Distal Femoral Replacement for Acute Distal Femoral Fractures in Elderly Patients

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Objectives: To evaluate outcomes and complications using cemented modular distal femoral replacement in elderly patients with distal femoral fractures.

Design: Retrospective chart review, case series.

Setting: A Level 1 and Level 2 trauma center, both tertiary referral hospitals.

Patients/Participants: Eighteen patients older than 60 years (average age 77 years) who had cemented distal femoral replacement for distal femoral fractures (comminuted, intraarticular, osteoporotic, arthritic) between 2005 and 2013. Patients with previous knee surgery were excluded.

Intervention: Cemented modular distal femoral replacement.

Main Outcome Measures: Implant status, complications, Knee Society Score, Musculoskeletal Tumor Society score, and Western Ontario and McMaster Osteoarthritis Index.

Results: All patients were extremely or very satisfied with their outcomes. For patients with functional outcome data, Knee Society Score averaged 85.7 with a functional score of 35, Musculoskeletal Tumor Society score averaged 19.2, and Western Ontario and McMaster Osteoarthritis Index score averaged 23.1 at an average follow-up of 2.3 years. Range of motion was 1–99 degrees. Implant-related complications occurred in 2 patients (11%); one required revision to total femoral replacement because of periprosthetic fracture and the other had a deep infection that required exchange of the components. No patient had aseptic loosening or patellar maltracking. There were no perioperative deaths or late amputations.

Conclusions: Cemented modular distal femoral replacement is a viable treatment option in elderly patients that permits immediate full weight-bearing, with most patients returning to preoperative functional status.

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Institutional Review Board, University of Tennessee Health Science Center, deemed this study exempt from review and waived requirements for informed consent.

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INTRODUCTION

Distal femoral fractures occur in a bimodal distribution, with low-energy trauma in elderly patients and high-energy injuries in young adults. The annual incidence of distal femoral fractures is 4.5 per 100,000 adults, with a male-to-female ratio of 33:67,[1] and 50% of these fractures occur in patients older than 70 years.[2] Given the rapid expansion of this patient population, the number of distal femoral fractures in elderly patients will continue to increase.

Restoration of or improvement upon pre-injury levels of function presents multiple difficulties in the treatment of distal femoral fractures in elderly patients. Lower pre-injury activity levels and bone quality combined with more medical comorbidities lead to worse outcomes after fixation than in a younger patient population[3–5]: the 1-year mortality rate after this injury is 22%, with a 9% late above-knee amputation rate in elderly patients.[3]

Nonoperative treatment with immobilization and protected weight-bearing is poorly tolerated because of the associated morbidity of prolonged recumbency, including pneumonia, skin breakdown, and thromboembolic disease.[5] Open reduction and internal fixation (ORIF) with locking plates is less successful in elderly patients because of osteoporosis and degenerative joint disease. Osteoporotic bone is less able to support internal fixation to resist axial and torsional loading or to buttress impacted articular segments.[6] Restoring anatomic alignment in a knee with degenerated anatomy is difficult, and many patients initially treated with ORIF require delayed knee arthroplasty.[7] Elderly patients also may be unable to adhere to protected weight-bearing regimens because of baseline weakness and decreased cognitive status leading to failure of fixation.

Arthroplasty is an accepted initial treatment for comminuted fractures of the proximal and distal humerus, as well as the femoral neck and acetabulum, in elderly patients.[8] Primary prosthetic replacement avoids the early and late issues associated with internal fixation, such as malunion, nonunion, osteonecrosis, and need for delayed arthroplasty. Use of a tumor endoprosthesis for acute distal femoral fractures has been described.[9–11] Cemented modular

distal femoral replacement enables immediate full weight-bearing, which facilitates mobilization and avoids the complications of prolonged recumbency. The purpose of this study was to evaluate outcomes of a cemented modular rotating-hinge distal femoral endoprosthesis as a treatment option for elderly patients with distal femoral fractures.

PATIENTS AND METHODS

Approval was obtained by the University of Tennessee Institutional Review Board before retrospective data collection. Included were patients older than 60 years with acute traumatic distal femoral fractures treated with cemented distal femoral replacement. Patients who had previous surgery for knee injuries were excluded. Relative indications for the distal femoral replacement were comminuted fractures, intra-articular fractures, osteoporotic bone, and preexisting degenerative joint disease (Fig. 1). The assessment of presence of significant osteoporosis was made by the treating surgeon using standard radiographs; no DEXA scans were used. Because weight-bearing films to assess joint space narrowing were not possible, the severity of degenerative joint disease was determined by the presence of subchondral sclerosis, subchondral cyst formation, and periarticular osteophyte formation. These patients were deemed likely to incur higher failure rates with traditional ORIF or to require arthroplasty after ORIF.

