Primary Total Knee Arthroplasty for Distal Femur Fractures: A Systematic Review of Indications, Implants, Techniques, and Results

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Take-Home Points

- Arthroplasty is a rarely utilized and, therefore, a rarely reported treatment for distal femur fractures.
- Arthroplasty carries certain advantages over fixation, including earlier weight-bearing, a benefit for elderly individuals.
- Arthroplasty is more often described in situations of comminution, often necessitating constrained prostheses.
- It is not unreasonable to utilize arthroplasty in extra-articular fractures in poor-quality bone, which can take the form of unconstrained prosthesis and supplemental fixation.
- The true complication rate is unclear, given that the few papers reporting high complication rates were in sicker populations.

Distal femur fractures (DFFs) in the elderly historically were difficult to treat because of osteoporotic bone, comminution, and intra-articular involvement. DFFs in minimally ambulatory patients were once treated nonoperatively, with traction or immobilization, but surgery is now considered for displaced and unstable fractures, even in myelopathic and nonambulatory patients, to provide pain relief, ease mobility, and decrease the risks associated with prolonged bed rest. Options are constantly evolving, but poor knee function, malunion, nonunion, prolonged immobilization, implant failure, and high morbidity and mortality rates have been reported in several studies regardless of fixation method.

Arthritis after DFF has been reported at rates of 36% to 50% by long-term follow-up. However, total knee arthroplasty (TKA) for posttraumatic arthritis is more complex because of scarring, arthrofibrosis, malunion, nonunion, and the frequent need for hardware removal. These cases have a higher incidence of infection, aseptic loosening, stiffness, and skin necrosis. Primary TKA is a rarely used treatment for acute DFF. Several authors have recommended primary TKA for patients with intra-articular DFFs and preexisting osteoarthritis or rheumatoid arthritis, severe comminution, or poor bone stock. Compared with open reduction and internal fixation (ORIF), primary TKA may allow for earlier mobility and weight-bearing and thereby reduce the rates of complications (eg, respiratory failure, deep vein thrombosis, pulmonary embolism) associated with prolonged
immobilization. As the literature on TKA for acute DFF is scant, and to our knowledge there are no clear indications or guidelines, we performed a systematic review to determine whether TKA has been successful in relieving pain and restoring knee function. In this article, we discuss the indications, implant options, technical considerations, complications, and results (eg, range of motion [ROM], ambulatory status) associated with these procedures.

**Methods**

On December 1, 2015, we searched the major databases Medline, EMBASE (Excerpta Medica database), and the Cochrane Library for articles published since 1950. In our searches, we used the conjoint term *knee arthroplasty* with *femur fracture*, and *knee replacement* with *femur fracture*. Specifically, we queried: (“knee replacement” OR “knee arthroplasty”) AND (intercondylar OR supracondylar OR femoral OR femur) AND fracture) NOT arthrodesis NOT periprosthetic NOT “posttraumatic arthritis” NOT osteotomy. We also hand-searched the current website of JBJS (Journal of Bone and Joint Surgery) Case Connector, a major case-report repository that was launched in 2011 but is not currently indexed by Medline.

All citations were imported to RefWorks for management and for removal of duplicates. Each article underwent screening and review by Dr. Chen and Dr. Li. Articles were included if titles were relevant to arthroplasty as treatment for acute (within 1 month) DFF. Articles and cases were excluded if they were reviews, published in languages other than English, animal studies, studies regarding nonacute (>3 months or nonunion) DFFs or periprosthetic fractures, or studies that considered only treatments other than TKA (ie, plate osteosynthesis).

Full-text publications were obtained and independently reviewed by Dr. Chen and Dr. Li for relevance and satisfaction of inclusion criteria. Disagreements were resolved by discussion. Given the rarity of publications on the treatment, all study designs from level I to level IV were included.

The same 2 reviewers extracted the data into prearranged summary tables. Data included study size, patient demographics, AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) fracture type either reported or assessed by description and imaging (33A, extra-articular; 33B, partial articular with 1 intact condyle; 33C, complete articular with both condyles involved), baseline comorbidity, implant used and fracture treatment (if separate from arthroplasty), postoperative regimen, respective outcomes, and complication rates.

