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Original Research

Single-Institution Experience With Nononcologic Total Femoral Replacement

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ABSTRACT

Background: Revision hip and knee arthroplasty volume continues to rise, and total femur replacement (TFR) remains a key salvage option in patients with extensive bone loss. Prior research has demonstrated mixed results of this procedure, and this study aimed to characterize the outcomes of nononcologic TFR in one of the largest single-center modern series.

Methods: A retrospective analysis was conducted on 23 nononcologic TFR procedures performed on 22 patients between 2012 and 2021. Primary outcomes included TFR revision rate and indication for revision, while secondary outcomes included overall reoperation rate, complications, patient ambulatory status, and assistive device requirements.

Results: The average age at time of TFR was 65.7 years, with periprosthetic fracture (65.2%) and periprosthetic joint infection (34.8%) as predominant indications. More than half of patients (52.2%) required TFR revision, primarily due to periprosthetic joint infection (75.0%). Despite a high complication profile, only 1 patient underwent limb amputation and there was only 1 mortality during the study period. Overall, 63.6% of patients were ambulating (assisted or unassisted) at final follow-up.

Conclusions: Nononcologic TFR remains a viable limb-salvage option for patients undergoing revision arthroplasty with extensive bone loss. Despite a notable revision rate and infection risk, the majority of patients maintain or regain ambulatory function, emphasizing the procedure's role in preserving limb function. Clinicians should weigh potential complications when considering TFR, emphasizing patient counseling and risk mitigation strategies.

Introduction

Hip and knee arthroplasty continues to see rapid growth due to an aging population and broader indications for knee and hip arthroplasty in younger patients [1]. As the rate of primary arthroplasty increases, the annual volume of revision total joint arthroplasty in the United States has been projected to increase between 78% and 182% by 2030 [2,3]. While total femur replacement (TFR) was originally developed for reconstruction following resection of malignant bone tumors [4-6], it has become a viable limb-salvage option in nononcologic patients undergoing revision arthroplasty in the setting of massive bone loss [7,8]. A major proposed benefit of TFR, like other endoprosthetic reconstructions, is the ability to allow potential immediate weight bearing and mobilization following surgery and with less energy expenditure for ambulation when compared to amputation [9,10]. Early reports of TFR have been limited to small case series given how rarely this procedure has been performed historically [4,5,11,12]. However, there are a selected number of more recent case series that better characterize the outcomes of this limb-salvage procedure for nononcologic patients [7,8,13-17]. Recurrent periprosthetic joint infections (PJIs) and periprosthetic fractures (PPFs) are the most frequently cited indications for nononcologic TFR [18-20]. Data from the early 2000s suggested that TFR is a good option for patients undergoing revision total knee or hip arthroplasty in the setting of massive bone loss [13,17]. However, with the widespread availability of implants that can address bone loss in revision arthroplasty, such as augments, cones, and sleeves, TFR has become

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a procedure of last resort. More recent literature suggests that nononcologic TFR carries a significant complication profile, with revision rates ranging from 30%-70% [7,8,14,15,17,18]. The purpose of this study was to characterize the outcomes of nononcologic TFR in one of the largest single-center modern series of patients.

Material and methods

Approval for this single-institution study was obtained from the Institutional Review Board. Data were collected for all patients who received a nononcologic TFR between June 2012 and June 2021 from the electronic medical record system. Preoperative clinic notes, operative notes, and postoperative clinic notes were reviewed for each patient. Baseline demographic variables (age, laterality, and sex) and patient-specific characteristics (medical comorbidities, revision indication, implant specifics, and duration of follow-up) were collected. Patients with no postoperative imaging or follow-up visits were excluded from the study.

The primary outcome of interest for this study was TFR revision rate and indication for revision. Secondary outcomes included overall reoperation rate, complications (eg, PJI, PPF, deep venous thrombosis, nerve palsy, and implant loosening), patient ambulatory status, and use of an ambulatory assistive device.

Given the size of this cohort, results were analyzed using descriptive statistics. Values are reported as the mean and range, where applicable.

Results

A total of 23 nononcologic TFR in 22 patients were performed. One of these patients had bilateral operations. The average age at the time of TFR was 65.7 years (range: 50-82). Of the 22 patients, 59.1% were women. The average time to most recent follow-up visit was 37.9 months (0.8-104.1) and 69.6% of patients had follow-up longer than 1 year. Osteoarthritis (47.8%) and rheumatoid arthritis (30.4%) were the most common indications for the patient's index arthroplasty. PPF (65.2%) and PJI (34.8%) were the 2 indications for our patients to undergo TFR. The mean number of surgeries prior to TFR on the ipsilateral femur was 5.4 [2-12].

