Locked compression plate for the treatment of periprosthetic femoral fractures above a total knee arthroplasty

Abd El-Bary H. Gouda

Department of Orthopedic Surgery, Faculty of Medicine, Benha University, Benha, Egypt

Correspondence to Abd El-Bary H. Gouda, MD, Department of Orthopedic Surgery, Faculty of Medicine, Benha University, Benha, Egypt
Tel: 00201006157161;
E-mails: goudaabdelbary@hotmail.com; abdelbaryg@yahoo.co.uk

Received 22 November 2012
Accepted 02 January 2013

Egyptian Orthopedic Journal 2015, 50:1–7

Background

The incidence of periprosthetic femoral fractures above a total knee arthroplasty (TKA) is continuously increasing because of an increasing number of knee joint replacements and an enhanced survivorship of the elderly population after knee arthroplasty. Locked compression plate (LCP) devices designed for the distal femur offer advantages for the treatment of such fractures. LCPs can be inserted with relative ease, provide a fixed-angle construct and improve the fixation in osteoporotic bones.

Patients and methods

During the period between January 2008 and March 2011, 12 displaced distal femoral periprosthetic fractures above a well-fixed nonstemmed TKA in 12 patients were treated by a lateral LCP. The mean age of the patients at the time of surgery was 62 years (range 58–68 years), comprising 10 women and two men. One patient did not complete the follow-up and was excluded from the analysis. Hence, 11 fractures were available for a minimum follow-up of 6 months or until fracture healing.

Results

Radiographical union was obtained in 10 (91%) out of 11 patients. Nonunion occurred in one (9%) case. The mean consolidation time was 14 weeks (range 12–16 weeks). No axial deviation over 10° was noted. There were no mechanical complications due to failure of the implant. No general, decubitus, or infectious complications were noted. Functional recovery was satisfactory.

Conclusion

Osteosynthesis with LCP is effective in the treatment of periprosthetic, distal femoral fractures above a TKA without component loosening. It is beneficial for the management of these challenging fractures with a high rate of fracture healing.

Keywords:

distal femoral fracture, locked compression plating, periprosthetic

Egypt Orthop J 50:1–7

1110-1148

Introduction

Periprosthetic fractures after total knee arthroplasty (TKA) occur as a result of low-energy trauma, usually compounding some surgical pitfalls and patient-related factors [1,2].

Patient-related and technique-related predisposing factors include osteoporosis, osteopenia, osteolysis, malalignment, anterior femoral notching, poor flexion (stiff knee), corticosteroid use, and rheumatoid arthritis [1,3–5]. The reported periprosthetic fracture incidence ranges from 0.3 to 2.5% [1,6].

However, unfortunately, an increase in the periprosthetic fracture incidence would be inevitable due to the increased life expectancy and osteoporotic patient numbers [5,7,8] as well as an increasing number of knee joint replacements [9]. A wide variety of treatments have been described in the literature, from closed nonoperative treatment and external fixators to open/closed reduction-internal fixation with different implants such as compression plates, blade plates, locking plates, and flexible or rigid intramedullary devices [8]. Locked compression plate (LCP) fixators improved the stability of plate osteosynthesis significantly in the treatment of these fractures [10,11]. These devices provide stable fixation in the osteopenic bone, are adaptable to different types of fractures and prostheses and can be inserted using a minimally invasive approach [12,13].

The aim of this study was to evaluate the treatment of distal femoral periprosthetic factures above a TKA with LCP fixation.

Patients and methods

During the period between January 2008 and March 2011, 12 distal femoral periprosthetic fractures above a TKA in 12 patients were treated by a lateral LCP in Benha University Hospital. The mean age of the patients at the time of surgery was 62 years (range 58–68 years), comprising 10 women and two men. The inclusion criteria were isolated, closed, and displaced distal femoral periprosthetic fractures above a TKA secondary to low-energy trauma. All the implants were cemented, nonstemmed, and stable. There was no hip arthroplasty on the same side. All the included fractures were type II (displaced fractures with a stable prosthesis) according to the Rorabeck and Taylor classification, 1999 [14] (Fig. 1). The exclusion criteria were open fractures and type I and type III fractures (undisplaced distal femoral periprosthetic fractures and fractures that were associated with loosening of the prosthesis requiring revision arthroplasty, respectively). Approval have been taken verbally from the patients.

