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Original Research

Distal Femoral Replacements for Acute Comminuted Periprosthetic Knee Fractures: Satisfactory Clinical Outcomes at Medium-Term Follow-up

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ABSTRACT

Background: Fracture fixation techniques of comminuted periprosthetic distal femoral fractures have high risk of complications. The aim of this study was to evaluate short- to medium-term outcomes of comminuted periprosthetic distal femoral fractures treated with distal femoral replacements (DFR) at a tertiary arthroplasty unit.
Methods: Retrospective consecutive study of all patients who underwent DFR for periprosthetic fractures with minimum 2-year follow-up between 2010 and 2018. Clinical outcomes, surgical complications, revision for any cause, loosening, Knee Society Score and mortality data were collected at final follow-up.
Results: Thirty patients with average age 81 years (range, 65-90; 6 males and 24 females) were included. All had comminuted fractures (Rorabeck type-2/3). All patients had cemented DFRs. Three patients (10%) with multiple comorbidities died postoperatively. Average time from admission to being fit for discharge was 9 days (range, 3-14). Clinical outcomes and follow-up were available for 27 patients with a median follow-up duration of 4 years (2-13 years). Complication rate was 7.4% with one reoperation, change of polyethylene insert. None of the components have been revised to date. Average Knee Society Score at final follow-up was 78 (range, 57-92) with median arc of motion flexion-extension being 100° (range, 60°-125°).
Conclusions: In our experience, DFRs for comminuted periprosthetic fractures allow immediate mobilization and rehabilitation leading to satisfactory clinical outcomes with low complication rate for this challenging group of patients.
Level of evidence: level IV.

Introduction

Periprosthetic fractures after total knee arthroplasty (TKA) are defined as fractures of the femur or tibia occurring within 15 cm of the joint line or 5 cm from an intramedullary stem when present [1]. The rate of these fractures ranges from 0.3% to 5.5% in the published literature and projected to rise with increasing demand of TKA [2] with the distal femur being most commonly affected [3,4]. The mechanism of injury is commonly a low-energy trauma in elderly patients [5]. Osteoporosis with advanced age is considered one of the main risk factors with a high stress mismatch zone between the osteoporotic metaphyseal bone and the implant [3,4,6]. Surgical risk factors include component malalignment, anterior femoral notching particularly with distal fractures and with implant to fracture time and increased time since primary TKA [7-9].

The aim of surgical management is to restore function to, or near, preinjury level of activity, minimize complications, and allow pain-free full weight-bearing status with adequate alignment. Surgical treatments for distal femoral periprosthetic fractures

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include open reduction and internal fixation with lateral locking plates and retrograde intramedullary nailing or revision arthroplasty with distal femoral replacement (DFR) [5,8,10,11]. *Rorabeck* and Taylor [12] devised a commonly used classification system to describe these fractures: type-I (nondisplaced, well-fixed component), type-II (displaced, well-fixed component), and type-III (fractures around a loose component). However, this system does not take into account the location of the fracture which is a determinant of choice of treatment [7]. Other important factors that dictates surgical treatment include remaining bone stock, bone quality, fracture morphology and degree of comminution, patient's functional level, cognitive function, and medical comorbidities. Mortality rate of patienst with periprosthetic femur fractures is similar or higher than that of hip fracture patients [13].

Fracture fixation techniques require a period of restricted weight-bearing until the fracture heals with high rates of delayed union/nonunion while revision arthroplasty with endoprostheses allows immediate weight-bearing status and quicker recovery particularly in cases where internal fixation is likely to fail because of mechanical factors, loose implants, or patients' factors [3,14,15].

Our hypothesis is that DFRs are a viable alternative to fixation techniques with satisfactory clinical outcomes. The aim of this study was therefore to evaluate the short- to medium-term outcomes of periprosthetic distal femoral fractures treated with DFR at our tertiary arthroplasty unit.

