Total Femoral Replacement for Salvage of Periprosthetic Fractures

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Patients with complex periprosthetic fracture patterns of the femur may ultimately require amputation. Some authors have described the use of mega-endoprostheses as a salvage procedure. This study reports functional outcome, complications, and implant and patient survival after total femoral replacement (TFR) for salvage of periprosthetic fracture of the femur. A prospective database of 20 consecutive patients who underwent TFR for salvage of a periprosthetic fracture was compiled. Patient demographics, mobility information, and preoperative and postoperative Short Form 12-item Survey (SF-12) and 1-year Toronto Extremity Salvage Score (TESS) data were recorded. Postoperative complications were obtained from the hospital database and patient medical notes. One patient was lost to follow-up and was excluded from analysis. The study included 8 men and 11 women, with a mean age of 68.4 years. No significant difference was noted in the prefracture physical (4.4; P = .13) or mental (0.3; P = .78) component scores of the SF-12 compared with 1-year scores. The TESS at 1 year was 69%. However, patients were more likely to require a walking aid postoperatively (P < .0001). One-fourth of the patients had a postoperative medical complication. In addition, 1 patient had a dislocation and 2 patients had a periprosthetic infection. The implant survival rate was 86% at 10 years; however, the 10-year mortality rate was 58%. Although TFR for salvage of a periprosthetic fracture of the femur offers good functional outcome and implant survival, it is at the expense of postoperative complications, and TFR is associated with a high long-term mortality rate.

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Total hip replacement (THR) and total knee replacement (TKR) are effective for end-stage osteoarthritis of the hip and knee, and approximately 110,000 are performed each year in the United Kingdom. The 10-year risk of periprosthetic fracture after primary THR is 2% and 1% after primary TKR, doubling to 4% and 2%, respectively, after revision surgery. Although the risk of periprosthetic fracture has not increased during the past decade, the number of patients with a periprosthetic fracture presenting to orthopedic trauma services has increased because of the increasing rate of primary THR and TKR and the associated burden of revision surgery during this time.

Management of periprosthetic fractures is challenging, with most patients requiring surgical intervention with revision of the component or internal fixation. A relatively high rate of postoperative complications is associated with fixation of periprosthetic fractures, and 10% to 33% of patients require additional surgery because of failure of fixation, infection, or further periprosthetic fracture. Patients with complex periprosthetic fracture patterns and those undergoing unsuccessful internal fixation may ultimately require amputation. As a limb-saving procedure, some authors have described the use of a mega-endoprosthesis for revision arthroplasty surgery.

Buchman first described total femoral prosthesis in 1965. Since then, there have been numerous reports of total femoral prosthesis for malignant tumors of the femur and for limb-saving revision arthroplasty surgery. The use of total femoral replacement (TFR) for revision arthroplasty has been reported in heterogeneous cohorts of patients with multiple indications, such as aseptic loosening, periprosthetic infection, and periprosthetic fracture. The outcome of patients with these various indications may be different, and patients with aseptic loosening or infection usually have worse preoperative function than patients who sustained a periprosthetic fracture with a previously well-functioning implant. It is unknown whether TFR for salvage of periprosthetic fracture returns patients to their previous functional status.

The primary goal of this study was to assess whether TFR for salvage of periprosthetic fracture of the femur returns patients to their preinjury functional state. The secondary goal was to assess patient and implant survival after TFR and the postoperative complications that occurred.

**Materials and Methods**

During an 11-year period from 2000 to 2010, a prospective TFR database was compiled by a dedicated research assistant (D.M.). Twenty patients were identified during this study period who underwent TFR for salvage of a periprosthetic fracture. One patient was from outside the catchment area for the study center and did not have outcome data recorded. However, the patient’s general practitioner was contacted and stated that the patient had died of a myocardial infarction 4 years after TFR and had not undergone revision during this period. Therefore, this patient was excluded from the study cohort. The mean age of the remaining 19 patients was 68.4 years (range, 42-85; standard deviation [SD], 13.2). There were 8 men, with a mean age of 73.2 years (range, 52-85), and 11 women, with a mean age of 64.9 years (range, 42-82).

