Original Article

# Distal Femur Fracture Fixation Failure: The Role of Distal Femur Replacement in a Revision Setting

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## Abstract

**Introduction:** Distal femur fractures are a common fracture seen in both high and low-energy traumas in young and elderly patients. The standard of care in healthy, mobile, younger patients remains open reduction and internal fixation (ORIF) through various fixation devices. However, the standard of care for comorbid and elderly patients remains unclear. In these patients, rates of nonunion vary between 6% and 20%, requiring revision surgery. Our study sought to identify patients who have gone endoprosthesis conversion to a distal femur replacement following failed ORIF. **Methods:** This descriptive study includes a total of eight patients who underwent a revision distal femoral replacement (DFR) following failure of primary distal femur ORIF and data were gathered through chart review. Patient comorbidities, demographic characteristics, hospital disposition, complications, and mortality were collected and described. **Results:** The average age of this cohort was 52.1 years, with 6 being female, and with a follow-up mean of 3.02 years. The most common medical comorbidities present in these patients at the time of ORIF were diabetes, hypertension, obesity, smoking, and renal insufficiency. 87.5% of patients were able to tolerate weight bearing following DFR conversion, compared to 62.5% tolerating weight bearing before revision. Complications requiring revision surgery occurred in 3/8 patients, which included: aseptic loosening, prosthetic joint infection, and patellar maltracking. **Conclusion:** DFR in a revision setting following acute distal femur ORIF can be an acceptable treatment options with outcomes similar to primary DFR. Further investigation is warranted to determine optimal timing and indications for primary DFR in a fracture setting.

**Keywords:** Distal femur fracture, endoprosthesis, open reduction and internal fixation

## Introduction

Distal femur fractures comprise 0.4% of all fractures and 3% of femur fractures, producing a bimodal age distribution in young men and elderly women, with the most common mechanism being domestic falls in this population.[1] At present, the mean age at time of injury is 61, with over 50% of patients over the age of 65 at the time of injury.[1] For patients to have the capability to regain previous mobility and function, definitive fracture fixation or arthroplasty is a necessary procedure. At present, the standard of care for distal femur fractures, especially in elderly and patients with compromised bone, remains unclear. Common practices include open reduction and internal fixation (ORIF) using plates and potentially locking screws, as well as anterograde and retrograde intramedullary nailing for extra-articular fractures or select intra-articular fractures. Choice of fixation routinely depends on fracture characteristics and surgeon comfort level with given constructs and devices. However, complications and morbidity of these standards remain high, with nonunion rates of 6%–20%,[2-4] and postoperative skin and soft tissue infection rates of 3.6% in distal femur fractures,[5] contributing to prolonged hospital stay

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and increased morbidity. In addition, the prolonged nonweight bearing status required of primary ORIF logically increases the chances of medical and surgical complications in vulnerable patient populations. Those patients who go on to develop a fracture nonunion often require additional surgery, adding additional rehabilitation time, financial strain, and decreased long-term mobility and function.

An interesting paradigm exists in the standard of care for common orthopedic fractures – it is well known that arthroplasty is the superior treatment for fractures of the femoral neck,[6,7] yet there is a paucity in evidence-based guidance in the management of distal femur fractures despite having similar mortality rates as fractures of the femoral neck.[8] For these reasons, the role of arthroplasty in the management of distal femur fractures has become an exciting area of current research. Potential advantages of distal femoral replacement (DFR) involve immediate weight bearing, avoidance of posttraumatic arthritis, and nonunion/malunion. Disadvantages of DFR include a more extensive exposure with limited salvage options in the event of treatment failure.[9] Current indications for treatment of distal femur fractures with DFR include advanced age, low-demand functional status, and comminuted, articular fractures in patients with poor bone stock.[10] A study by Rosen and Strauss sought to repair distal femur fractures in geriatric patients with primary arthroplasty, with the goals of promoting early mobilization and weight bearing. Interestingly, their study found no major surgical or medical complications experienced by their 24 patients.[11] Further studies have produced similarly promising results, with reliable pain relief, improved functional scores, and low rates of revision.[12] There is very little evidence in terms of how patients who undergo primary fixation fair in the event of failure with subsequent conversion to DFR. Similar questions have arisen in the area of the proximal humerus and femoral neck. Previous studies have shown that patients who require arthroplasty for failed fixation of the proximal humerus require more reoperations compared to those who undergo primary arthroplasty;[13,14] whereas, in the femoral neck, those who require conversion to arthroplasty after failed fixation suffer more complications and poorer function potentially leading to more aggressive consideration for arthroplasty upfront.[15-17] Despite small studies evaluating function and outcomes of primary DFR for distal femur fracture, we do not have a similar study to those previously mentioned looking at patients who require conversion arthroplasty after fixation failure. This study seeks to describe a cohort of patients who have undergone conversion to DFR or oncologic endoprosthesis following failure of distal femur ORIF for acute fracture fixation.[18]

