CLINICAL ARTICLE

Challenge of Managing Distal Femur Fractures with Long-stemmed Total Knee Implants

Nabil A Ebraheim, MD, Trevor Carroll, MS, Bridget Bonaventura, MS, Muhammad Z Moral, MD, Youssef G Jabaly, BS, Jiayong Liu, MD

Department of Orthopaedic Surgery, University of Toledo Medical Center, Toledo, Ohio, USA

Objective: Treatment of distal femur fractures by long-stemmed total knee arthroplasty (TKA) is challenging, because of poor bone stock, decreased blood supply, history of multiple knee surgeries and an absence of standard treatment. Few published studies are available concerning this. The purpose of this study was to share surgical technique and better describe our patients' comorbidities, which add to the challenge of managing individuals with these fractures.

Methods: Between August 2008 and September 2013, seven patients presented to our level I trauma center with distal femoral fractures associated with long-stemmed TKA implants. Their average age was 68.71 years (range, 52–81 years). The most common mechanism of injury was fall (five patients), followed by a traumatic fracture of the femur while walking (one patient), and being lifted out of bed (the one nonambulatory patient). This retrospective study reports a treatment protocol, including surgical technique, and short-term outcome in seven patients in whom locking compression plates (LCP) were used.

Results: Six fractures were classified as Rorabeck type II, and one as type III. The average time to full-weight-bearing was 5.5 months. At this institution, good short-term results have been achieved by using an LCP with screws placed proximal to the long-stem and distal to the fracture. The six patients all achieved full-weight-bearing, taking an average of 5.5 months (range, 3–7 months).

Conclusions: LCP is an effective form of management of distal femur fractures around long stem TKAs. An individualized operative approach possibly incorporating bone-graft substitutes, cerclage wire and a post-operative bone stimulator is recommended.

Key words: Femur fracture; Locking compression plate; Total knee arthroplasty

Introduction

Rates of total knee arthroplasty (TKA) have increased as individuals maintain high activity levels and the general population ages. The increased use of primary TKA coupled, with individuals with TKAs living long, active lives, has increased the incidence of wear and failure of implants. Such wear and failure is typically treated by revision surgery using long-stemmed TKAs. A rare complication in individuals with primary and revision TKAs is fracture about the implant. Periprosthetic fractures above the knee are infrequent, occurring in 0.3%–2.5% of individuals with primary TKA, but in up

to 30% after revision^{1–6}. Supracondylar femoral fracture is the most common primary and revision periprosthetic fracture, the incidence being 0.3%–2.5% and 1.6%–38%, respectively^{2–5}. These fractures are likely to occur more frequently as the population ages and more individuals require revision TKAs.

Most distal femur periprosthetic fractures are the direct result of low-energy trauma. Contributing risk factors include increasing age, female sex, osteopenia, osteoporosis, corticosteroids, myasthenia gravis, Parkinson disease and rheumatoid arthritis^{7–12}. Previous revision arthroplasty is also reportedly a risk factor^{11,13}. In addition, treatment of fractures

Address for correspondence Jiayong Liu, MD, Department of Orthopaedic Surgery, University of Toledo Medical Center, 3065 Arlington Avenue, Toledo, Ohio, USA 43614 Tel: 001-419-3835361; Fax: 001-419-3833526; Email: jiayong.liu@utoledo.edu

Disclosure: The authors have no conflicts of interest to disclose.

Received 13 May 2014; accepted 12 June 2014

associated with long-stemmed TKA is particularly challenging, because of poor bone stock, decreased blood supply, history of multiple knee surgeries and an absence of standard treatment.

Long-stemmed implants are often excluded from studies of periprosthetic fractures or categorized generically with stemless TKAs¹⁴. There is therefore little specific data on treating and managing distal femur fractures with long-stemmed TKAs. Over the last five and a half years, seven patients with fractures associated with long-stem TKAs have been treated in this institution. The purpose of this study was to share surgical technique and better describe our patients' comorbidities, which add to the challenge of managing individuals with these fractures.