Preoperative assessment

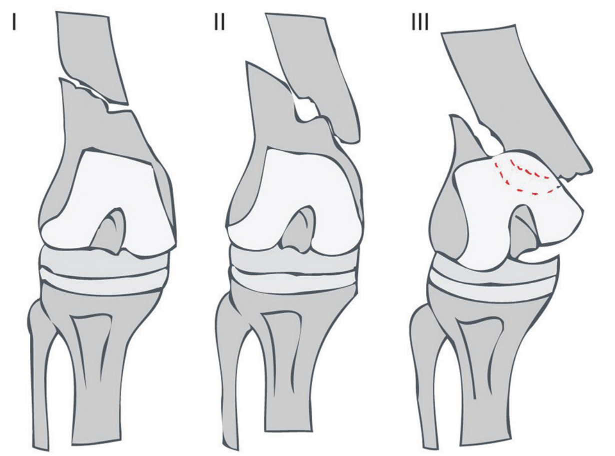
The preoperative clinical evaluation involved questions related to general factors that included smoking, the peripheral vascular and neurological status, the nutritional status, comorbidities such as diabetes, alignment of the injured leg, the preinjury range of motion of the knee, the knee extensor mechanism, signs of loosening of the prosthesis (weight-dependent pain, knee instability, reduced walking distance), infection, and the activity level [15,16].

Radiographic assessment included anterior posterior, lateral, and sometimes oblique radiographs of the knee and the femur and former radiographs if available [15,16]. Specifically, the lateral radiograph is used to assess the following:

(a) The integrity of the femoral component–bone interface to assess potential loosening;
(b) The bone block attached to the femoral component; and
(c) The position of the cement mantle and flange for the femoral component [17].

Classification: All the fractures were classified according to the Rorabeck and Taylor classification (1999) [14] (Fig. 1).

Figure 1



The classification system of supracondylar femoral fractures above a total knee arthroplasty created by Rorabeck and Taylor, 1999 [14]. Type I: undisplaced fracture and prosthesis is well fixed. Type II: displaced fracture and prosthesis is well fixed. Type III: prosthesis is loose, fracture may be displaced or undisplaced.

Surgical procedures

Implants consisted of an anatomical distal femoral LCP. It has a combined plate hole, which allows for the use of conventional bone screws or locked screws.

All the operative procedures were performed on a classic table with the patient in the supine position.

The lateral approach to the distal femur was used in all the cases to apply the LCP.

We used the concept of biological internal fixation, which entails preserving the biologic reactivity of the tissue as much as possible. This process includes careful tissue dissection, epiperiosteal bone dissection, and indirect reduction of the fracture to avoid the stripping and devascularization of bone fragments. Indirect reduction of fractures without disturbance of the soft tissue envelope around the fracture and reduced blood loss. Reduction was always attempted using external manoeuvres under fluoroscopic control: traction, valgus/varus (by an assistant) and cushion under the distal fragment if the fracture was distally situated to counteract recurvatum due to the influence of the gastrocnemius muscles or hamstrings. The aim was to obtain a global reduction of the segment and reconstruct the anatomical axis. For osteosynthesis with LCP, we followed specific mechanical guidelines [13,18–22]. The goal of osteosynthesis was to obtain a long construct with at least five holes beyond the fracture on the proximal femur, and the screws were applied bicortical as often as possible with maximal fixation in the distal fragment (Figs 2–4) and as alternating locked screws with free holes (in some of the cases) (Fig. 4). We limited the gap between the plate and the bone (Figs 2–4) to have a stiffer, more homogenous assembly, and placed the plate properly on the lateral femoral condyle [23]. We used the combination of both the internal fixator mode and the compression mode (hybrid fixation) to allow for ideal plate anchorage that is adapted to the bone [24].