## Methods

This descriptive study was an Institutional Review Board approved retrospective cohort analysis of patients who failed primary distal femur ORIF via nonunion or implant failure and was subsequently revised to arthroplasty of the knee through DFR or total knee arthroplasty (TKA) from 2009 to August 31, 2019 by the primary surgeon. CPT coding was used to identify patients who underwent Distal Femur Replacement, Oncologic Total Knee Replacement, or Standard TKA through code 27447. Inclusion criteria included history of distal femur fracture repaired by ORIF, history of DFR and TKA secondary to failed ORIF, and a minimum of 3-month follow-up by an orthopedic surgeon in adult subjects 18 years and over. Exclusion criteria include patients who had DFR or TKA for another indication besides a distal femur fracture, oncologic diagnosis, and those who did not have minimum 3-month follow-up.

Using CPT coding, code 27,447 was utilized to gather all patients who underwent knee arthroplasty by the primary surgeon. A total of 97 patients were identified to have undergone knee arthroplasty. 14 patients were found to have had failure of prior distal femur ORIF, and 11 patients were included for final data analysis. Reasons for exclusion included inadequate follow-up and oncologic diagnoses. Our group sought to elucidate patient factors which may have contributed to failure of distal femur ORIF.

Thirty-day and 1-year mortality were collected from all patients included in the study. Other variables gathered through retrospective chart review included age, gender, follow-up in years, radiographic fracture outcome, diagnosis of diabetes mellitus and hypertension, body mass index (BMI), smoking status within 12 weeks before or after surgery, time to primary fixation, open fracture, fracture comminution, substance abuse (as defined by illicit drug use or alcohol use >7 drinks per week for women and >14 drinks per week for men), preoperative ambulatory status, method of fixation, postoperative ambulatory status, time to "weight bearing as tolerated," hospital length of stay (LOS), disposition at discharge, and time from primary fixation to DFR revision. Patient medical comorbidities, fracture descriptions, method of fixation, and level of ambulation were identified and reported as per the electronic medical record (EMR). The presence of oncologic diagnosis was defined as any malignancy diagnosed before the date of surgery.

These data were gathered and organized within Microsoft Excel (Microsoft, Redmond, WA, 2016) under a protected file within the institution's firewall.

## Results

A total of eight patients were included for this descriptive study. Fourteen patients were originally identified to have undergone an arthroplasty procedure secondary to failed distal femur ORIF within the study's date ranges, but 3 were excluded due to inadequate follow-up, with one being a mortality within 30 days. Three more were excluded due to the presence of an oncologic diagnosis before DFR. This is shown in a flowchart in Figure 1.

Demographic information of this cohort: the mean age was 52.0 with a standard deviation (SD) of 6.1. In this group, there

were five male and six female patients. Mean follow-up in years was 3.02 with a SD of 1.8.