The patients in this study had several medical comorbidities in conjunction with their orthopaedic problems. All patients were classified as American Society of Anesthesiologists 3. Seven patients (31.8%) had an inflammatory arthritis on disease modifying agents, 5 (22.7%) were active smokers, 3 (13.6%) were diabetic, 3 (13.6%) had coronary artery disease, and 3 (13.6%) had chronic kidney disease. Additionally, 10 patients (45.5%) had body mass index more than 30, and 1 patient had body mass index less than 18.5. These findings are summarized in Table 1.

Of the 23 TFRs that met the inclusion criteria for this study, 12 (52.2%) required revision of the implant. Of these 12 revisions, 9 (75.0%) were due to PJI, 2 (8.7%) were due to PPF (1 of the tibia and 1 of the proximal femur about an intramedullary TFR), and 1 (4.3%) was due to mechanical failure of the implant. One patient sustained recurrent hip dislocations and was later revised due to PJI. There was a 0% nerve palsy and deep venous thrombosis rate. There was no evidence of aseptic loosening in this cohort. Given that the entire femur was replaced, it was not possible to have loosening about the femur, and no loosening was identified about the acetabulum or tibia on final follow-up x-rays. All patients in the study had an acetabular component (either new or maintained from prior surgery), and there were no hemi-arthroplasty TFRs. At time of final follow-up, 1 patient underwent limb amputation and there was 1 mortality 3 years after TFR due to sepsis from persistent PJI. In the patients who required revision, the average time to revision was 20.1 months (1.1-94.4). Two patients required return to the operating room for reasons that did not require revision of the implant (1 incision and drainage [I&D] for superficial wound dehiscence and 1 I&D of a hematoma). At the time of I&D, the joints were aspirated prior to surgery without evidence of infection. However, the patient who underwent I&D for wound dehiscence went on to require revision due to PJI 4 months later, and the patient who underwent hematoma evacuation did not require further surgery (Table 2). The overall rate of PJI in our study was 39.1%. Of the 8 patients whose indication for TFR was PJI, 3 of them (37.5%) went on to have PJI of their TFR. Additionally, 6 of the 15 (40.0%) patients who underwent TFR without history of prior PJI developed a new PJI after the procedure.

Prior to TFR, 5 patients (22.7%) were ambulatory without an assist device, 11 (50.0%) were ambulatory with an assist device, and 6 (27.3%) were nonambulatory. At final follow-up, 8 patients (36.4%) were ambulatory without an assist device, 8 patients (27.3%) were ambulatory with an assist device, and 8 patients (36.4%) were nonambulatory (Table 3). Compared to their preoperative clinical visit, 7 patients experienced an improvement in their ambulatory status, 5 worsened, and 10 had no change in their ambulatory status. Notably, 3 patients went from being previously ambulatory to nonambulatory, whereas only 1 patient went from being nonambulatory to ambulatory post-TFR at final follow-up.

Table 1
Study sample characteristics.

Variable	Mean	Range
Age (y)	65.7 y	50-82
Number of prior surgeries	5.4	2-12
Time to final follow-up (mo)	37.9	0.8-104.1
Variable	**N**	**%**
Sex		
Women	13	59.1
Men	9	40.9
Index surgery indication		
Osteoarthritis	11	47.8
Rheumatoid arthritis	7	30.4
Trauma	3	13.0
Hemophilia	2	8.7
TFR indication		
Periprosthetic fracture	15	65.2
Prosthetic joint infection	8	34.8
BMI distribution		
<18.5	1	4.5
18.6-30	11	50.0
30.1-40	7	31.8
>40	3	13.6

BMI, body mass index; TFR, total femur replacement.

Table 2
Total femur replacement outcomes.

Case mix, complications, and reoperations	N	%
TFR revision		
Yes	12	52.2
No	11	47.8
Revision indication		
Infection	9	75.0
Periprosthetic fracture	2	16.7
Mechanical failure of the implant	1	8.3
Nonimplant-related reoperations		
I&D for wound dehiscence	1	4.3
I&D for hematoma	1	4.3
	Mean	**Range**
Time from TFR to revision (mo)	20.0	1.1-94.4

I&D, incision and drainage; TFR, total femur replacement.