Three fractures were supplemented with nonstructural allograft (bone substitute).

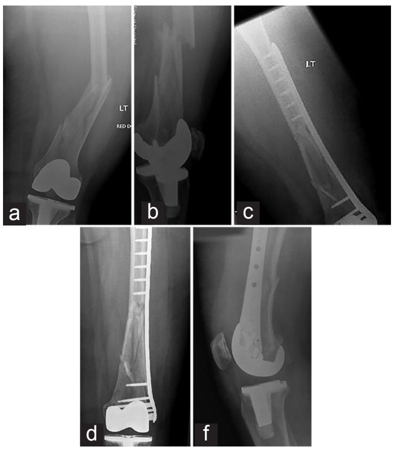
Postoperative management

Active physiotherapy (such as quadriceps and hamstring strengthening) was helpful in maximizing

Figure 2

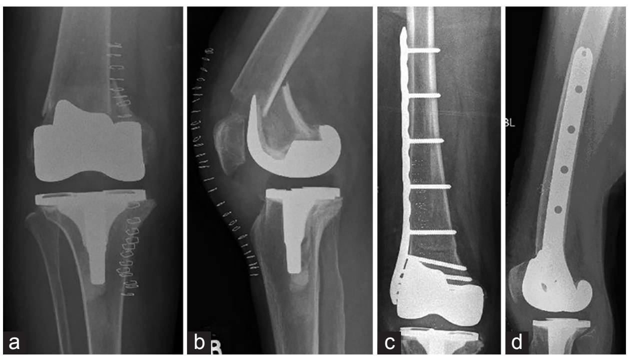
(a–c) Anteroposterior, lateral, and oblique preoperative radiographic views of the left knee of a 60-year-old women showing a type II distal femoral periprosthetic fracture above a stable total knee arthroplasty (TKA). (d) 12 weeks' postoperative radiograph: consolidation was obtained (anteroposterior). (e, f) 24 weeks' postoperative radiographs (anteroposterior and lateral views, respectively).

Figure 3



A left distal femoral periprosthetic fracture (type II) on a total knee arthroplasty (TKA) in a 63-year-old woman. (a, b) Preoperative anteroposterior and lateral views. (c, d) (anteroposterior views) and (e) (lateral view) showing consolidation that was obtained at 18 weeks postoperatively.

Figure 4



A right distal femoral periprosthetic fracture (type II) on a total knee arthroplasty (TKA) in a 59-year-old man. (a, b) Preoperative anteroposterior and lateral views. (c, d) (anteroposterior and lateral view) showing consolidation that was obtained at 14 weeks postoperatively.

the functional recovery and was initiated on day 2 after the removal of the drains. Patients were allowed toe-touching, partial weight-bearing (for 6–8 weeks or until fracture healing was visible radiographically), or full weight-bearing. The quality of the bone, the stability of the constructs, and the patient's preoperative mobility were important criteria in the decision of how much weight-bearing to allow.

Follow-up

For elderly patients, after fixation of the fractures, the most suitable criterion for clinical evaluation was the functional recovery rather than the range of motion of the TKA.

Radiographic evaluation consisted of assessing the first occurrence of fracture consolidation, defined as the appearance of a bony callus on at least two cortices (Figs 2–4). Furthermore, anatomical axes were assessed to detect any malunion. Thus, the anatomical axis of the proximal fragment was compared with the anatomical axis of the distal fragment. Any deviation of more than 10° in an anteroposterior or a strictly lateral standard radiograph was considered to be pathological. Rotation was evaluated clinically on a horizontal level [13,21,22].

We compared the immediate postoperative roentgenogram with those obtained at the latest follow-up.