Table 1 describes the preoperative and postoperative functional status, method of fixation for ORIF, radiographic outcome for primary ORIF, hospital LOS following arthroplasty, disposition upon discharge, and time to weight-bearing-as-tolerated (WBAT) in days. The number of patients who were documented as able to bear any weight on the affected extremity pre and postoperatively is shown to be 5/8 (62.5%), and 7/8 (87.5%), respectively. Average hospital LOS was found to be 11.0 ± 17.6 days. Average time from primary ORIF to revision DFR was calculated to be 87.4 ± 125.5 days. Time to WBAT following DFR is reported at a mean of 3.6 in this cohort with a SD of 4.8.

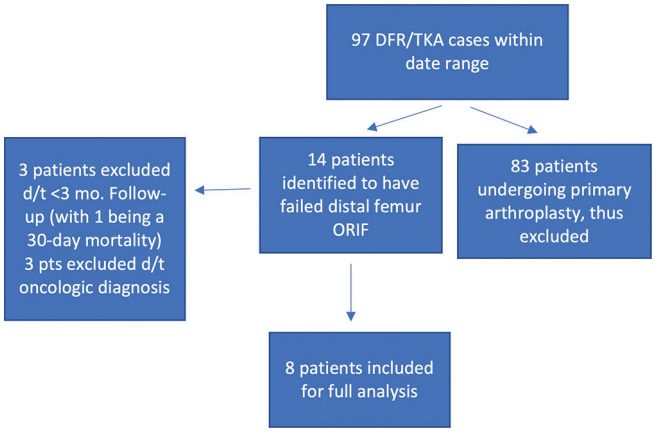


**Figure 1:** Flow chart for arthroplasty secondary to failed open reduction and internal fixation

Table 2 describes the selected medical comorbidities identified to be risk factors for poor bone healing in this. A total of five patients were found to be diabetic (62.5%). In addition, five patients were found to have essential hypertension for a total of 62.5%. The average BMI for this group was found to be 35.3 ± 5.8. There were three smokers in this group, for a total of 37.5%. There were no patients identified with HIV or hepatitis. There was one patient on immunomodulating therapy, and one patient with documented methicillin-resistant *Staphylococcus aureus* colonization (12.5%). Three patients had documented renal insufficiency (37.5%). Three of four patients with documented open or closed fracture status were found to have open fractures (75%), with three having status unknown. Seven patients had comminuted fractures at presentation (87.5%). Two patients had radiographically evident and significant bone loss (25%). One patient reported substance abuse within 12 weeks of DOS (12.5%).

Table 3 describes the hospital location of primary ORIF (whether outside or at our institution), any documented NWB duration following primary ORIF, any documented disposition upon discharge from primary ORIF, and time from acute fracture to ORIF. It should be noted that weight-bearing duration and disposition are as found within the EMR. Although only three patients were able to be calculated on this statistic, the average length of time between initial acute fracture to ORIF was 2.0 ± 1.0 days.

**Table 1: Functional outcomes and time to weight bearing for the arthroplasty cohort**

| Patient number | Preoperative ambulatory status | Method of primary ORIF | Radiographic outcome (union, nonunion, types) | Postoperative ambulatory status | Hospital LOS (days) | Disposition at discharge | Time from acute Fx ORIF to revision surgery (months) | Time to WBAT following DFR (days) |
|---|---|---|---|---|---|---|---|---|
| 1 | Walker assisted | Plate, interlocking screws | Atrophic nonunion | NWB, revised to AKA | 4 | Discharged home in stable condition | 24 | 4 |
| 2 | Unassisted ambulator | Lateral plate, locking screws | Atrophic nonunion | Unassisted ambulator | 6 | Discharged to acute rehab hospital | 4 | 1 |
| 3 | NWB | Lateral plate and cerclage wire | Oligotrophic nonunion | Unassisted ambulator | 3 | Discharged to skilled nursing facility | 37 | 1 |
| 4 | Crutch assisted | ORIF, revised to retrograde IMN | Atrophic nonunion | Cane assisted | 3 | Discharged home with walker | 226 | 1 |
| 5 | NWB | Antegrade IMN | Septic Nonunion, Significant Bone loss | Unassisted Ambulator | 3 | Discharged to Home | 308 | 1 |
| 6 | Unassisted ambulator | Variable angle locking plate | Atrophic nonunion | Unassisted ambulator | 54 | Discharged to acute rehab hospital | 6 | 14 |
| 7 | Walker assisted | External fixation | Atrophic nonunion | Walker Assisted | 6 | Discharged to acute rehab hospital | 7 | 6 |
| 8 | NWB | Plate and screws | Nonunion | Cane assisted ambulator | 9 | Discharged to skilled nursing facility | - | 1 |
| Overall | 62.5% (NWB) | | | 87.5% (ambulating) | 11±17.5 | | 87.4±125.5 | 3.6±4.8 |

