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Total knee arthroplasty with distal femoral replacement is associated with an important complication rate. A case series

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ABSTRACT

Background: With the aging population and an increasing number of total knee arthroplasties (TKAs) performed yearly worldwide, revision surgeries for many causes (septic or aseptic loosening, periprosthetic femoral fractures (PDFF), non-unions, malunions) are more frequent and challenging. Distal femoral replacement (DFR) is sometimes the only option to restore knee function and quality of life. DFR in non-oncologic patient is still a rare indication and few reports are published on this topic, with a non-consistent variety of functional results, complication rates and survivorship.

Methods: We present a retrospective series of patients who underwent a DFR for a non-oncologic indication between 2010 and 2017. Nineteen patients were available for a full evaluation (clinical and radiological) with a mean follow-up of 48.3 months (range 15–99). Goniometry was performed at the six-week postoperative visit. Complications were reported. Osteolysis and/or signs of aseptic loosening were described using the Knee Society Radiographic Evaluation. Survivorship was calculated for aseptic loosening, infection, and revision for any cause.

Results: The mean Knee Society Score was good for the pain score (42.2, range 10–50) and fair for the function score (60.6, range 0–100). Four deep infections (21.1%) were successfully treated with mobile parts exchange and debridement. Three patients presented femoral osteolysis ≥5 years after the DFR. Survivorship for aseptic loosening was 100% at four years, 81.8% after five years and 53.3% after eight years.

Conclusions: TKA with DFR is a valuable option for patients with a severe bone loss and poor bone quality in the distal femur. DFR restores an acceptable quality of life but is related to an important complication rate.

1. Introduction

Total knee arthroplasty (TKA) performed with simultaneous distal femoral replacement (DFR) was first designed to treat bone tumors located around the distal femur. Over the years, indications have broadened, and this surgery is now increasingly used as a salvage procedure in primary complex TKA, in revision TKA, and in complex or periprosthetic distal femoral fractures (PDFF) [1–3].

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Recently, a dramatic increase in the number of primary and revision knee arthroplasties performed worldwide has been observed [4–9]. The prevalence of periprosthetic fractures has also surged [2,10,11]. These revisions require increased constraint due to instability concerns and once the primary prosthesis is removed, bone loss is often a concern. Again, DFR is sometimes the only option to restore knee function and a satisfying quality of life.

Bone deficiency is a serious challenge that orthopedic surgeons face in their practice due to an aging patient population. Primary TKAs with poor bone stock can compromise the femoral component fixation and DFR sometimes remains the only possible option to preserve function [3,12]. Fixation of geriatric and complex distal femoral fractures lacking adequate bone fixation can also be very challenging. DFR procedures offer good return to function and the benefit of earlier mobilization, which is critical for these elderly patients [1].

DFR in non-oncologic patient is still a rare indication and few reports are published on this topic, with a large heterogeneity on indications, functional results, complication rates and survivorship. Most series, even the more recent, present a small number of patients (from 11 to 58). Follow-up is still mid-term and varies from one to eight years.

The paucity of the available literature and the difficulty to plan a more robust study (related to the scarcity of cases) promotes the need to present all valuable series to best help the surgeons for future cases. The purpose of this study was to evaluate the clinical function, implant survivorship, and surgical complications of DFR in non-oncologic patients.

2. Methods

2.1. Study design

We conducted a retrospective study in an academic center including all patients who underwent a DFR between 2010 and 2017 by the same senior surgeon (MB). No DFR is performed by other surgeons in this center.

To be included in this study, patients must have completed a follow-up of at least 12 months after the DFR surgery was performed for a non-oncologic indication. All patients agreed to come for a single visit including a clinical and radiological evaluation.