**Results**

We identified 728 articles: 389 through Medline, 294 through EMBASE, and 45 through the Cochrane Library (Figure 1).
After duplicates were removed, 476 articles remained. After titles and abstracts were reviewed, 22 articles met the screening criteria. Five series included patients with TKA-treated acute DFF but did not report their specific outcomes (these were described separately).

The current evidence regarding primary TKA for acute DFF is primarily level IV (Table 1). Only 1 level III study\textsuperscript{16} compared TKA with ORIF. Three case series\textsuperscript{11,19,24} met our inclusion criteria (Table 1, Table 2). In addition, 5 case series involved patients who met our criteria, but these studies did not separately report results for DFFs and proximal tibia fractures,\textsuperscript{9,20-22} or separately for acute fractures and nonunions or ORIF failures.\textsuperscript{8}
These studies were considered level IV and were tabulated separately (Table 3). Specific patient characteristics and management strategies varied significantly between studies, though many studies augmented 33A fractures with internal fixation, whereas 33C fractures more often underwent resection and placement of highly constrained implants. Of 117 acute DFFs reviewed, 20% were 33A fractures, 7% were 33B fractures, and 73% were 33C fractures (Table 1). Of the studies that specified, there were 8 cases of rheumatoid arthritis and 18 cases of osteoarthritis (Table 2).

Modular, hinged, and tumor-type arthroplasty designs accounted for 83% of the treatments included in this review. Trade names are listed in Table 4. Authors who used these implants took a more aggressive approach, often resecting the entire femoral epiphyseal-metaphyseal area, menisci, and collateral ligaments. The majority of patients who underwent resection had 33C fractures (Tables 1, 3).
Figures 2A-2D show an aggressive resection example. Authors who used less constrained arthroplasty designs focused on bone preservation, augmentation with graft, and internal fixation. In and colleagues thought that if the cruciate and collateral ligaments are found to be intact, then resecting these ligaments and performing the deep cuts necessary for linked prostheses are too aggressive. Their internal fixation methods included use of cannulated screws, Dall-Miles cabling (Stryker), and plate osteosynthesis. Choi and colleagues took a similar approach but also used stem extensions in 6 of 8 fractures assessed to be unstable (Figures 3A-3H).

Yoshino and colleagues used posterior-stabilized implants with femoral stem extensions (Figures 4A-4C).

Intraoperative use of an external fixator to align and stabilize a comminuted fracture before insertion of an intramedullary guide and during femoral cutting has also been described. All 33B and many 33A fractures were treated in this fashion.

The majority of authors who treated fractures with resection and modular implants allowed their patients full weight-bearing soon after surgery (Table 1), whereas authors who treated their patients partly with fracture fixation often had to delay weight-bearing (Table 1).
Overall, results were encouraging, with most studies finding between 90° and 135° of flexion to near full extension after each type of treatment. At follow-up, most survivors achieved full weight-bearing and were capable of walking up and down stairs.

Cement use was universally described in the literature. Some authors avoided placing cement in the fracture site (to reduce the risk of nonunion), whereas others used bone cement to fill metaphyseal defects that remained after fracture resection and implantation. Complication rates were modest, and there were no reports specifically on implant loosening or fracture nonunion. The majority of complications were recorded in 2 studies that used megaprostheses in sicker populations: Bell and colleagues noted debilitating illnesses in all their patients, and Appleton and colleagues included 9 nonambulatory patients and 36 patients who required 2 assistants to ambulate. All deaths were attributed to medical comorbidities and disseminated malignancy. Contrarily, studies by Pearse and colleagues and Choi and colleagues included previously ambulatory patients and reported no deaths or complications (Table 2). Likewise, in studies that combined results of DFFs and proximal tibia fractures, death and complication rates varied from 7% to 31% (Table 3).