LOS: Length of stay, ORIF: Open reduction and internal fixation, WBAT: Weight-bearing-as-tolerated, DFR: Distal femoral replacement, AKA: Above knee-amputation, INM: Intramedullary nailing, NWB: Nonweight bearing

**Table 2: Medical comorbidities and nonunion factors in the arthroplasty cohort**

| Patient number | DM | HTN | BMI | Smoker within 12 weeks of fixation | Immunomodulator therapy | Renal insufficiency | Open fracture | Comminution | Bone loss | Substance abuse |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Yes | Yes | 29.5 | Yes | No | No | - | Yes | No | No |
| 2 | No | Yes | 38 | Yes | No | Yes | Yes | Yes | No | Yes |
| 3 | Yes | No | 41.8 | No | Yes | No | - | Yes | No | No |
| 4 | Yes | Yes | 36.2 | Yes | Yes | Yes | - | Yes | No | No |
| 5 | No | No | 24.2 | No | No | No | Yes | Yes | Yes | No |
| 6 | No | No | 32.9 | No | No | No | Yes | Yes | Yes | No |
| 7 | Yes | Yes | 32.3 | No | No | Yes | No | Yes | No | No |
| 8 | Yes | Yes | 47.7 | No | No | No | - | No | No | No |
| Overall (%) | 62.50 | 62.50 | 35.3±5.8 | 37.50 | 12.50 | 37.50 | 75 (3/4) | 87.50 | 25 | 12.50 |

DM: Diabetes mellitus, HTN: Hypertension, BMI: Body mass index

**Table 3: Additional patient factors before distal femoral replacement conversion**

| Patient number | ORIF at outside hospital | Weightbearing limitation following ORIF | Disposition following ORIF | Time from acute Fx to ORIF (days) |
|---|---|---|---|---|
| 1 | Yes | 1 year | - | - |
| 2 | No | 12 weeks | Acute rehabilitation hospital | 1 |
| 3 | Yes | 8 months | - | - |
| 4 | Yes | - | - | - |
| 5 | Yes, with 3 Surgeries also at our institution | - | - | - |
| 6 | No | Never returned prior to DFR | Remained hospitalized until DFR | 3 |
| 7 | Yes | 7 weeks | Skilled nursing facility | 2 |
| 8 | Yes | - | - | - |

DFR: Distal femoral replacement, ORIF: Open reduction and internal fixation

The 30-day and 1-year mortality rates were calculated. The total number of included patients for this calculation is 9 due to the fact that the patient who expired within 30 days was excluded from full analysis but included for mortality calculations. One of nine patients expired within 30 days, with 2 of nine having expired within 1 year.

62.5% of patients (5/8) went on to have no complications following the DFR performed by the primary surgeon. Two patients (25%) went on to have revision due to mechanical difficulties with the implant. One patient (12.5%) had a length course with prosthetic joint infections and was ultimately revised to an above-knee-amputation (AKA).