Table 3
Ambulatory status.

Status	N	%	N	%
	Preoperative	Preoperative	Postoperative	Postoperative
Independent	5	22.7	8	36.4
Cane	2	9.1	1	4.5
Crutches	0	0	1	4.5
Walker	9	40.9	4	18.2
Nonambulatory	6	27.3	8	36.4

Discussion

TFR is a rare surgical procedure relative to primary or revision total joint arthroplasty. Our institution performs approximately 1000 primary total joints and 200 revision surgeries per year, and there were only 23 TFRs performed over the 9-year study period. While TFR is not required frequently, it remains a viable option for limb salvage in cases of extensive femoral bone loss in the setting of revision hip or knee arthroplasty. TFR is thought by many to be a reasonable alternative to amputation for these multiply revised patients as a superior option for pain control, function, and mobility [7-10]. The aim of this study was to analyze a single institution's experience with TFR in the setting of revision arthroplasty over a 9-year period and compare these results with the existing body of literature.

The average age of patients in this study at the time of TFR was 65.7 years, consistent with prior studies in that these procedures are typically performed in the sixth or seventh decade of life [7,8,13-15,17,21]. The indications for TFR in this cohort were exclusively PPF (65.2%) and PJI (34.8%). This differs from previous series, where aseptic loosening was an indication for TFR [7,8,16,21].

Importantly, we found that our patients had an average of 5.4 surgeries prior to TFR. This is higher than what has been described in previous studies. Berend et al. found that their patients had an average of 3.3 prior surgeries about the hip. However, about half of them had never had a prior knee surgery, and of those who did, they had 1.9 prior knee arthroplasty surgeries prior to TFR. Similarly, Friesecke et al. found that their patients had 3.2 surgeries about the hip and 0.5 at the knee. Both of these studies collected their data prior to the 2000s. More recent literature demonstrates a higher number of surgeries prior to TFR (3.6-4.6) [7,15,16]. This suggests that as modern implant and fixation options have become widely available, surgeons are forced to perform TFR later in the patients' clinical course.

Our data indicate an overall implant revision rate of 52.2% (Fig. 1). This revision rate is higher than previously reported studies, but it is consistent with more contemporary literature. This trend is summarized in Table 4. This cohort had a significant number of medical comorbidities, and all patients were classified as American Society of Anesthesiologists 3. These patients had proven to be poor hosts, leading to the high number of revision surgeries and eventual TFR. Given the associated medical burden, this also contributes to the relatively high revision rate identified in this study.

Furthermore, it is likely that in earlier studies, TFR was being performed sooner than it may be today due to lack of better fixation options. For instance, many of the patients in the Berend et al. and Friesecke et al. studies were indicated for TFR in the setting of a revision total hip arthroplasty with few previous TKA procedures, which may not be necessary today with splined tapered revision hip stems and porous metal cones for revision TKA. The complication

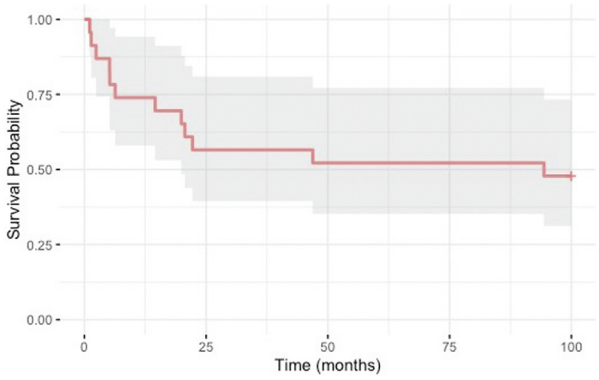

Figure 1. Kaplan-Meier survival analysis with TFR revision-free survival of 47.8%. TFR, total femur replacement.

and revision rates are likely higher in the more modern studies because as TFR has been further limited in its indications, the patients undergoing the procedure are higher risk at baseline. Notably, only 1 patient went on to limb amputation and 1 patient died during the study period, indicating the power of modern nononcologic TFR to achieve limb salvage safely [13,16,17].