Material and methods

This was a retrospective consecutive study of all patients who underwent a DFR for periprosthetic distal femoral fractures with minimum 2-year follow-up between 2010 and 2018. Patients were identified using a prospective database. Demographic, clinical, and surgical data were collected from patients' electronic health records. All patients underwent routine preoperative anesthetic assessment and received a spinal anesthetic with upper thigh tourniquet and perioperative prophylactic antibiotics. Surgeries were performed by the senior authors (B.V.B and P.J.J.).

Implants

The METS SMILES Total Knee Replacement (Stanmore Implants Worldwide Ltd., Elstree, UK) is a modular system consisting of a SMILES distal femoral component, a range of shafts in 15-mm increments to suit differing lengths of resections, options of hydroxyapatite-coated or hydroxyapatite-uncoated collars, and a range of cemented stems to fit the intramedullary canal. We routinely use the SMILES knee rotating hinge metal casing tibia with cemented stems (140 or 180 mm). We also use the LPS Limb Preservation System (DePuy, Warsaw, IN) with cemented stems, cemented metaphyseal sleeves, and mobile bearing hinge. The minimum distal femoral resection for LPS is 70 mm when using an extra-small DFR component. Choice of implant is dictated by the degree of bone loss and adjunctive fixation required as well as patient factors, the soft-tissue envelope, and surgeon preference.

Operative technique

Using the old midline incision and extending as far proximally as needed to expose the distal femur, knees were approached through a standard medial parapatellar arthrotomy with subluxation/eversion of the patella. The distal femur is then approached through the fracture site, in flexion, exposing the posterior surface. The capsule is then dissected off the bone, using a femoral peel approach, allowing removal of the femoral component and fracture fragments. A perpendicular cut to the anatomical axis of the distal femoral is then made, and the femoral canal is prepped with reamers to accept an appropriate diameter cemented stem. Attention is then turned to the tibia which is prepped in the standard fashion, removing the component with minimal bone loss. The canal is reamed to accept an appropriate diameter cemented stem. A trial is then assembled and articulated with the tibial component. The joint line level is restored and checked using a combination of anatomical markers and length measurements including the patellofemoral articulation [16]. Achieving correct rotation of the components is crucial to ensure patellofemoral tracking, and this can be challenging with the loss of traditional landmarks such as the transepicondylar axis [17]. Once satisfactory trial positioning is obtained, a mark is placed on the femur and the tibia using diathermy to identify the position of the definitive implants which are assembled to match the trials and cemented in place, using Palacos R + G (Heraeus Medical GmbH, Wehrheim, Germany). Additional antibiotics can be added to the cement as required [18]. Routine closure is then performed in layers over a drain which is removed in 24 hours. Full weight-bearing is commenced as tolerated with routine physiotherapy. Follow-up was performed regularly at 6 weeks, 3 months, and 12 monthly thereafter; tertiary referral patients were returned to their referring units for local follow-up.

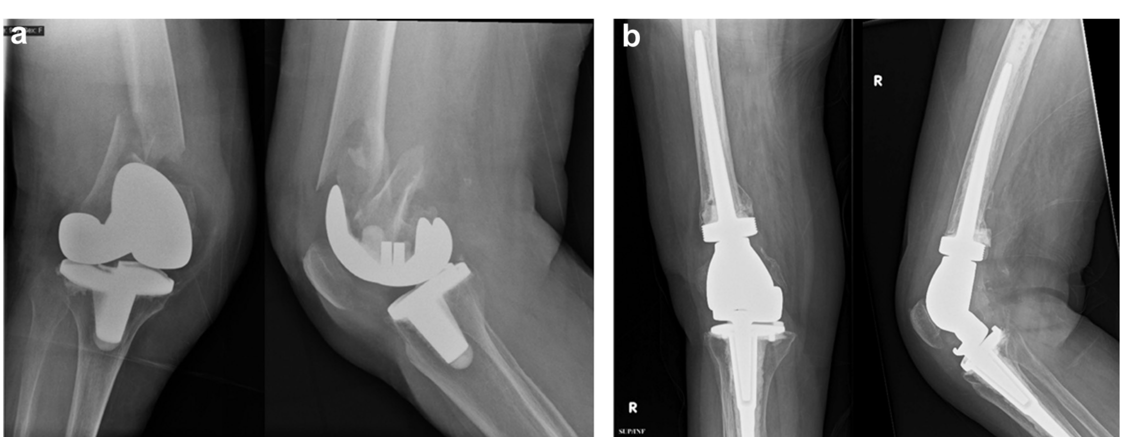

Fig. 1. (a) Preoperative anteroposterior and lateral radiograph of right knee with comminuted periprosthetic fracture in a 90-year-old female. (b) Anteroposterior and lateral postoperative radiographs at 2 years follow-up.