Clinical Cases

Between August 2008 and September 2013, seven patients presented to our level I trauma center with distal femoral fractures associated with long-stemmed TKA implants. Institutional review board approval was obtained for this retrospective review of the radiographs and medical records of these seven patients. Their average age was 68.71 years (range, 52–81 years). Six of the seven individuals were female and six of the seven were ambulatory at the time of fracture. The most common mechanism of injury was fall (five patients), followed by atraumatic fracture of the femur while walking (one patient), and being lifted out of bed (the one nonambulatory patient).

The seven patients had an average of 3.71 comorbidities (range, 2–5), the commonest being hypertension (five patients), type 2 diabetes mellitus (three patients) and dementia (three patients). The three patients with neurological disorders all died within less than three years of complications of Alzheimer's disease, multiple sclerosis with dementia symptoms and unspecified dementia; and not from causes related to their fractures. Two patients were morbidly obese with body mass index ≥ 40 . Two patients had rheumatoid arthritis. In addition, one patient had been nonambulatory for three years because of complications of multiple sclerosis; this patient was taking long-term low dose prednisone. The Rorabeck classification system was used¹⁵ (Fig. 1). Although the Su classification is increasingly accepted for periprosthetic knee fractures, their initial validation study excluded patients with stems¹⁶. The Rorabeck classification includes data about the fracture and the prosthesis and can be used to guide management. The key factors considered in this classification system are whether the fracture is displaced or undisplaced and whether the prosthesis is stable or unstable. Patients were followed until full-weight-bearing. Fracture data and relevant patient characteristics are summarized in Table 1.

Surgical Technique

In all cases, operations occurred within 48 h of admission. Most patients had significant comorbidities, and in these cases, general medicine and/or cardiology specialists were consulted for operative clearance. Longitudinal incisions were

Fig. 1 Lewis and Rorabeck classification of supracondylar periprosthetic fractures proximal to total knee arthroplasty. Type I: Undisplaced fracture-prosthesis intact; Type II: Displaced fracture-prosthesis intact; Type III: Displaced or undisplaced fracture-Prosthesis loose or failing.

made on the lateral aspect with sharp dissection down to the tensor fascia. Blunt dissection was then made down to the femur (Fig. 2). At this point reduction was performed manually or assisted with reduction clamps. Where oblique fractures extended distally from the proximal tip of the stem, cerclage wire was used to assist with maintaining the reduction. A distal femoral locking compression plate (LCP) that extended proximally along the femur at least two femur cortical diameters was then placed over the fracture. Correct placement was confirmed radiographically. Two locking screws were initially inserted into the distal femur, after which two bicortical screws were placed proximal to the stem and their positions confirmed radiographically. Next, at least four to six locking screws and cortical screws were placed distally and proximally, respectively. Additional screws were placed overlying the stem if further fixation was needed. Finally, the area was irrigated with saline. Where there was some gapping at the fracture site, a bone-graft substitute, INFUSE (Medtronic, Memphis, TN, USA) or PRO-DENSE (Wright Medical Technology, Arlington, TN, USA), was used.

Postoperatively, patients were non-weight-bearing, given deep vein thrombosis prophylaxis, and sent for rehabilitation. Bony union was defined clinically as full-weight bearing by six months. Delayed union was defined as healing taking longer than 6 months. A bone stimulator was introduced in cases with delayed bone healing three months postoperatively.