PJI was the primary indication for revision in this cohort, with 39.1% of the TFRs requiring revision for PJI. This is consistent with findings from Amanatullah, Toepfer, and Christ who all found similar infection rates [7,8,15]. Interestingly, of the patients indicated for TFR due to prosthetic joint infection, 37.5% went on to get infected, whereas 40.0% of the patients without history of prior infection developed a new infection. This suggests that nononcologic TFR is high risk for the development of PJI regardless of history of prior infection. As a result, it is prudent to consider infection in all aspects of total femoral replacement and try and mitigate these risks where possible. The measures used to prevent infection have evolved at our institution over the course of the study; however, some of the key tenants include preoperative intravenous antibiotics, 24 hours of postoperative intravenous antibiotics, high doses of local antibiotics in cement and calcium sulfate beads, and meticulous sterile technique (eg, clean and dirty setups, frequent changing of drapes). Aseptic cases were routinely performed as a single-stage procedure. Alternatively, septic cases were performed in 2 stages with explantation and a course of microbial-directed antibiotics, followed by reimplantation.

At final follow-up, the majority of patients in this study (63.6%) were able to ambulate and 36.4% of patients were able to ambulate unassisted. Most patients (77.3%) had either an improvement in their ambulatory status or remained the same. However, 3 of the patients who were previously ambulatory became nonambulatory, whereas

Table 4
Comparison of revision rate and infection rate with historical data.

Reference	Revision rate	Infection rate
Berend et al., 2004 [17]	18/59 (30.5%)	8/59 (13.6%)
Friesecke et al., 2005 [13]	Not stated	12/100 (12%)
Fountain et al., 2007 [14]	8/14 (57.1%)	3/14 (21.4%)
Amanatullah et al., 2014 [8]	6/20 (30%)	7/20 (35%)
Toepfer et al., 2016 [15]	13/18 (72.2%)	8/18 (44.4%)
Putman et al., 2019 [16]	Not stated	8/29 (27.6%)
Christ et al., 2019 [7]	8/16 (50%)	7/16 (44%)
This study	11/23 (52.2%)	9/23 (39.1%)

only 1 patient became ambulatory after previously being unable to walk. Previous studies demonstrate a similar distribution of ambulatory status [7,16], although our study trends toward more patients ambulating without an assist device or being nonambulatory rather than using an assist device. TFR presents an opportunity for patients with several arthroplasty revisions to improve their ambulatory status and even ambulate unassisted, but there is also risk of a decline in ambulatory status. It is important to communicate to patients the spread of outcomes preoperatively as there is a wide range of possible outcomes.

There are a number of limitations to this study. It is retrospective in nature and subject to the inherent biases of a retrospective study. Additionally, our study had limited follow-up with more than 1-year follow-up in 69.5% of patients. While this may omit future complications or changes in ambulatory status, we felt that it was important to include all patients undergoing this rare procedure to accurately characterize this cohort. Finally, all cases in this study were performed by a single surgeon, which may limit the generalizability of these findings to other groups performing this procedure, as implant, antibiotic, and management choices were those of a single practitioner.

Despite these limitations, this study significantly contributes to the literature as one of the largest contemporary cohorts of nononcologic TFRs. Our study supports the current body of evidence in that TFR presents a viable limb-salvage option for the multiply revised arthroplasty patient with poor remaining bone stock. However, this is associated with a high complication rate, with almost half of patients requiring a revision surgery. Infection was the most common indication for revision, with nearly equivalent rates of subsequent PJI found in patients with or without a prior history of infection. It is important to discuss these potential risks when indicating patients for TFR.

Conclusions

Nononcologic TFR is a viable limb-salvage option for patients undergoing revision total hip and total knee arthroplasty with extensive bone loss. Potential revision and reoperation are high, and PJI is the most common indication for revision. However, limb-salvage rates are high, and the majority of patients remain ambulatory following nononcologic TFR.

Conflicts of interest

Alexandra Stavrakis is a paid consultant for Smith and Nephew. Edward J. McPherson received royalties from Zimmer-Biomet; is in the speakers bureau for Austin Medical Ventures, BoneSupport, and Zimmer-Biomet; is a paid consultant for Austin Medical Ventures and Zimmer-Biomet; and is in the medical/orthopaedic publications editorial/governing board of Reconstructive Review. Alexander B. Christ is a paid consultant for Smith & Nephew, Zimmer Biomet, Onkos, Globus, and Daiichi-Sankyo and is a board member in AAOS, MSTS, ORS, and American Radium Society.

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CRediT authorship contribution statement

Ryan Ouillette: Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Kevin Chen:** Formal analysis, Data curation. **Matthew Dipane:** Data curation. **Alexander Christ:** Writing – review & editing, Conceptualization. **Edward McPherson:** Writing – review & editing, Investigation. **Alexandra Stavrakis:** Writing – review & editing, Investigation, Conceptualization.