Patient demographics, mobility, and independence, defined as the ability to go shopping without assistance, were recorded. The pathology, primary implant, indication for TFR, and number and duration of previous attempts at revision or fixation of the periprosthetic fracture were obtained from the patient’s notes. The preoperative American Society of Anesthesiologists (ASA) grade was obtained from the chart. Fractures were graded according to the Vancouver classification.

Length of stay was recorded at discharge to the nearest full day. Need for transfusion, occurrence of a postoperative medical complication (pneumonia, urinary tract infection, myocardial infarction, deep venous thrombosis with a positive Doppler scan), transfer to the high-dependency unit, readmission to the hospital, dislocation, and implant infection were also recorded.

The TFR was performed with a generic modular reconstruction system (Global Modular Restoration System; Stryker, Mahwah, New Jersey) that incorporated a hinge rotating platform knee joint. Surgery was performed with the patient in the lateral decubitus position and, where possible, using previous skin incisions.
A posterior approach to the hip joint was used. The sciatic nerve was identified and protected with reflection of the external rotators over the nerve. This approach was extended distally with a lateral approach to the femur and tibial tuberosity unless there was a previous midline knee incision, which was then incorporated. The knee joint was exposed via a lateral parapatellar approach, and the patella was reflected medially. Implants were removed with the femur (Figure 1). The acetabulum and tibial plateau were prepared in a routine fashion. Soft tissue tension was assessed with the modular trial component before definitive TFR insertion (Figure 1).

Clinical evaluation was performed with the Short Form 12-item Survey (SF-12) and the Toronto Extremity Salvage Score (TESS). The SF-12 score is a generic health status measure that includes a physical component score and a mental component score. The TESS is a measure of physical disability that consists of 30 questions that are rated on a 5-point Likert scale according to the patient’s reported difficulty in performing the activity. Patients were asked to complete the SF-12 questionnaire to indicate their disability before the periprosthetic fracture, and the results were recorded as prefracture scores. They were again asked to complete the SF-12 questionnaire and the TESS 1 year after TFR. One patient died before the 1-year follow-up assessment, but the patient’s data were included with the 1-year outcome measures.

### Table 1

<table>
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<th>Case</th>
<th>Sex</th>
<th>Age, y</th>
<th>Independent</th>
<th>ASA Grade</th>
<th>Primary Pathology</th>
<th>Primary Implant</th>
<th>Vancouver Classification</th>
<th>Indication for TFR</th>
<th>Length of Follow-up, y</th>
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<td>Yes</td>
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</tbody>
</table>

Abbreviations: ASA, American Society of Anesthesiologists; DFO, distal femoral osteotomy; F, female; IM, intramedullary; M, male; OA, osteoarthritis; ORIF, open reduction and internal fixation; PFR, proximal femoral replacement; RA, rheumatoid arthritis; TFR, total femoral replacement; THR, total hip replacement; TKR, total knee replacement.

*All patients had a periprosthetic fracture, and the stated indication for total femoral replacement is the reason why fixation was not attempted.*
follow-up were also asked to complete an additional SF-12 questionnaire. Both the SF-12 and the TESS are scored from 0 to 100, with a higher score indicating a greater level of function. Each patient’s mobility status was recorded at 1 year. Patient satisfaction was assessed at 1 year with a previously described Likert scale.18

Approximately half of the SD of a scoring measure is accepted as the minimal clinically important difference.19,20 The minimal clinically important difference for the physical and mental components of the SF-12 score was defined as 5 for the cohort, or half of the SD for the dataset analyzed. This value was supported by a recent study that identified the minimal clinically important difference in the SF-12 score after TKR as 5 points.21

The mortality rate was calculated with data from the General Register Office for Scotland.

Statistical analysis was performed using the Statistical Package for Social Sciences, version 17.0 (SPSS Inc, Chicago, Illinois). Paired Student’s t test was used to assess for significant differences between prefracture and postoperative scores because the scores were normally distributed. Dichotomous variables were assessed using the chi-square test. The Kaplan-Meier method was used to investigate patient and implant survival.22

Ethical approval was obtained from the regional ethics committee (Research Ethics Committee, South East Scotland Research Ethics Service, Scotland [11/ AL/0079]) for collection, analysis, and publication of the presented data.