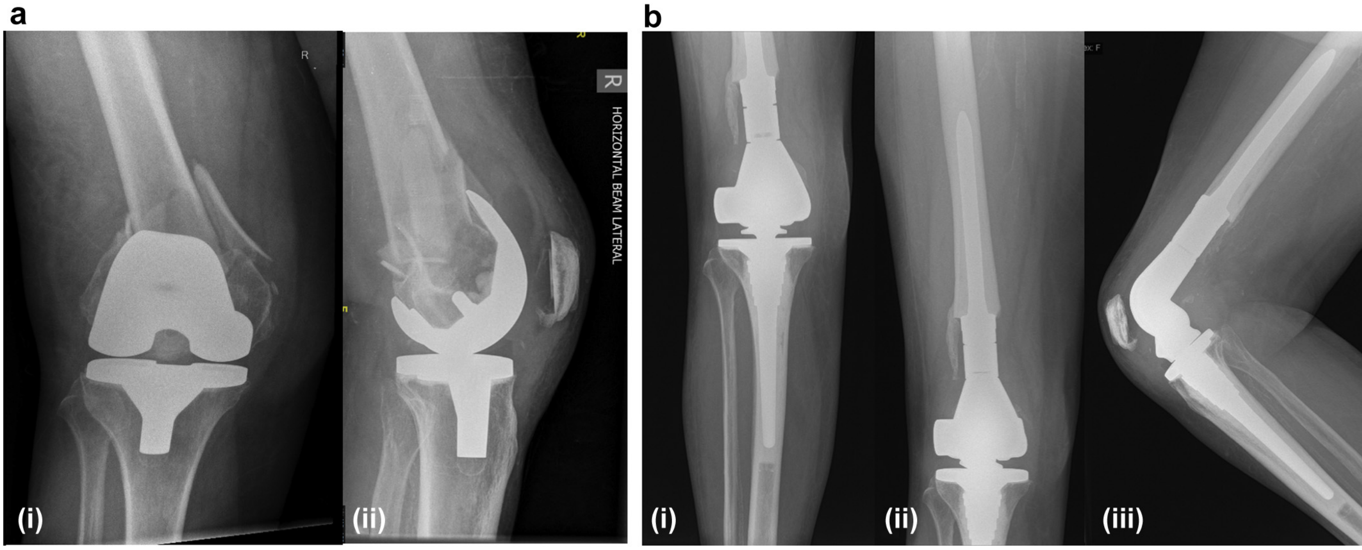

Fig. 2. (a) Preoperative anteroposterior (i) and lateral (ii) radiograph of right knee with comminuted periprosthetic fracture in a 70-year-old female. (b) Anteroposterior (i) and lateral (ii) postoperative radiographs at 2 years follow-up.

Outcome measures

Clinical outcomes, surgical complications, hospital length of stay, revision for any cause, loosening, and mortality data were collected. Knee Society Score (KSS) [19] at final follow-up was used as patient' reported outcome measure; if KSS score was not collected at the final follow-up visit, we contacted the patients for the purposes of this study to undertake clinical assessment.

Statistical analysis

The values of all parameters are presented as percentages. SPSS 16.0 software (SPSS Inc., Chicago, IL) was used for descriptive statistical analysis and Kaplan-Meier survival analysis.