TABLE 1 Relevant clinical characteristics

Sex	Age (years)	Side	Event	Comorbidities	Rorabeck classification	Plate	Cable	Bone-graft substitute	Discharge	Full-weight-bearing (months)
F*	79	Right	Fall	D, HTN, DM, OPO, PR	II	Periarticular LCP, Zimmer	No	Prodense	Rehab	7†
F	68	Left	Lifted from bed	D, HTN, MO, NA, PR	II	Periarticular LCP, Zimmer	No	None	Rehab	Lost to follow-up after 3
M	81	Right	Fall	D, HTN, OA, PR	III	Periarticular LCP, Zimmer	No	None	Rehab	7
F	52	Left	Fall	RA, PR	II	Periprosthetic LCP, Zimmer	Yes	None	Rehab	5
F	68	Left	Fall	HTN, DM, PR	II	Periarticular LCP, Zimmer	No	Infuse	Rehab	6
F	64	Right	Atraumatic, walking	HTN, DM, MO, CS, PR	II	Supracondylar femur plate, Medacta	No	Infuse	Rehab	5
F	69	Left	Fall	RA, PR	II	Supracondylar LCP, Synthes	No	None	Rehab	3

D, dementia; DM, diabetes mellitus; F, female; HTN, hypertension; LTS, long-term steroid; M, male; MO, morbid obesity; NA, nonambulatory; OA, osteoarthritis; OPO, osteoporosis; PR, previous revision; RA, rheumatoid arthritis.

*patient had ipsilateral THA; †second fracture one month postoperatively, at proximal tip of LCP, while being helped to go to the restroom.

Fig. 2 Surgical incision.

Results

Six fractures were classified as Rorabeck type II, and one as type III¹⁵. All patients achieved full-weight-bearing, except one (a previously nonambulatory patient), who was lost to follow-up after three months. The average follow-up for the remaining six patients was 8.66 months (range, 5–11 months). One patient with an ipsilateral total hip arthroplasty and a body mass index of 40 had a second fracture one month post-operatively at the proximal tip of the LCP while being moved in her skilled nursing facility. This repair consisted of open reduction with internal fixation using a longer LCP spanning both prostheses.

All six surgical wounds healed without complication. The six patients all achieved full-weight-bearing, taking an average of 5.5 months (range, 3–7 months) (Figs 3–5). Two patients had delayed healing, both achieved full-weight bearing at 7 months.

Discussion

Any fracture of the distal femur is inherently challenging because of the poor blood supply. Compared with the proximal and central femoral areas, there is limited muscle surrounding the distal femur, decreasing blood flow to the periosteum. The nutrient artery of the femur, which supplies much of the proximal and central areas, is not as prominent in the distal femur. This paucity of blood supply to the distal femur decreases the rate of bone healing and increases time to full-weight-bearing.

Long-stemmed TKAs complicate management of distal femur fractures for a variety of reasons. First, fracture repair is technically challenging. It is difficult to maintain the femoral length, because there tends to be less bone stock available as a result of multiple knee revisions. Femoral shortening is also problematic with comminuted fractures: it is challenging to maintain satisfactory reduction and some femoral shortening is usually unavoidable. In this study, we used bone-graft substitutes to ameliorate the consequences of bone loss. Multiple operative solutions have been proposed for fractures associated with long-stem TKAs, including modified intramedullary nails, external locking plates, less invasive stabilization system locking plates and LCPs. Mody *et al.* elected to use a custom-made hollow intramedullary nail in the shape of a cap and extended circumferentially over the long-stem implant¹⁷. They

Fig. 3 A 52-year-old woman with rheumatoid arthritis and a long-stemmed TKA fell. (A) Antero-posterior and (B) lateral radiographs of distal femur fractures. (C) Antero-posterior and (D) lateral radiographs taken on postoperative day one showing LCP and cerclage wire. (E) antero-posterior and (F) lateral radiographs taken 11 months postoperatively.