RESULTS

Most of the patients were independent (n=16), with only 3 requiring help to do their shopping, but all patients lived independently in their own homes (Table 1). The ASA grade ranged from 2 to 4, with older patients generally having a higher grade (Table 1). The indication for the primary implant for most patients was osteoarthritis or rheumatoid arthritis. Three patients had a primary implant for metastatic bone tumors, and 2 of these patients had metastatic renal cell carcinoma. One received a proximal femoral replacement that fractured below the stem. The other had an intramedullary nail that fractured at both the proximal and distal aspects of the femur. The third patient had metastatic prostate cancer that was also managed with an intramedullary reconstruction nail, and again there was a proximal femoral fracture in addition to a fatigue fracture of the metalwork. The most common Vancouver classification was type D (n=8) (Table 1). Mean time from periprosthetic fracture to TFR was 5 months (range, 5 days–14 months). The variation in time to TFR was dictated by the indication; patient 10 underwent surgery within 5 days as a primary revision procedure, whereas patient 12 had staged TFR with implantation at 14 months to manage infection of a periprosthetic fracture that occurred after previous open reduction and internal fixation (Table 1). The mean follow-up time was 5.4 years (range, 0.7–12.4 years; SD, 3.3).
Mean length of stay was 26 days (range, 5-74; SD, 16). All patients required blood transfusion either intraoperatively or postoperatively (Table 2). All except 2 patients required admission to the high-dependency unit (1 level down from intensive care) postoperatively. A single patient dislocated the hip joint postoperatively, and this was relocated by closed manipulation. Two additional patients had recurrent periprosthetic infection. After multiple surgical debridements and lavage in combination with intravenous antibiotics, 1 patient retained the implant and continued to receive long-term antibiotic treatment, whereas the other patient required hip disarticulation for recurrent periprosthetic infection 6 years after TFR.

No significant difference was found in either the generic physical component score or the mental component score of the SF-12 at 1 year and at final follow-up compared with preinjury scores (Table 3). Although the difference was not greater than the minimal clinically important difference, the 95% confidence interval (CI) for the difference at 1 year and the final physical component score relative to preinjury scores were greater than 5 (Table 3). Mean TESS at 1 year (n=18) was 69.4 (range, 45.9-91.0; SD, 13.7). All patients (n=18) were satisfied or very satisfied with the outcome at 1 year. Despite the good functional outcome and high rate of patient satisfaction, at 1 year, 16 of 18 patients required a walking aid, whereas only 5 of the 19 required an aid prefracture (odds ratio, 22.4; chi-square, $P<.0001$).

Nine patients died during the study period, with a 1-year mortality rate of 5% (95% CI, 3.2-6.8) and a 10-year mortality rate of 58% (95% CI, 55.6-60.4) (Figure 2). A single patient required revision of TFR for recurrent periprosthetic infection, as discussed earlier. This resulted in an 86% implant survival rate at 10 years (95% CI, 81.7-90.3) for TFR (Figure 3).

An interesting radiologic phenomenon observed by the senior author (J.T.P.) was reconstitution of the femur around the TFR despite excision of the femur (Figure 4). This became apparent at 1 year and was present, to various extents, in most patients in the study.

**Discussion**

The most important finding of this study was that TFR for salvage of periprosthetic fracture offered a good functional outcome, according to SF-12 score and TESS, although most patients required a walking aid. This good functional outcome was associated with an implant survival rate of 86% at 10 years. To achieve this outcome, most patients required admission to the high-dependency unit and blood transfusion, and one-fourth had a postoperative medical complication. In addition, 1 patient had a dislocation and 2 patients had a periprosthetic infection, with potential loss of limb. This complication rate may relate in part to the frailty of the patient cohort, signified by a high 10-year mortality rate of 58%.