## Discussion

While distal femur fractures have classically been treated by means of primary ORIF, there has been increasing interest in primary arthroplasty in certain vulnerable patient populations. There is currently much debate in regard to who would be the best candidates for primary arthroplasty and who should be treated with ORIF. Both techniques can be successful but also expose patients to potential complications with a high mortality rate within 1 year.[19] It is our belief that most patients can be successfully treated by means of ORIF, most notably healthier elderly individuals who are not adversely affected by potential weight bearing or activity restrictions or who have a higher baseline mobility. However, certain patients who may be unable to physically adapt to these restrictions should be considered for primary arthroplasty. While there is evidence to allow early weight bearing on fixation constructions,[20-22] it is still common practice is to limit weight bearing.[23] This certainly is a more complicated discussion when taking into considerations all of the other variables that affect the decision for weight bearing including patient demographics, fracture characteristics, fixation construct, concomitant injuries, etc. Arthroplasty, including DFR, has a well-established ability to allow for full and early weight bearing in a population where restrictions can be debilitating.[24] Clouding this argument is whether or not patients who are allowed to early weight bear actually do. Previous studies would suggest that the actual time to weight bearing, not just time at which the surgeon allows weight bearing, is not dramatically different between primary ORIF and DFR.[19]

Multiple previous studies have looked at acute DFR or arthroplasty for distal femur fractures. Most of these studies are small series as it is still uncommon to perform primary arthroplasty in a fracture setting. Our aim was to describe patients and their outcomes who have previously undergone attempted primary fixation and were later converted to DFR. All patients experienced an improvement in weight-bearing status after their revision with the exception of one who experienced continued complications and required an AKA. In addition, 3/8 patients were able to be discharged home

from the hospital and another 3/8 patients were able to be discharged to acute rehab facilities rather than experience long stays in skilled nursing facilities. This small series of patients would suggest that DFR is a reasonable option in the setting of failed ORIF. That being said, many of these patients may have experienced a quicker recovery had their original surgery been a DFR, without the unnecessary time of limited weight bearing, added surgical risk, or additional time in care facilities. It is difficult to say whether their outcomes would have fared any differently had they been selected for primary DFR rather than attempted ORIF. Further investigation including a comparison of patients who received primary arthroplasty versus revision arthroplasty for failed ORIF is warranted to see if patients are adversely affected in a revision arthroplasty setting versus a primary arthroplasty setting, as similar to what has been investigated in the proximal humerus and femoral neck.[14,16]

Mortality is a significant risk in these patients. In our small cohort, we saw three patients die within 1 year of revision and thus were excluded from our overall analysis. This likely is a representation of the multiple comorbidities present in this patient population and is similar to other previously published studies for DFR in a primary setting as well as previous studies on mortality in elderly patients with distal femur fractures.[8,25] It is also possible that these patients were put at additional risk of morbidity and mortality due to the revision surgery required to convert them from failed ORIF to DFR. Surgery in elderly individuals may not be tolerated as well compared to younger individuals. This is especially relevant in elderly populations with multiple comorbidities, the same population who may benefit from primary DFR rather than attempted ORIF which will likely limit their weight bearing and mobility and lead to extended stays at rehab centers or extended care facilities.

Limitations to our study include its descriptive nature. We are unable to draw any concrete conclusions given the lack of a control group. Ideally, we would compare patients who have received primary DFR for distal femur fractures and compare them to a group who received DFR for revision of a failed ORIF. By comparing groups, we would hopefully aim to find if there is a difference between revision and primary arthroplasty, potentially suggesting more aggressive or conservative selection of this treatment modality. An additional limitation is the small number of patients being evaluated in our cohort. Given the rare instances of either acute or revision DFR for fracture, it is difficult to obtain appropriate numbers for even a retrospective study, let alone prospective. Future efforts may need to be more multi-institutional, although that does introduce confounding variables including differences in treatment preferences, implant utilization, and surgeon experience when evaluating outcomes.

## Conclusion

With consideration of medical comorbidities and fracture characteristics highlighted above, distal femur replacement as a revision to failed ORIF of acute distal femur fractures could provide an acceptable treatment option. Results of revision DFR in our cohort are comparable to reported primary DFR outcomes in the setting of acute distal femur fracture, but further investigation is needed to determine optimum timing and indications. Future studies comparing primary DFR for fracture to cases of DFR in a revision setting after failed ORIF are warranted.

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### Conflicts of interest

There are no conflicts of interest.

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