2.2. Patients

During the study period, 28 patients received a DFR for a non-oncologic indication. Nine patients were lost to follow-up: one patient died nine days after the surgery (DFR for complex distal femoral fracture) from cardiac failure, two patients died 18 and 24 months after the surgery from causes not related to the DFR, one patient had a short follow-up (6 months) and five patients refused to participate. The medical charts and a phone contact with the five lost patients did not demonstrate any complications and/or reoperations.

Nineteen patients were available for a full evaluation at a mean 48.3 months follow-up (range 15–99). The cohort was mainly composed of women (n = 14, 73.7%) and the mean age at the study visit was 83.3 years (range 73–93). The DFR was performed for: revision TKA for periprosthetic distal femoral fracture (n = 12, 63.2%), revision TKA for loosened TKA with massive bone loss (n = 4, 21.1%), revision TKA for broken femoral stem with distal femoral non-union (n = 1, 5.3%), primary TKA for complex distal femoral fracture (n = 1, 5.3%), and primary TKA in a complex distal femoral non-union (n = 1, 5.3%). Table 1 presents the demographic characteristics of this cohort.

2.3. Surgical technique

The indication to perform a TKA with DFR was confirmed on a pre-op CT-scan demonstrating severe bone loss and poor bone quality. All surgeries were performed by the senior author (MB) using the Zimmer Segmental© rotational-hinge knee arthroplasty

Table 1
Patient characteristics.

Mean age at primary TKR (years)[a]	70.2 ± 9.2 (53.9–82.7)
Mean age at DFR surgery (years)[a]	79.7 ± 5.4 (71–92.2)
Mean interval between TKR and DFR (years)[a]	10.2 ± 7.1 (0.1–24.4)
Mean follow-up (months)[a]	48.3 ± 30.5 (15–99)
Mean age at follow-up visit (years)[a]	83.3 ± 5.5 (73–93)
Sex	
Female	14 (73.7%)
Male	5 (26.3%)
Operated side	
Left	9 (47.4%)
Right	10 (52.6%)
Bone Mass Index (kg/m^2)[a]	30.7 ± 8.2 (19.6–50.8)
BMI > 30	9 (47.4%)
Diabetes	7 (36.8%)
Smoking	3 (15.8%)
Anticoagulant medication	8 (42.1%)

[a] Values expressed as mean ± SD (range).

revision system (Zimmer, Warsaw, IN). Seventeen knees were approached through a standard medial parapatellar approach and two cases required a quadriceps snip to improve surgical visualization. After removal of any previous components, the distal femur was excised cautiously while protecting the posterior structures in order to prevent any neurovascular injury. A neutral varus-valgus tibial bone cut with a neutral slope was performed using an extra-medullary guide. All tibial components were fully cemented. Using the AORI Classification of bone defects [13], six patients requiring revision with additional severe tibial bone loss (four type 2B and two type 3) required the addition of a metaphyseal tibial trabecular metal cone (Zimmer, Warsaw, IN) to obtain adequate fixation. One patient was grafted with morselized allograft to optimize bone stock.

The height of the distal femoral bone cut was determined by the height of the femoral bone loss and by the height required to achieve full knee extension. Using this specific knee system, the minimal femoral bone resection is 90 mm. Prior to the distal femoral bone cut, a prophylactic cerclage was positioned around the distal diaphysis to prevent fracture propagation while reaming the femoral diaphysis. Femoral rotation was set using the linea aspera and/or any previous landmark showing the deepest groove in the trochlea. During trialing, rotation was reassessed to ensure adequate patellar tracking. All patients were fit with a straight 130-mm fully cemented femoral stem. Five patients required a diaphyseal metal extension to address long oblique periprosthetic fractures.

The surgical site was routinely drained for 24 h. Table 2 summarizes the surgical data and Figure 1 illustrates a typical construct.

Post-operatively, full weight-bearing and early knee mobilization was initiated for all patients and supervised by a physical therapist.

2.4. Outcome measures

During follow-up visits, patients underwent a full clinical and radiological evaluation. The clinical evaluation consisted of a standard physical examination (knee aspect, scars, maximum knee passive goniometric range of motion and stability, global alignment) and the Knee Society Score (KSS) [14] was completed.