Results

There were 30 consecutive patients with an average age of 81 years (range, 65-90); 6 males and 24 females. Mechanism of injury was simple mechanical falls in 24 patients and falls due to medical compilations (dizziness, loss of balance, and collapse) in the remaining 6 patients. Only 5 patients had been mobilizing independently before their falls and 25 with walking aids. All patients had multiple comorbidities (ASA-II 1/30, ASA-III 26/30, ASA-IV 3/30). All had comminuted fractures (*Rorabeck* type-II/III) and were thought to have a high risk of failure using fracture fixation techniques. All patients had cemented DFRs; 21 patients (70%) had METS SMILES Total Knee Replacement (Stanmore Implants Worldwide Ltd.) (Fig. 1), and 9 patients had LPS Limb Preservation

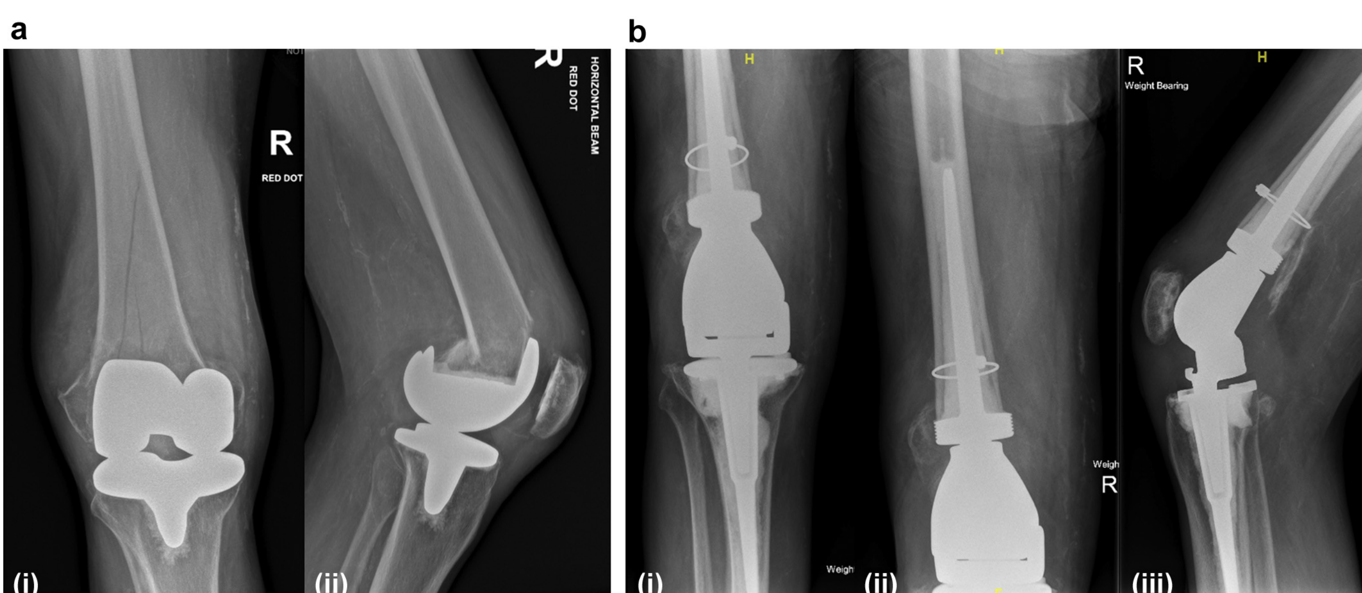

Fig. 3. (a) Preoperative anteroposterior (i) and lateral (ii) radiograph of right knee in a 78-year-old male with comminuted periprosthetic fracture of the distal femur propagating proximally around posterior-stabilised knee. (b) Postoperative radiographs (anteroposterior i/ii and lateral iii) at 5 years follow-up demonstrating the use of a cable around the distal femur ensuring anatomical reduction "reconstituting tube" then cementing distal femoral replacement component and allowing the patient to mobilise fully weight-bearing in the immediate postoperative period.