References

[1] Kremers HM, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA, et al. Prevalence of total hip and knee replacement in the United States. J Bone Joint Surg Am 2015;97:17.
[2] Schwartz AM, Farley KX, Guild GN, Bradbury TL. Projections and epidemiology of revision hip and knee arthroplasty in the United States to 2030. J Arthroplasty 2020;35:S79–85.
[3] Kurtz SM, Ong KL, Schmier J, Mowat F, Saleh K, Dybvik E, et al. Future clinical and economic impact of revision total hip and knee arthroplasty. J Bone Joint Surg Am 2007;89(Suppl 3):144–51.
[4] Morris HG, Capanna R, Campanacci D, Del Ben M, Gasbarrini A. Modular endoprosthetic replacement after total resection of the femur for malignant tumour. Int Orthop 1994;18:90–5.
[5] Buchman J. Total femur and knee joint replacement with a Vitallium endoprosthesis. Bull Hosp Joint Dis 1965;26:21–34.
[6] Jones KB, Griffin AM, Chandrasekar CR, Biau D, Babinet A, Deheshi B, et al. Patient-oriented functional Results: of total femoral endoprosthetic reconstruction following oncologic resection. J Surg Oncol 2011;104:561–5.
[7] Christ AB, Mendez L, Gausden EB, Blevins JL, Bostrom MP, Sculco PK. Outcomes and complications following non-oncologic total femoral replacement. Hip Int 2020;30:725–30.
[8] Amanatullah DF, Trousdale RT, Hanssen AD, Lewallen DG, Taunton MJ. Nononcologic total femoral arthroplasty: retrospective review. J Arthroplasty 2014;29:2013–5.
[9] Ramanathan D, Siqueira MBP, Klika AK, Higuera CA, Barsoum WK, Joyce MJ. Current concepts in total femoral replacement. World J Orthop 2015;6:919–26.
[10] Ahmed AR. Total femur replacement. Arch Orthop Trauma Surg 2010;130:171–6.
[11] Steinbrink K, Engelbrecht E, Fenelon GCC. The total femoral prosthesis. A preliminary report. J Bone Joint Surg Br 1982;64:305–12.
[12] Marcove RC, Lewis MM, Rosen G, Huvos AG. Total femur and total knee replacement: a preliminary report. Clin Orthop Relat Res 1977:147–52.
[13] Friesecke C, Plutat J, Block A. Revision arthroplasty with use of a total femur prosthesis. J Bone Joint Surg Am 2005;87:2693–701.
[14] Fountain JR, Dalby-Ball J, Carroll FA, Stockley I. The use of total femoral arthroplasty as a limb salvage procedure. The sheffield experience. J Arthroplasty 2007;22:663–9.
[15] Toepfer A, Harrasser N, Petzschner I, Pohlig F, Lenze U, Gerdesmeyer L, et al. Short- to long-term follow-up of total femoral replacement in non-oncologic patients. BMC Musculoskelet Disord 2016;17:498.
[16] Putman S, Migaud H, Saragaglia D, Jenny JY, Dujardin F, Hue AG, et al. Total femur replacement in non-oncologic indications: functional and radiological outcomes from a French survey with a mean 6 years' follow-up. J Orthop Traumatol Surg Res 2019;105:591–8.
[17] Berend KR, Lombardi AV, Mallory TH, Adams JB, Dodds KL. Total femoral arthroplasty for salvage of end-stage prosthetic disease. Clin Orthop Relat Res 2004:162–70.
[18] Morimoto S, Futani H, Ogura H, Okayama A, Maruo S. Successful reimplantation of total femoral prosthesis after deep infection. J Arthroplasty 2003;18:216–20.
[19] Hwang JS, Beebe KS, Patterson FR, Benevenia J. Infected total femoral replacements: evaluation of limb loss risk factors. Orthopedics 2011;34:e736–40.
[20] Clement ND, Macdonald D, Ahmed I, Patton JT, Howie CR. Total femoral replacement for salvage of periprosthetic fractures. Orthopedics 2014;37:e789–95.
[21] Hoell S, Butschek S, Gosheger G, Dedy N, Dieckmann R, Henrichs M, et al. Intramedullary and total femur replacement in revision arthroplasty as a last limb-saving option: is there any benefit from the less invasive intramedullary replacement? J Bone Joint Surg Br 2011;93:1545–9.