Medical records were reviewed to determine mechanism of injury, medical comorbidities, length of hospital stay, disposition after discharge, and outcome measures, including range of motion, stability, and postoperative complications. The objective data reported by the physician at the most recent office visit were recorded. Patients were asked to complete several questionnaires at follow-up appointments: Knee Society Score, Musculoskeletal Tumor Society (MSTS) score, and Western Ontario and McMaster Osteoarthritis Index (WOMAC) score. The Knee Society Score is a functional scoring system with 100 points scored on the basis of pain, range of motion, alignment, stability, and function. The WOMAC score has a maximum of 96 points and is based on patient symptoms, stiffness, pain, and function with activities of daily living. The MSTS score is based on 6 categories (pain, function, emotional acceptance, support, walking ability, and gait) scored from 0 to 5 for a maximal score of 30. Some patients declined to complete these questionnaires. The information from these questionnaires, if available, from the most recent office visit was used for evaluating outcome. Radiographs were routinely obtained at each follow-up visit.

All patients signed informed consent after verbalizing understanding the risks, benefits, and alternatives to the proposed surgical procedure. Patients with open fractures had initial debridement and irrigation, followed by resection and placement of an antibiotic spacer before distal femoral replacement. The implant system used was the LPS Limb Preservation System (DePuy Synthes, Warsaw, IN). This is a tumor prosthesis with modular distal femoral components, a cemented femoral stem, modular tibial components, and a rotating hinge articulation.

The procedure was primarily performed through an anterior midline incision. A direct lateral approach was used for open fractures where the traumatic arthrotomy made this approach more appropriate and for fractures that extended to the mid-diaphysis of the femur because of the extensibility of this approach. The distal femoral fracture fragments were resected by subperiosteal dissection and retained on the operating room back table to allow for approximate sizing of components to aid in joint line restoration. After a 1-cm proximal tibial cut, the tibial canal was sequentially reamed and broached to the appropriate size, followed by assembling of the final components. The tibial components were placed in a press-fit fashion with a small amount of cement beneath the tibial tray. The femoral canal was reamed sequentially, and trial components were assembled in the femur. Trialing was

FIGURE 1. Anteroposterior (A) and lateral (B) radiographs of comminuted, intraarticular distal femoral fracture with degenerative joint disease.

performed to assess rotation and patellar tracking. A canal plug was placed, and the femoral canal was cleaned with a bottle brush and then pulsed lavage and dried. The canal was filled retrograde with pressurized gentamicin bone cement, and final components were cemented into place (Figs. 2, 3). The wound was closed in layers with absorbable sutures.

Postoperatively, all patients were allowed immediate full weight-bearing. Physical therapists worked with patients twice daily while in the hospital, with immediate range of motion and strengthening as tolerated. Disposition location was determined in conjunction with the physicians, physical therapists, and case managers, and decisions were based on the patient's assistance requirements, progress in physical therapy, and family support available.

RESULTS

Eighteen patients with an average age of 77.1 years (range, 62–94 years) met inclusion criteria for the study. During this same period, 125 patients were treated with ORIF for an intraarticular distal femur fracture (CPT Code 27513). Medical comorbidities in the group included heart disease (50%), diabetes (33%), hypertension (83%), and liver disease (6%). Mechanism of injury was a same-level fall in 14 patients and a motor vehicle accident in 4 patients. Four patients had open fractures, all Gustilo type II. Average time to definitive surgery for closed fractures was 7 days and for open fractures was 11 days. The average intraoperative blood loss was 344 mL, with a tourniquet time of 100 minutes. The average American Society of Anesthesiologists class was 3 (severe systemic disease). The average length of hospital stay was 11 days (range, 5–43 days); 12 patients were discharged to inpatient rehabilitation facilities, 5 to skilled nursing facilities, and 1 to home. All patients were permitted to bear full weight postoperatively. At average follow-up of 2.2 years (range, 0.3–5.9 years), the average range of motion was 1–99 degrees. Eight patients died an average of 4.7 years after surgery of causes unrelated to their fracture. All prostheses in the remaining 10 patients currently are well-functioning.