found radiographic evidence of postoperative callus formation and healing at six weeks and thirty-two months in two cases. Tanaka *et al.* managed a fracture associated with a long-stemmed TKA by custom-cutting the proximal end of a 16 mm diameter intramedullary nail to connect with the stem of the femoral component¹⁸. It was then secured with a locking screw at the distal end and reinforced with autogenous iliac graft. The patient achieved partial weight-bearing after six weeks and full weight-bearing at one and one-half years. Although rarely used, Biswas *et al.* reported implementing an external locking plate successfully in a case series of five patients with femoral shaft fracture post Stanmore TKAs¹⁹. All five patients (age, 78–86) had solid union by 16 weeks postoperatively without

any major complications. However, infection of the pin sites, and potentially the knee, are a major complication of this approach^{6,20,21}. The most commonly accepted approach to treating fractures around stemless TKAs is LCPs; however, it is unclear if this method is useful for fractures associated with long-stemmed TKAs. Fulkerson *et al.* treated 18 patients with supracondylar periprosthetic femoral fractures with Less Invasive Stabilization System locking plates (Synthes, Paoli, PA, USA)¹⁴. For cases with fixed femoral stems, unicortical locking screws were placed into the cement mantle. Uncemented stems were not used. All individuals had stable fractures and underwent closed reduction. Specific results regarding fractures with long-stems were not presented.

Fig. 4 An 81-year-old man with a long-stemmed TKA fell. (A) Antero-posterior and (B) lateral radiographs of distal femur fractures. (C) Antero-posterior and (D) lateral radiographs taken on postoperative day one showing LCP. (E) Antero-posterior and (F) lateral radiographs taken nine months postoperatively showing broken screw.

Fig. 5 A 64-year-old woman with a long-stemmed TKA fractured her distal femur after falling. (A) Antero-posterior and (B) lateral radiographs of distal femur fractures. (C) Antero-posterior and (D) lateral radiographs taken on postoperative day one showing LCP. (E) Antero-posterior and (F) lateral radiographs taken five months postoperatively when she was full-weight-bearing.

Inserting LCPs is difficult with long-stem implants, because the stem interferes with bicortical screw placement. To secure the locking plate, Ehlinger *et al.* has suggested attempting to place bicortical screws posteriorly to the implant or, if this not possible, using monocortical screws²². To circumvent this problem, in this study we used locking plates, which are long enough to place four to six bicortical screws proximal to the long-stem implant and four to six locking screws distal to the fracture. This method of screw placement was likely sufficient in these six patients: none of them experienced hardware failure in this short-term study.

The second challenge is impaired blood supply, which contributes to the increased time until full-weight-bearing. In the process of inserting a long-stemmed implant, the medullary cavity's vasculature is compromised, further decreasing the distal femur's ability to repair bone. In addition, patients with previous multiple knee surgeries have increased local scar tissue that decreases blood perfusion. In this study, we used LCPs to reduce periosteal blood supply damage. Even with the aforementioned risk factors for compromised blood supply, four of the six patients had achieved full weight-bearing by six months and the other two were full-weight-bearing by seven months.

The third challenge is comorbidities, which contribute both directly and indirectly to postoperative delay in bone healing. Factors directly contributing to poor healing are

increased age, type 2 diabetes and hypertension. An indirect factor in patients with dementia is difficulty tracking improvements during rehabilitation, because they were poor historians. This includes patients not communicating current pain levels. Fortunately, there were no surgical wound complications in this current study and time to full-weight-bearing was an average of 5.5 months in the six patients who achieved ambulation. At this institution, in addition to ensuring appropriate medical management, if healing was poor at three months, a bone stimulator was introduced, with good results.

The primary limitations of this study are its relatively small sample size and that it is a retrospective analysis. The study also has no controls. Because the seven patients were drawn from the institution's directory of operative reports, the study includes no patients who were treated non-operatively. Because non-operative techniques involving a femoral stem have complication rates of 48%–70%, this approach is currently not advocated unless a patient's comorbidities preclude surgery²³. Future larger, randomized, prospective studies are needed.

In conclusion, LCPs could be effective in managing distal femur fractures associated with long stem TKAs. We have found an individualized operative approach that can include use of bone-graft substitutes, cerclage wire and a postoperative bone stimulator useful in these challenging situations.

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