Weight-bearing standard AP, lateral and infrapatellar knee X-rays were obtained at every follow-up visit. The presence of osteolysis and/or signs of aseptic loosening were described using the Knee Society Radiographic Evaluation. Goniometry was performed once at the six-week postoperative visit.

A comparison with preoperative X-rays was not performed as only five patients were operated for an elective planned surgery.

The survivorship was described for the following end points: aseptic loosening, infection and revision for any cause.

2.5. Statistical analysis

The small number of available patients and the heterogeneity of the cohort prevent to perform valuable comparative analyses. This study is presented as a case series and simple descriptive statistics were performed using Microsoft Excel (Redmond, WA). The main results were expressed as means and standard deviations (range). Subgroup analysis was realized with a Fisher exact test ($p < 0.05$). Survival curves were obtained.

3. Results

During the interval between the DFR surgery and the study visit, six patients (31.6%) presented with at least one major orthopedic complication, for a total of nine complications. Four patients (21.1%) suffered from acute deep infection within the first three months following DFR implantation and required mobile parts exchange (distal femur, polyethylene, hinge mechanism, and tibial plastic sleeve) and debridement. The cemented femoral stem and the cemented tibial component were retained. *Staphylococcus epidermidis* was identified as the infectious agent in two of the cases, while methicillin-resistant *Staphylococcus aureus* and *Klebsiella pneumoniae* each accounted for one case. Post-operative intravenous antibiotics were administered for six weeks followed by 12 months of suppressive oral antibiotics. Mobile parts exchange and debridement allowed eradication of infection in all four patients. The indication for DFR was a PPDF for two cases and revision TKR with massive bone loss for the other two cases. No infected patient had a previous history of infection in the involved knee.

Table 2
DFR surgical data.

Surgical time (min)[a]	144.1 ± 27.7 (100–215)
Tourniquet time (min)[a]	121.1 ± 19.8 (95–165)
Blood loss (ml)[a]	290 ± 200 (50–900)
Transfusions required	2.3 ± 1.9 (0–8)
Femoral resection (mm)[a]	124.8 ± 29.3 (90–186)
Tibial augment	
TM cone	6
Morcellized graft	1
Femoral augment	
Diaphyseal metal extension	5

[a] Values expressed as mean ± SD (range).