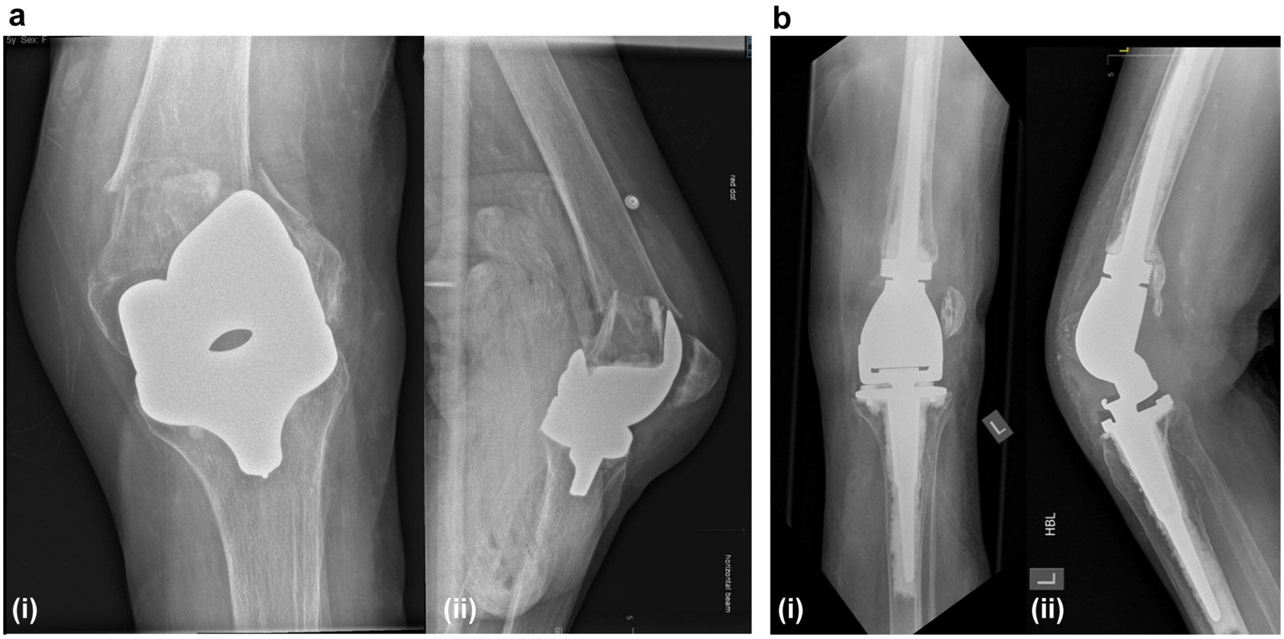

Fig. 4. (a) Preoperative anteroposterior (i) and lateral (ii) radiograph of left knee with comminuted periprosthetic fracture in an 85-year-old female. (b) Anteroposterior (i) and lateral (ii) postoperative radiographs at 9 months follow-up with patella dislocation.

System (DePuy, Warsaw, IN) (Fig. 2). Three patients (10%) with multiple comorbidities died postoperatively; 2 patients within the same acute admission (hospital acquired pneumonia, myocardial infarction) and a third died in a nursing home facility 9 weeks postoperatively. Average length of hospital stay was 17.8 days (range, 3-34); however, average time from admission to being fit for discharge was 9 days (range, 3-14). Clinical outcomes and follow-up was available for 27 patients with a median follow-up duration of 4 years (2-13 years) (Fig. 3).

Two patients (2/27; 7.4%) developed complications; one patient required reoperation at 7 years for change of polyethylene which had dislocated after a fall. Her implant remains in situ at a total of 13 years of follow-up. Another patient dislocated her patella (Fig. 4) but was able to continue mobilizing and opted for conservative management because of her low demands and medical comorbidities. Both of these patients had poor functional scores. There were no cases of infection, and none of the patients have undergone revision to date. The average KSS score at the final follow-up visit was 78 (range, 57-92) with a median arc of motion flexion-extension 100° (range, 60-125°; Table 1).

Table 1
Clinical outcomes at final follow-up.

Outcome	Number of patients, median (range)	
Operative time (n = 30)	128 mins (105-153)	
Blood loss[a] (n = 30)	523 mls (419-838)	
Hospital length of stay (d)	17.8 (3-34)	
Time to “fit for discharge” (d)	9 (3-14)	
Follow up (y)	4 (2-13)	
Arc Flexion-Extension	100° (60-125)	
Knee Society Score (n = 27)	78 (57-92)	Poor 4 (14.8%) Fair 4 (14.8%) Good 3 (11.1%) Excellent 16 (59.3%)
Complications	2/27	1 reoperation for insert dislocation 1 patella dislocation

[a] Combined intraoperative and drain output.