Complications

Overall, complications occurred in 7 (39%) patients; however, implant-related complications occurred in only 2 (11%). One patient had a periprosthetic fracture that required revision to a total femoral prosthesis, and 1 patient had a deep infection that required debridement and irrigation and exchange of the modular components (well-fixed stems were retained). No patients had aseptic loosening, patellar maltracking, or loosening of components. Complications are listed in Table 1.

Patient A became hypotensive on the evening of surgery and was transferred to the intensive care unit for observation. The hypotension responded to volume replacement, and the patient returned to the floor 2 days later and had no further complications.

A 2-cm stage 2 gluteal decubitus ulcer developed postoperatively in patient B while an inpatient; it healed with superficial wound care and prophylactic cephalexin.

During preoperative evaluation, patient D was found to have severe 3-vessel disease and underwent coronary artery bypass grafting before treatment of the femoral fracture 7 days later. This patient developed a nonocclusive thrombus of the deep femoral vein after coronary artery bypass grafting and before distal femoral replacement, which was treated with an inferior vena cava filter. This patient also developed thrombosis-associated heparin-induced thrombocytopenia that was treated with 6 months of anticoagulation. At 3-year follow-up, the patient was doing well.

Patient E presented 1 year after surgery with a stitch abscess on the anterior aspect of the knee. This was opened and cultures grew gram-positive cocci. An aspiration of the knee showed no growth. Despite treatment with oral antibiotics, drainage from the anterior aspect of the knee continued, and formal debridement and irrigation of the superficial tissues and closure were done. No arthrotomy was performed. This incision healed, and the patient was doing well at the most recent follow-up 5.8 years after the initial procedure.

Patient L presented 4 weeks after surgery with worsening knee pain and redness. The knee was aspirated and

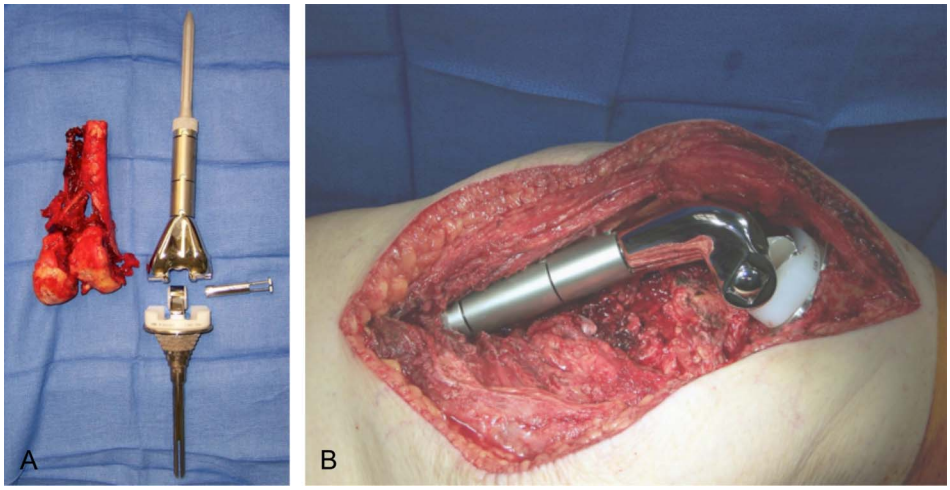

FIGURE 2. Clinical photos of distal femoral resection adjacent to prosthesis (A) and prosthesis after implantation (B). **Editor's Note:** A color image accompanies the online version of this article.