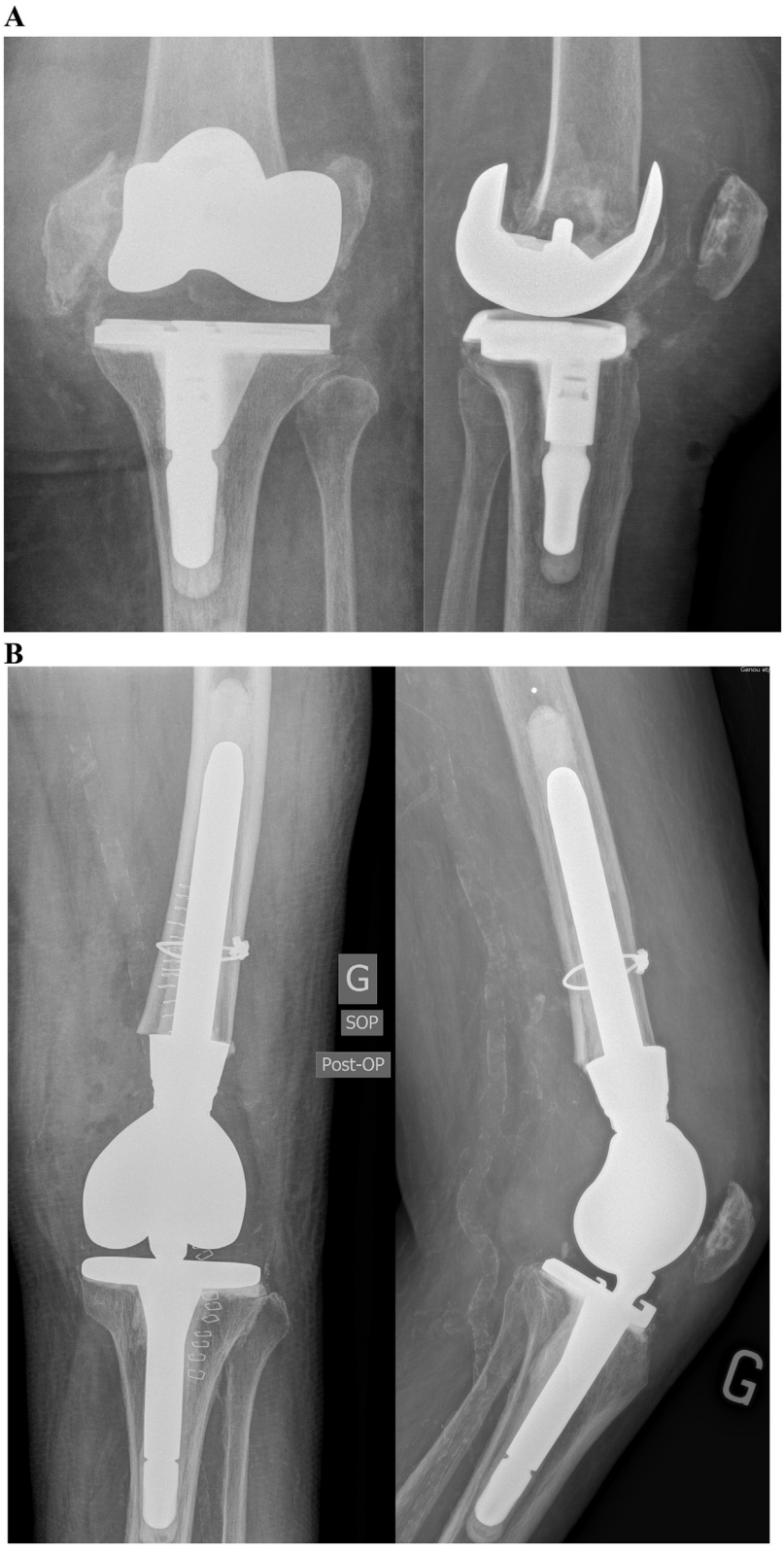


Figure 1. A & B. Pre-operative and post-operative X-rays for a 77 year-old female who sustained a distal supracondylar fracture from a fall three weeks following her initial TKA.

Subgroup analyses were not significant for any infectious risk factors: diabetes ($p = 0.11$), use of anticoagulant therapy before surgery ($p = 0.34$), and obesity ($p = 0.42$). There was no connection between infection and surgical time, tourniquet time, DFR with or without augment.

One of the four infected cases required a medial gastrocnemius rotational flap for adequate soft-tissue coverage. Another infected patient suffered an extensor mechanism rupture following a fall nine months after being treated for infection. Since this last patient had lost walking abilities due to severe deconditioning, it was decided not to treat this condition. One patient required an acute debridement with mobile parts exchange for a significant hematoma with skin tempting. No microorganism was found. Another patient sustained a periprosthetic tibial fracture following a fall from a height four years after DFR revision. This condition required a tibial component revision with a proximal tibial replacement. The patient healed uneventfully with a good return to function despite a 10° extension lag.

3.1. Clinical results

Nineteen patients presented at the study visit. All patients were free from infection and all wounds were clean and closed. The global subjective alignment was neutral for all patients.

Six patients still complained of residual knee pain but were not taking any pain medication. Two patients were unable to walk and required a wheelchair, mainly for major deconditioning rather than knee difficulties. Only six patients walked without an aid (mainly walker for the others).