Survivorship analysis

Three of 30 patients died postoperatively, and further 4 patients later died at 1.2, 2, 3.5, and 5 years for unrelated causes. At median 4-year follow-up, patients’ survivorship for the entire data set was 74.6% (Fig. 5). To date, none of the components have been revised, although one patient had a reoperation with change of polyethylene insert.

Discussion

In this study, we present our experience in managing periprosthetic distal femoral fractures in a consecutive series with medium-term outcomes using revision arthroplasty techniques with DFRs. Our unit is a specialist tertiary arthroplasty center with high-volume revision knee workload averaging 117 revisions per year [24]. Our indications to use DFR in favor of fixation techniques is when the distal segment does not offer enough support for the retained prosthesis. Further with the use of cemented stemmed DFR implants, immediate weight-bearing is encouraged eliminating nonunion as a surgical complication of fixation techniques. Furthermore, similar to hip fracture patients, early mobilization is crucial to minimize perioperative medical complications associated with these fractures [13,25,26].

Traditionally, fixation techniques of using locking plates or retrograde intramedullary nails have high rate of failure and require long periods of immobilization until the fracture heals. In a recent multicenter retrospective study of 55 patients (3 level-I trauma centers) with distal femoral periprosthetic fractures treated with precontoured locking plate, Campbell *et al* reported overall complication rate of 24% and nonunion rate of 18% [27]. Similarly, Hoffmann *et al* reported that 36 periprosthetic distal femoral fractures (35 patients from 2 trauma centers) managed with locking plate fixation had an overall nonunion rate 30.6% [7]. Shin et al, in their systematic review, compared the outcomes of locking compression plating and retrograde intramedullary nailing for periprosthetic supracondylar femoral fractures [28]. Six studies reported nonunion rate between the 2 treatment modalities, which were 24/221 (10.9%) in the locking plate group vs