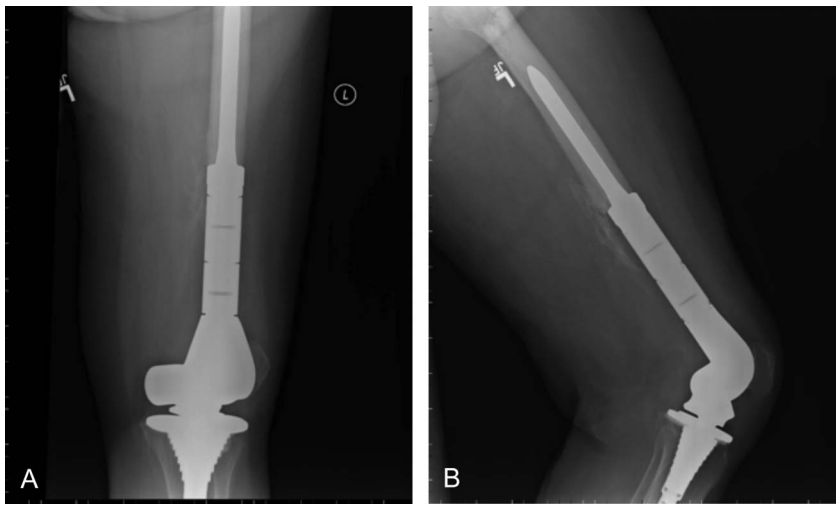

FIGURE 3. Anteroposterior (A) and lateral (B) radiographs after distal femoral resection and implantation of prosthesis.

showed gram-positive cocci on Gram stain. Debridement and irrigation of the knee were done, with placement of antibiotic beads and retention of the components. The cultures from this procedure eventually grew methicillin-resistant *Staphylococcus aureus*. Six days after the initial debridement and irrigation, repeat debridement was done, with exchange of the modular components and placement of new antibiotic-impregnated calcium sulfate beads. The femoral body and the rotating hinge polyethylene components were exchanged while retaining the well-fixed femoral stem and tibial components. The decision was made to continue suppressive minocycline indefinitely. Two years later, however, the patient returned to clinic complaining of increasing knee pain after admitting that she had stopped taking her antibiotics. A repeat aspiration grew *Serratia marcescens*. Debridement and irrigation were done, with polyethylene exchange and replacement of antibiotic-impregnanted calcium sulfate beads. The patient was successfully treated with oral suppressive antibiotics until her death 6.3 years after distal femoral replacement.

Patient O had a history of chronic obstructive pulmonary disease and sustained a distal femoral fracture along with bilateral rib fractures in a motor vehicle accident and remained intubated in the intensive care unit for 2 days after surgery because of respiratory failure. This patient was transferred to the floor on the third postoperative day and had an unremarkable further hospital course.

Patient R sustained a distal femoral fracture ipsilateral to a primary total hip replacement done 6 years earlier. She had distal femoral replacement without complication and was well until 2 years later when she fell and sustained an interprosthetic fracture between the hip and distal femoral implants. She had revision to a total femoral prosthesis and was well at latest follow-up 3 years after surgery, with a Knee Society Score of 90.

Functional Outcomes

Of the 18 patients, complete follow-up data consisting of MSTS, Knee Society, and WOMAC scores were available for 12 patients at an average of 1.7 (0.6–5.2) years after surgery. Knee Society Score averaged 85.7, with a functional score of 35, the MSTS score averaged 19.2, and the WOMAC score averaged 23.1. All 12 patients reported being extremely or very satisfied with their outcome at latest follow-up. Of the 13 patients for whom documentation was available, 12 returned to their baseline functional status and 1 patient who was previously ambulated without any assistive device required a cane. Eight of the 18 patients were followed until they died an average of 4.7 years after surgery. For the surviving 10 patients, follow-up averaged 2.5 years and all currently have well-functioning prostheses.

DISCUSSION

To our knowledge, this is the largest study of acute modular endoprosthetic reconstruction of distal femoral fractures in a native knee. All patients were allowed to ambulate full weight-bearing immediately after surgery, and there have been no mechanical complications to date. One patient required revision to a total femoral replacement because of an interprosthetic fracture. Twelve of 13 patients returned to their preoperative functional levels, with 1 patient who previously did not use any assistive device requiring a cane. All patients reported being extremely or very satisfied with their outcomes at latest follow-up. This is the first study to report functional scoring outcomes for this treatment method for acute distal femoral fractures in elderly patients. At time of this report, all surviving patients have well-functioning prostheses; 8 of the 18 patients were deceased at an average of 4.6 years after surgery.