All knee joints were stable in the frontal and sagittal plane. The mean passive knee flexion was 102.2° (range 60 to 125) and passive extension −2° (range 0 to −10). Three patients have an active extension lag >10°, and the others have fully recovered the quadriceps strength. No patellar maltracking was reported.

The mean Knee Society Scores were good for the pain score (42.2, range 10–50), good for the knee score (76.8, range 10–95), and fair for the function score (60.6, range 0–100). The score value was not related to the presence of complications, obesity or other comorbidities.

Despite these fair results, most patients were subjectively satisfied with the surgery and would recommend it (mean satisfaction score on a Likert scale = 8.21, range 6–10).

3.2. Radiological results

The six-week post-op goniometry showed an average restoration of the mechanical axis at a mean 0.7 degrees of valgus (range 5.6 degrees of varus to 4.5 degrees of valgus). Only two patients present a mechanical axis outside the target ±3°.

At the latest follow-up, there was evidence of femoral stem loosening in three patients. These patients had no osteolysis around the tibial component. The femoral osteolysis appeared early in the follow-up, after the fifth year for all patients. Interestingly the mechanical axis in these three patients was in valgus (0.5, 2.3 and 4.5°). All X-rays from other patients showed no evidence of loosening or osteolysis around both the femoral and tibial components.

3.3. Survivorship

The short-term survivorship for aseptic loosening is excellent with 100% of DFR retained after four years. Three patients presented some degrees of osteolysis five years and later after the DFR, reducing progressively the survivorship to 81.8% after five years and 53.3% after eight years.

All infections were acute and appeared during the first three months, reducing dramatically the short-term survivorship for this reason to 78.4%. However, no new infections appeared, and infection-free survival remained stable throughout the eight years of follow-up.

When considering all reoperations for any cause, the short-term survivorship rapidly decreased to 72.2%, as most events appeared during the first year. The eight-year survival rate of DFR was 54%.

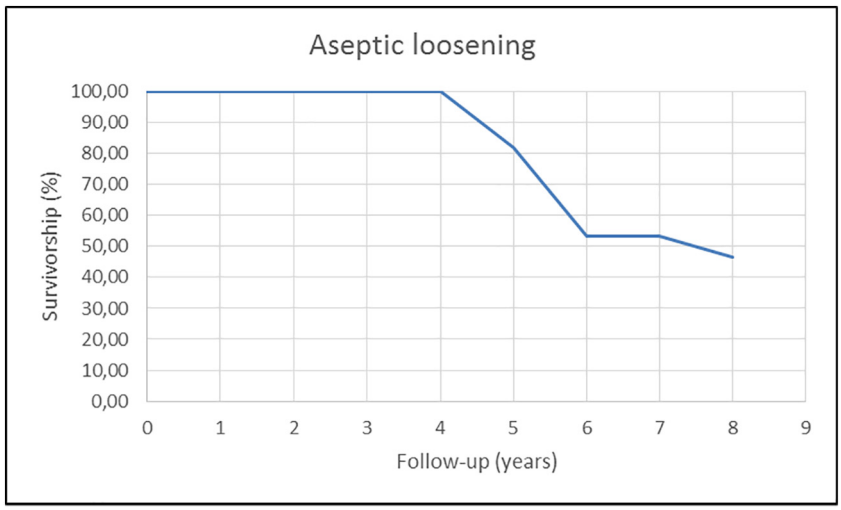
Figure 2 illustrates the survivorship curves.