**Discussion**

DFFs in the elderly historically were difficult to treat. Reported outcomes are largely favorable, but, even with newer plate designs, catastrophic failures still occur in the absence of bony union. After ORIF, patients’ weight-bearing is often restricted for 12 weeks or longer—a protocol that is undesirable in elderly patients, especially given that the rate of mortality 1 year after these fractures has been found to be as high as 25%.

Arthroplasty for DFFs—performed either with ORIF, or independently with a constrained implant—is a documented treatment modality, but the evidence is poor, and results have been mixed. Patients who received hinged TKA with major fracture resection had higher complication rates. However, the problems were mostly medical, not associated with surgical technique. Appleton and colleagues found a higher than expected 1-year mortality rate, 41%, but used an unhealthy baseline population (44% cognitive impairment, 17% nonambulatory before injury). Although Boureau and colleagues found a 1-year mortality rate of 30%, only 1 in 10 deaths was attributable to a perioperative complication. Among the remaining cases involving resection and megaprostheses for previously ambulatory patients, only 1 perioperative death was recorded (Table 2). Therefore, the risks associated with patients’ baseline health and ambulatory status must be weighed against the benefits of aggressive arthroplasty.

An overwhelming majority of 33C fractures were treated with megaprostheses—a finding perhaps attributable to the higher likelihood that patients with osteoporosis have intra-articular, comminuted injuries. In addition, surgeons may have been more likely to indicate 33C fractures for joint replacement, whereas 33A and 33B patterns were more amenable to fracture fixation. Interestingly, few type B fractures (0 in primary analysis and only 9 of 67 cases in Table 3) were treated with megaprostheses. In these situations, 1 condyle and ligamentous constraint remain intact, reducing the need for a constrained implant.
There were no reports of atraumatic or aseptic loosening, though use of rotating platforms with linked prostheses helps minimize this complication. Also surprising is the lack of nonunions in any of the reviewed studies, as nonunion is one of the most devastating complications of ORIF. Only 1 superficial and 2 deep infections were reported in all of the literature—representing 1.8\% of all cases, which is comparable to the rate for elective primary TKA.\textsuperscript{30} In elderly patients with significant comorbidities, the main surgical goals are to minimize operative time and reduce time to mobility. It is therefore imperative to keep in mind that arthroplasty is elective. However, functional results of primary TKA for DFF may be more encouraging for healthier patients, as many can achieve satisfactory ROM and early weight-bearing. Therefore, TKA for DFF may benefit healthy and ambulatory patients in the setting of intra-articular comminution. Whether this treatment affects mortality rates remains to be seen.

There were several limitations to this study. First, the literature on the topic is scant. Second, exclusion criteria were kept lax to allow for inclusion of all treatments. This came at a cost to internal validity, given the heterogeneous population and differences in comorbidities between studies. Fracture classification was inconsistent as well: Although AO/OTA classification was dominant, descriptive classifications were used in several cases\textsuperscript{7,10,12} (these descriptions, however, were sufficient for assigning equivalent AO/OTA classes). Details on preoperative functional status and comorbidity status and on postoperative protocols were also limited, though ROM and ambulatory status were provided in most studies. Last, most of these studies were single case reports or case series, so there may be reporting bias in the body of the literature, as reflected in the discrepancies between encouraging case reports and concerning case series with longer follow-up. Such bias can be avoided with larger, controlled sampling and adequate follow-up.

TKA should be considered for acute DFF in patients who have knee arthritis and are able to tolerate the physiological load of the surgery. In the choice of implant design, several factors should be considered, including bone quality, articular involvement, degree of comminution, and ligamentous injury. Unconstrained knee designs should be considered in cases in which the fracture pattern appears stable and the collateral ligaments are intact (eg, 33A and 33BB fractures). Megaprostheses, which may allow for immediate weight-bearing but require considerable bone resection, would be beneficial in 33C fractures and in fractures with ligamentous compromise. However, their complication rates are unclear, and comparative studies are needed to investigate whether the rates are higher for these patients than for patients treated more traditionally.

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