Although ORIF with locked plating is the most common treatment method for distal femoral fractures, unique patient factors in the elderly population make this a more challenging treatment option than in younger patients.[8,12–14] ORIF generally requires restricted weight-bearing for 6 weeks to 3 months,[15] with which many elderly patients may be unable to comply.[16] Because of poor fixation in osteoporotic bone, loss of reduction may occur with late sequelae of posttraumatic arthritis, malunion, nonunion, and stiffness. Some authors have recommended supplementing internal fixation with spanning external fixators to overcome insufficient fixation in osteoporotic bone.[17]

TABLE 1. Patient Complications With Ambulatory Status Before and After Injury, as Documented in the Medical Record

Patient	Age, y	Mechanism	AO Class	Open (O)/ Closed (C)	Time to OR, d	Time to Death, mo	Follow-up, mo	Pre-Injury Assistive Device	Postinjury Assistive Device	Complications
A	82	SLF	C	C	2	49.5	7.5	NA	NA	Hypotension
B	77	SLF	C	O	2	13.3	12.1	Walker	Cane	Stage 2 gluteal decubitus ulcer
C	77	SLF	C	C	8	50.2	4.1	Cane	NA	
D	94	SLF	B	C	9	N/A	32.3	Walker	NA	DVT
E	81	SLF	B	C	2	N/A	70.8	Cane	NA	Superficial suture abscess
F	71	SLF	C	O	3	N/A	14.0	NA	None	
G	62	MVA	C	C	1	N/A	12.2	NA	None	
H	65	MVA	C	C	17	N/A	10.0	NA	None	
I	84	SLF	C	O	5	64.6	13.0	NA	None	
J	75	SLF	C	C	2	N/A	28.0	None	Cane	
K	87	SLF	C	C	7	114.8	62.9	Walker	Walker	
L	78	SLF	C	C	4	76.6	49.6	Walker	Walker	Deep infection
M	76	SLF	B	C	4	N/A	3.8	Walker	Walker	
N	73	MVA	C	O	35	N/A	60.7	None	None	
O	76	MVA	C	C	3	82.2	28.9	NA	None	Respiratory insufficiency
P	63	SLF	C	C	27	3.2	2.8	None	Cane	
Q	81	SLF	B	C	2	N/A	35.7	None	None	
R	85	SLF	C	C	7	N/A	27.6	None	NA	Interprosthetic fracture

MVA, motor vehicle accident; SLF, same level fall; NA, unknown.

A retrospective study of 70 distal femoral fractures in patients with an average age of 60 years showed a nonunion rate of 20%, complication rate of 40%, and reoperation rate of 27%.[18] Because restricted weight-bearing precautions may result in other medical complications due to prolonged immobility, some have suggested allowing early weight-bearing after ORIF; however, a recent biomechanical study suggests that failure of fixation would be likely even in young patients.[19]

After fracture healing is complete, many patients with ORIF require total knee replacement. Total knee replacement in this setting, even though technically a primary joint replacement, is significantly more difficult because of joint contractures, difficulty with surgical exposure, and use of allograft and revision components.[4] Total knee replacement as a secondary procedure following periarticular fracture has disappointing results when compared with elective primary arthroplasty. Revision rates vary between 8% and 23%, with a complication rates of 24%–48% and "good" outcomes in 60%–70%.[20,21] A study by Papadopoulos et al[7] of 48 total knee arthroplasties in patients with previous distal femoral fractures showed an 8% revision rate, 15% complication rate, and 52% good outcomes.

There have been limited reports of acute arthroplasty using revision knee implants for distal femoral fractures. This was first described in 1982,[22] and the first studies of multiple patients were reported in 1989[23] and 1992.[2] Results of primary arthroplasty for acute distal femoral fractures have shown better outcomes than arthroplasty as a secondary procedure after ORIF of a distal femoral fracture.[2,24–26] Bell et al[2] reported a 15% complication rate and 85% good outcomes in 13 patients; however, follow-up was limited to 6 months. At 3-year follow-up, Malviya et al[24] reported 90% patient satisfaction and 81% return to pre-injury level of function after acute primary total knee arthroplasty for 26 periarticular knee fractures using stemmed cemented components. In this study, although, only 11 were for distal femoral fractures and the manner of data reporting does not permit comparison of outcomes to our study. In a small study comparing 6 elderly patients with no preexisting arthritis treated with a stemmed revision-type implant with 4 patients with internal fixation, the arthroplasty group showed a larger portion returning to independent walking, with quicker rehabilitation and better knee flexion.[25] Appleton et al,[26] however, reported using fixed-hinge, long-stemmed revision implants for acute distal femoral fractures in 54 medically frail patients who did not ambulate outside the home and showed a 41% 1-year mortality in this fragile population.