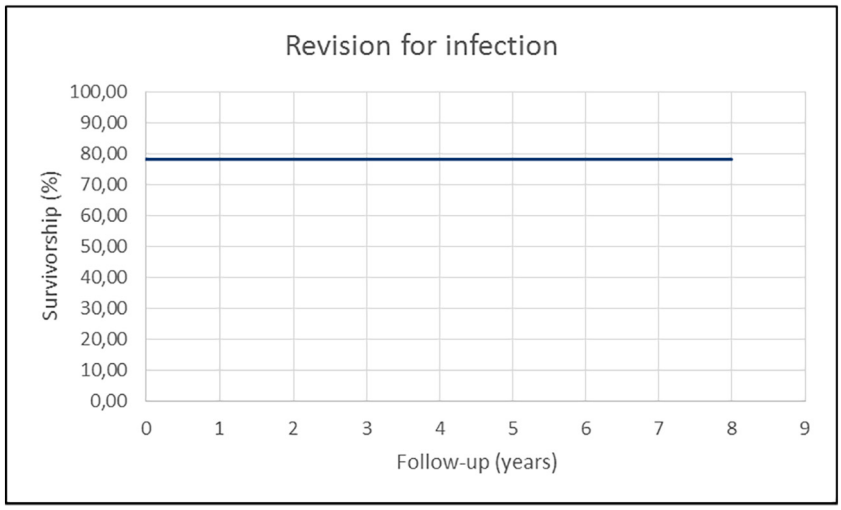
4. Discussion

This study demonstrates that TKA with DFR in non-oncologic patients offers interesting performance and survivorship in elderly patients over the long term. Most patients were satisfied with the procedure despite a high complication rate and achieved a good quality of life.

TKA with DFR was initially designed for reconstruction of large defects after resection of bone tumors in the distal femur. New indications were proposed in the last 15 years to solve (or save) complex cases with similar bone defects or poor bone quality: periprosthetic distal femoral fractures (PDFF), revision TKA for aseptic loosening with massive bone loss, failed distal femoral fracture ORIF (non-union, malunion), distal femoral fracture with poor bone quality preventing optimal fixation [10,15–20].

The traumatic cases represent the most frequent non-oncologic indication for TKA with DFR, mainly the PDFF. We observed in this series 15 patients (79%) operated for an acute trauma or a chronic post-trauma sequela. The main benefit to perform a DFR instead of attempting fixation is an early full weight-bearing with a significant reduction of in-hospital complications [20–22].





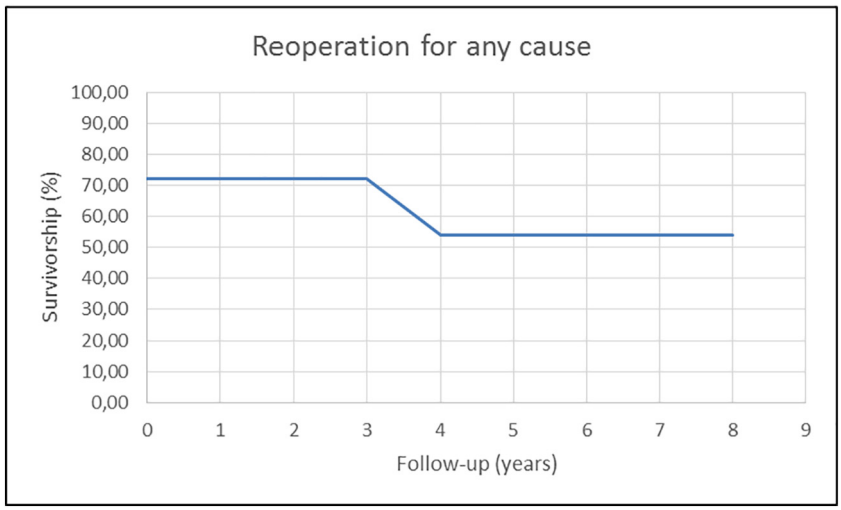


Figure 2. Survivorship curves for aseptic loosening (top panel), revision for infection (centre panel), and reoperation for any cause (lower panel).

PDFF is often related to a low-energy trauma and poor bone quality. There are several factors that put elderly patients at increased risk of PDFF, including osteoporosis [23–27], femoral notching [23], steroid therapy [25,28,29], rheumatoid arthritis [25,27,29,30], neurological diseases [31], local osteolysis [15,32], and infection [1]. However, in this series, the only identified risk factor is the old age with osteoporosis. No patient presented notching after the primary TKA.