All patients in the cohort had a periprosthetic fracture and required TFR as a salvage procedure. Peters et al.\(^\text{23}\) were the only other authors to report the functional outcome of pseudo-TFR for periprosthetic fracture of the femur. Using the existing THR, they attached the tip of the prosthesis to a custom-made intramedullary femoral nail that was then attached to the stem of the femoral TKR component. These authors showed good functional results, according to the Harris Hip score, and these findings were comparable to other studies reporting the outcome of TFR for all-cause salvage of periprosthetic disease.\(^\text{8,9,24}\) This series reported by Peters et al.\(^\text{23}\) was also retrospective, with no preinjury outcome scores available for comparison with postoperative results.

Authors reporting the use of a megaendoprosthesi for TFR as a salvage procedure for periprosthetic disease included various indications,\(^\text{8,9,23-25}\) with 21%.\(^\text{25}\) to 41%\(^\text{9}\) of reported cohorts sustaining...
a periprosthetic fracture. Patients with a periprosthetic fracture represent a distinct subgroup of patients who may have had a well-functioning implant before their injury, and this was found in the current cohort, with a high physical component score on preinjury SF-12. The surgical goal for these patients is to return them to their preinjury functional status rather than to improve this status, and the current study showed that this can be achieved with TFR.

The use of the SF-12, a generic health status measure with both physical and mental components, is original to this study. No significant difference was found between preinjury scores and those obtained at 1 year or at final follow-up. Although the mean difference did not exceed the minimal clinically important difference for the physical component score, the 95% CI was greater than the minimal clinically important difference. This may represent a type II error because of the small cohort of patients, and with a larger cohort, there could be a statistically significant difference. Alternatively, this may reflect the content of the SF-12 questionnaire, which has been shown to be dependent on age, with the absolute score tending to decrease with age and worsen with longer follow-up.

The TESS was used previously to assess the outcome of TFR for malignant tumors of the femur, but not for non-tumor-related purposes. Kalra et al showed a TESS of 52.4% after TFR for malignant tumors of the femur; however, this study reported a higher score of 69.4%. This may reflect the greater ability of the TESS because questions are included only if the task in question is relevant to the patient’s normal lifestyle. Mean patient age in the current study was 28 years older than that reported by Kalra et al. Therefore, patients may have different functional expectations because of their older age, and this could explain the difference in scores. An above-knee amputation, which could have been an alternative to TFR for some of the patients in the current study, is associated with a TESS of 64%, which is lower than was observed in the current study. However, a recent study from the Scandinavian sarcoma group found no significant difference between amputees and those undergoing limb-saving procedures.

The complication rates observed in the current study were similar to those of the largest reported series of non-tumor-related TFR. In addition, the authors found a high rate of medical complications, which has not been reported before. The survival rate of TFR varies throughout the literature from 44% at 4 years to 100% at 10 years. This variation may relate to the functional demands of the patient. The implant survival rate described (86% at 10 years) is greater than that reported in other studies for the survival of TFR for non-tumor-related indications. This may be the result of patient demands on the TFR; however, mean patient age in the current study is similar to that in other studies and therefore functional demands should be similar. An alternative explanation may relate to implant design, which has been shown to affect survival of THR and TKR.

The high mortality rate of 58% at 10 years reported in this study was similar to that seen after TFR for malignant tumors. The reported mortality rate after TFR is crude and ranges from 7% to 24% at 5 years, with no study using Kaplan-Meier analysis to analyze mortality. This difference in mortality rates is probably related to case-mix variables. This difference may reflect the greater level of comorbidity in the current patient group, as illustrated by the ASA grade, and may have accounted for the high mortality rate. However, the patient mortality rate was relatively low during the first year after surgery; only 1 patient in the current study died. This may reflect patient selection, with only those considered physically fit enough to endure surgery being offered TFR.

**CONCLUSION**

Although TFR is a rare indication for salvage of periprosthetic fracture of the femur, because of the increasing number of patients with periprosthetic fracture presenting to orthopedic surgeons and the associated complications of surgical management, a greater number of salvage procedures may be performed in the future. For salvage of a periprosthetic fracture of the femur, TFR offers a good functional outcome, but at the expense of postoperative complications.

**REFERENCES**