Use of modular tumor prostheses for non-tumor diagnoses including trauma has been reported.[4,9,27,28] In a study from the Mayo Clinic of 26 knees treated with tumor prostheses for nonneoplastic limb salvage, 11 were for nonunion of a periprosthetic fracture, 8 for revision arthroplasty with severe bone loss, 4 for nonunion of supracondylar femoral fractures, and 1 each for an acute periprosthetic fracture, fracture of a previous hinge implant, and a previous resection arthroplasty. None were used for an acute distal femoral fracture in a native knee. All the patients gained significant improvements in range of motion and functional scores.[27] Freedman et al[9] reported 2 patients with acute distal femoral fractures treated with modular distal femoral replacement and

noted immediate pain relief, early weight-bearing, and ability to proceed with aggressive rehabilitation. Berend and Lombardi[28] described 39 distal femoral replacements for non-tumor cases, including 13 periprosthetic fractures and 1 acute distal femoral fracture, with an 87% implant survivorship rate at 46-month follow-up. In 24 patients with acute distal femoral replacement using a rotating hinge tumor prosthesis for both acute distal femoral fractures or nonunions, Rosen and Strauss[4] reported 100% immediate weight-bearing, 8% complications, no revisions, and 71% return to preoperative ambulation levels. This study, however, was limited to short-term follow-up of a mean of 11 months (range, 5–23 months) and no functional scoring of results.

Most intraarticular distal femoral fractures at our institutions are treated with ORIF with locked plating constructs, including those in patients older than 60 years. Endoprosthetic reconstruction is offered only to those patients in whom ORIF is deemed likely to fail or who may require secondary procedures because of poor bone quality or preexisting degenerative joint disease. We have found this specific patient population to be better treated with endoprosthetic reconstruction. The exclusion of patients with previous knee surgery may explain in part the favorable comparison of our results to those for arthroplasty after internal fixation.[7,21,22] Given the lower activity level in elderly patients, implant survivorship is less of an issue than with younger, more active patients.

Our complication rate and functional results after endoprosthetic reconstruction compare favorably with those after ORIF in the geriatric population.[29–33] Konda et al[30] recently reported 30-day mortality, adverse events, and severe adverse events of 4.51%, 20.05%, and 12.03%, respectively, after ORIF in geriatric patients, and Smith et al[32] found an 18% 1-year mortality in patients (mean age of 77 years) with distal femoral fractures, most of which were treated with locked plating. Thomson et al[33] found no difference in the SF-36 physical functioning score between patients with intraarticular distal femoral fractures treated with ORIF and those treated with intramedullary nails; the score was approximately 2 SDs below population norms in both groups. Good or excellent results were obtained in only 45.9% of 111 distal femoral fractures treated with locked plates by Hoffman et al.[29] Shulman et al[31] reported "relatively good" functional results, based on Short Musculoskeletal Functional Assessment, after ORIF or intramedullary nailing of intraarticular distal femoral fractures. Elderly patients did have worse functional outcomes than younger patients in the Short Musculoskeletal Functional Assessment indices of Daily Activity, Functional, and Bother.

This operation can be technically demanding and is likely best suited to surgeons familiar with the procedure and who perform it regularly. The cost of this operation is significant as the components are several times more expensive than a standard distal femoral locking plate, although it may be less expensive overall than a case of a failed ORIF that requires additional hospitalization and revision arthroplasty components. The average time to definitive surgery for open and closed fractures is relatively high; however, as shown in Table 1, there were several outliers that increased the overall average. In addition to waiting for open wounds to stabilize and be without concern for infection, additional factors that increased time to surgery included preoperative medical clearance and coordination of care between hospitals and the orthopaedic trauma and arthroplasty surgeons. Patients with open fractures were not routinely kept on antibiotics while awaiting definitive surgery. Although patients with an antibiotic spacer were touch down weight-bearing on the involved extremity, they still returned to full weight-bearing sooner than the 6-week interval that would be typical had they undergone ORIF.

Weaknesses of this study include those inherent to its retrospective design and relatively short follow-up. Complete functional scoring was not available for 5 of the 18 patients at latest follow-up, and they lacked documentation of their preoperative functional levels, which prevented comparison to their postoperative functional status.

CONCLUSIONS

Intraarticular distal femoral fractures in elderly patients are difficult to treat because of poor bone quality, preexisting joint disease, and multiple co-morbidities. Modular endoprosthetic distal femoral replacement is an option that allows immediate full weight-bearing and restores most patients to their preoperative functional status.

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