].

Dislocation rate in our cohort was 5%. Our data were similar to the dislocation frequency reported by Grammatopoulos et al. [10] (3.7%), and compare favorably with the dislocation frequencies reported by Viste et al. [9] (14%) and Korim et al. [21] (16%). This can be due to the fact that we largely used constrained liners (73%) to reduce the risk of dislocation in

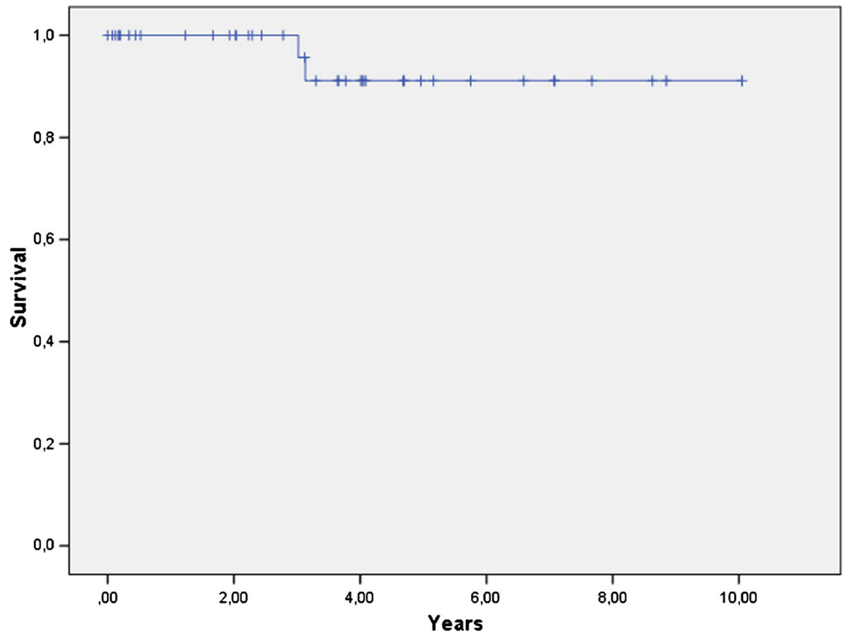

Fig. 3 Kaplan–Meier curve, with 95% confidence interval for revision of the femoral implant for aseptic loosening

addition to the reattachment of the greater trochanter and repair of the abductor mechanism when possible. Grammatopoulos et al. [10] used constrained liners only in 4% of their patients; however, modular dual mobility liners and a median head size of 36 mm were used to reduce instability. Parvizi et al. [8] reported a dislocation rate of 19% in their study of 48 PFRs. They highlighted the role of different factors in the reduction of the risk of dislocation in this type of reconstructions including restoration of length using modular components, reattachment of soft tissue and/or remaining trochanteric bone around a porous proximal implant component, and use of constrained liners [8]. However, longer-term follow-up is needed to assess the success of constrained liners in the setting of PFR. More recently, dual mobility liners and large heads were used in conjunction of PFRs to prevent instability with clinical success [9, 10]. Another possible solution to reduce the dislocation rate in this type of reconstructions, when the abductors are deficient, can be the use of artificial ligaments according to Du et al. [24]. In a cohort of 48 patients who received a total femur replacement for neoplastic reasons they found that the dislocation rate was lower when a band-shaped artificial ligament was wrapped spirally around the proximal site of the total femur prosthesis for periacetabular soft tissue reconstruction.

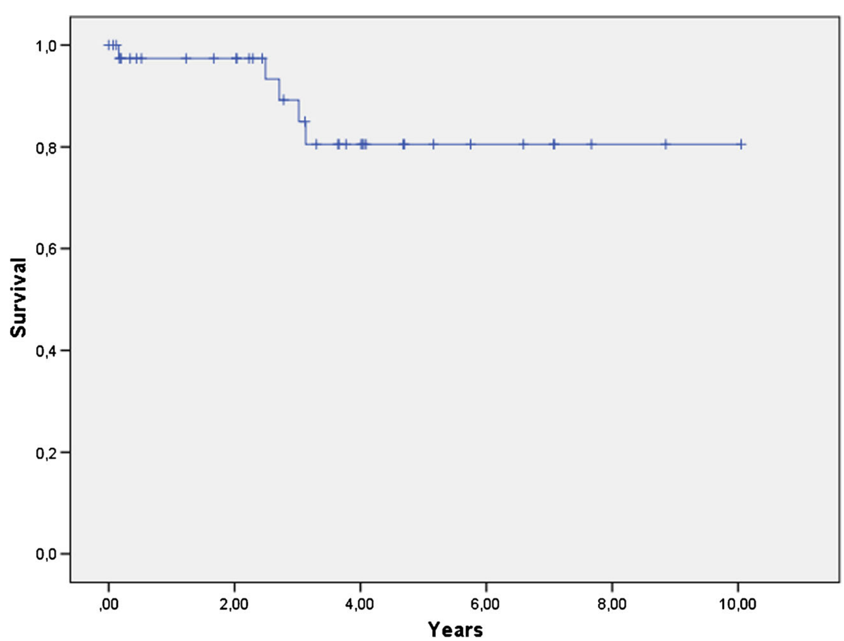

Fig. 4 Kaplan–Meier curve, with 95% confidence interval for revision of any component (implant and/or cup and/or liner and/or head) for any reason

The proportion of patients who had infections in our study (3 of 41, 7%) was comparable to that reported by Viste et al. [9] (5%), Korim et al. [21] (8%), and Grammatopoulos et al. [10] (11%). In our cohort 17 of 41(42%) patients received a PFR during a second-stage reimplantation for PJI after antibiotic spacer placement. The eradication of infection was achieved in 88% of our patients. Similar results were reported by Grammatopoulos et al. using the PFR to treat infections in 50% of their cohort [10].

There was no relation between the length of the reconstruction, indication for revision and failure rate. To our knowledge, there have been no studies analyzing the length of the PRF reconstruction and its impact on implant survivorship. Barry et al. [25] evaluated the length of the reconstruction in distal femoral replacement in non-oncologic knee arthroplasty revisions and reported that prostheses that extended past the metaphyseal-diaphyseal junction of the distal femur were associated with higher risks of infection, re-operation, and implant revision [25]. The biomechanical environment of the proximal femur may be more amenable to longer segmental reconstructions but larger numbers of long segment PFRs are needed to make any definitive conclusions.

This study has several limitations. First, the study was a retrospective review, and thus had all the inherent bias of retrospective studies. Second, the sample size is small because the nature of these procedures is infrequent and our institution's practice is to only use PFRs as the last resort for the massive proximal femoral bone defects. However, our series is among the largest contemporary series of PFRs present in the literature. Third, four patients died (9.7%) and 6 patients were lost to follow-up (14.6%), making our results likely represent a best-case scenario because those lost to follow-up are often performing worse. However, a worst-case curve was performed where all those died and lost to follow-up were considered as failures. Forth, there were no pre-operative and post-operative functional scores.

In conclusion, our study supports the use of PFRs as limb salvage option in non-oncologic revision hip arthroplasties for severe proximal femoral bone loss. The survivorship of the implant is acceptable, including its use in the treatment of periprosthetic joint infections, with a low incidence of aseptic loosening regardless of construct length. The use of constrained liners or artificial ligaments may decrease the risk of dislocation due to the loss of abductor mechanism encountered in these complex hip reconstructions. Further studies and even longer follow-up is required to assess the durability of these reconstructions.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest related directly or indirectly to the subject of this article.

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