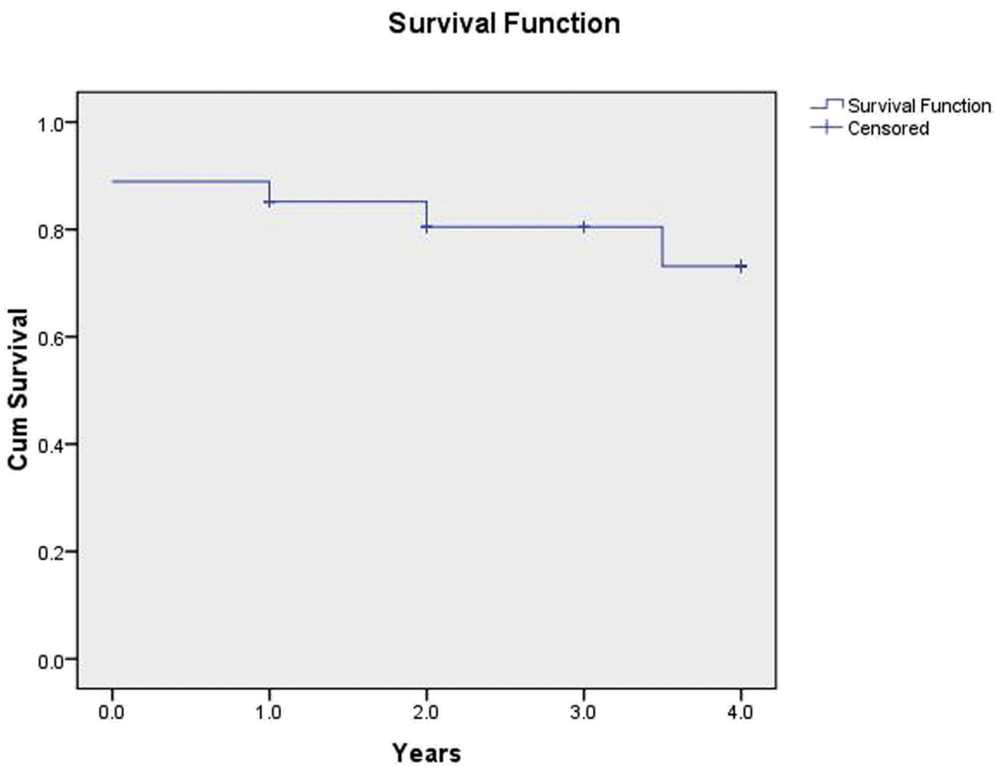

Fig. 5. Kaplan-Meier survivorship curve.

19/136 (14.0%) in the nailing group. Of those, 4 studies reported on further revision surgery required for nonunion cases, 24/109 (22.0%) vs 26/98 (26.5%) [28]. Finally, in a systematic review of 41 studies of distal femur periprosthetic fracture fixation by fracture type, Ebraheim *et al* [10] found that locking plates used to treat *Rorabeck type II* fractures had a complication rate of 35%, and those treated with intramedullary nailing had a higher complication rate of 53%.

Our patients were all *Rorabeck type II/III*, and our overall complication rate was 7.4%. The early postoperative mortality rate was 10%. However, mortality rates as high as 30% at 1 year after periprosthetic distal femoral fractures have been reported for this complex cohort of patients [13]. The hospital length of stay is often multifactorial and relies on local policies and the availability of rehabilitation placements or social/family support for those patients discharged home. Our average length of stay was prolonged with specific local delays related to housing modifications, availability of rehabilitation, and residential home placements. In our practice, we encourage patients to mobilize fully weight-bearing on the first postoperative day with appropriate supervision from physiotherapists. The functional scores achieved at various points of follow-up using the KSS indicate that almost two-third of our patients had good/excellent outcomes.

The use of DFR for managing periprosthetic fractures in distal femur is gaining popularity. A number of small case-series have reported similar clinical outcomes at short- to medium-term follow-up [14,20–23] Table 2. Wyles *et al* recently reported on the Mayo Clinic experience using DFRs with 144 cases (11 native fractures, 55 periprosthetic femoral fractures, 40 two-stage reconstruction for infection, 28 aseptic loosening, and 10 other indications) [29]. They reported 10-year cumulative incidences of revision for aseptic loosening, all-cause revision, and any reoperation of 17%, 27.5%, and 46.3%, respectively [29]. Our study is limited by the small number of patients included, the inherent limitations of its retrospective design, and the duration of follow-up. Further, we did not perform a cost-effectivness analysis as larger comparative studies are need for this important point as some argue that the use of DFR strategy for this cohort of patients is cost prohibitive. Therefore, larger comparative studies with cost-effectiveness analysis of DFR vs fixation techniques are needed in future research.

Table 2
Outcomes of DFR for periprosthetic fractures in the literature.

Study [number]	Average follow-up (mo)	Number of patients	Revision rate	Early postoperative mortality rate
Mortazavi *et al*, 2010 [20]	58.6	20	10%	10%
Jassim *et al*, 2014 [21]	33	11	0	9.1%
Rao *et al*, 2014 [22]	20	12	0	0
Rahamn *et al*, 2016 [14]	33.9	17	11.8%	5.8%
Darrith *et al*, 2020 [23]	58.2	22	13.6%	31.8%
Current study	48	30	0	10%

Conclusions

In our experience, the use of DFRs for comminuted periprosthetic distal femur fractures leads to satisfactory clinical outcomes with low complication rate for this challenging group of patients. Meticulous preoperative planning is crucial with appropriate surgical skills in using endoprostheses. From a technical point of view, it is advisable to avoid excessive tension/load on the extensor mechanism "overstuffing of patellofemoral joint" particularly with the use of hinged implants to minimize risk of extensor mechanism complications. Adequate restoration of the joint line also helps to restore normal mechanics of the patellofemoral joint. Early mobilizatoin and rehabilitatoin help to maintain and restore functoin and achieve satisfactory clinical outcomes.

Conflict of interests

The authors declare there are no conflicts of interest.

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