The management of complex PDFF has rapidly evolved in the last decade and is still performed on a case-based decision, as there is no evidence-based literature due to the paucity of cases. The high complication and reoperation rates (with a higher hospital length of stay) related to the alternative approaches (conservative management, ORIF, nailing) makes TKA with DFR a more popular and interesting solution [27–31]. This is also true for complex distal femoral fractures without TKA [33–36]. Chen demonstrated in a comparative study that early DFR for complex distal femoral fracture leads to better and easier outcomes than after failed ORIF [21]. All trauma cases treated with DFR in this series were discussed before the surgery in our trauma unit with the dedicated staff (orthopedic trauma surgeons and the senior author) to be sure DFR was the best option.

Patients in this series achieved a functional physical status and no patient required to change his previous location. Most patients are pain free and have a near normal function. The KSS scores (pain, knee and function) are like other reported series [1,12,19,37,38], and are not related to the mental or physical status or the presence of complications, as it was proposed in some series [20,39]. No factor was found in this series or in the literature as a predictive factor for functional outcome [22,40].

This series presents a mid-term survivorship of 19 patients with DFR with a mean 48 months follow-up (one to eight years). All prostheses were still retained, however osteolysis was observed in three patients after five years, reducing the survivorship to 81.8% after five years and 53.3% after eight years. To our knowledge the largest series is published by Hoellwarth and compared 53 DFR to 87 locked plates for PDFF. The follow-up was only one year and studied only mortality and complication rates. No DFR was removed during the first year, mortality and complications were not significantly lower with DFR [37]. Vertesich presented 30 DFR performed for failed TKA with poor bone stock. The survivorship was 75% at one year, 62% at three years and 41% at 10 years [19]. Berend reported on 37 patients with severe bone loss and instability undergoing TKA with DFR. Implant survivorship was 87% at a mean follow-up of 46 months [12]. Other series report survivorship from 45% to 100% with various number of patients [11 to 24] and shorter follow-up times (11 to 37 months) than in this series [22,38–42].

Although DFR is a suitable option for complex cases, it is still related to a high number of complications. We observed nine complications in six patients (31.6%), which is like other series [19,37,39]. Most complications occurred during the first year. The main significant complication in this series is a deep infection (21.1%) requiring prompt debridement with mobile part exchange. Simultaneous TKA with DFR represents a unique complex procedure with special technical considerations leading to a prolonged surgery, wide soft tissue trauma, greater dead space for hematoma formation, greater tourniquet time and blood loss. Several factors may have contributed to the high rate of infection observed in this study. It has long been known that patient factors that increase the risk of PJI include poor nutritional state, diabetes mellitus (DM), old age, obesity (BMI >30 kg/m^2), and extended hospital admission period [21,36,43–49]. Patients in this cohort are elderly and overweight/obese. Subgroup analyses were not significant for these risk factors, but the cohort is small, and a slight effect size would not be detected.

Although this study has a small number of cases, we present a complete clinical and radiological evaluation with one of the longest available follow-up time. All data were prospectively collected during the systematic follow-up schedule organized by the senior author, and all the patients accepted to take part to a single visit for a late update in their radiological and clinical function (performed by an independent investigator).

We acknowledge some limitations: the retrospective evaluation, the different indications for DFR and the small number of cases preventing valuable analyses. We do not have a comparative group. All surgeries were performed by the same surgeon.

5. Conclusion

TKA with DFR is a valuable option in elderly patients admitted for a PDFF or TKA revision with massive bone loss. Most patients recover an acceptable and satisfying function. Complication rates are high, mainly infection, and require thorough diagnosis and treatment to prevent later failure. A careful selection of cases is needed and further studies with longer follow-up times and larger samples are required.

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