Results

About 12 distal femoral periprosthetic fractures above the TKA in 12 patients were treated with lateral LCP. All the fractures were closed, type II (Rorabeck and Taylor classification) [14] and caused by a low-energy mechanism. The mean age of the patients was 62 years (range 58–68 years), comprising 10 women and two men. Eleven patients were available and underwent radioclinical evaluation during follow-up visits. One patient did not complete the follow-up until facture healing. The minimum follow-up period was 6 months or until fracture healing.

The procedure was performed on a standard table in all the cases using the lateral approach. Immediate full weight-bearing was allowed in three patients, partial weight-bearing was advised in five patients, and no weight-bearing was allowed for 6 weeks in four fracture cases. The functional recovery was satisfactory to the patients.

Radiographical union was obtained in 10 (91%) out of 11 patients who completed the follow-up. Nonunion occurred in one (9%) case. The mean consolidation time was 14 weeks (range 12–16 weeks). No axial deviation over 10° was noted.

Complications

There were no general, decubitus, or infectious complication in this study. There were no mechanical complications due to the failure of the implant. No modification of the implant's stability was found at the latest follow-up.

Discussion

Distal femoral fractures after TKA are an uncommon, but highly challenging injury [11]. Its management can be complex and requires the equipment, perioperative support, and surgical skills of both trauma and revision arthroplasty services [25].

The goals of treatment, whether surgical or nonsurgical, are fracture healing, restoration, and maintenance of the knee range of motion, pain-free function [26] and to obtain a global reduction with reconstruction of the anatomical axis [13,27]. The choice of treatment depends on the condition of the knee prosthesis (loose or well fixed), the fracture pattern, the quality of the bone stock, the presence of any other implant in the proximal femur, and the general physical condition of the patient. Management of periprosthetic fractures of the femur above a TKA is summarized in Table 1 [12].

Table 1 A summary of the management of a periprosthetic fracture of the femur above a total knee arthroplasty [12]

Fracture type	Description of fracture	Treatment recommendation
I	Undisplaced fracture and well-fixed prostheses	Bracing, non weightbearing
II	Displaced fracture and well-fixed prostheses	
	Good-quality bone	Internal fixation using conventional plate
	Poor quality bone with osteopenia and comminution	
	Decent-size distal fragment	Intramedullary nail or looking plate
	Extremely distal fracture	Locking plate or buttress plate with strut allograft
III	Displaced fracture, loose prostheses	
	No metaphysic pone loos	Revision knee arthroplasty using a long-stemmed femoral implant
	Metaphysical bone loss or nonunion following previous surgery	Structural allograft-prostheses composite or distal Femoral replacement prosthesis

With the exception of nondisplaced, stable fractures and patients who are unsuitable for surgery, surgical intervention is indicated to restore alignment, knee motion, and the implant stability [27]. Revision TKA with a long-stemmed prosthesis provides stable fixation and allows patients to start early movements and weight-bearing in cases of an extremely distal and comminuted fracture where secure fixation cannot be achieved [28–30], or if the fracture is associated with a loose and unstable implant [12,27]. Surgical options for fixation include flexible or rigid retrograde intramedullary devices, external fixators, fixed-angle devices (blade plates, dynamic condylar screws), condylar buttress plates, and, more recently, locking plates (internal fixators) [8]. Herrera and colleagues extracted data from 29 case series with a total of 415 fractures and concluded that modern-day treatment methods (retrograde intramedullary nailing and locked compression plating) are superior to conventional treatment options, including nonoperative treatment and conventional (nonlocking) plating methods (e.g. dynamic condylar screw, blade plate, and condylar buttress plate), in the treatment of distal femur fractures above a TKA [8].

Published data concerning retrograde nailing are controversial [13]. Some authors considered the current treatment of femoral periprosthetic fractures with the classic locked retrograde intramedullary nailing as the most successful technique, with a high fracture union rate and good range of knee motion with the lowest complication rates [1,8,31–33]. Despite these advantages, classic retrograde intramedullary nails are surpassed by locking plates in current practice because the applicability of this technique is confined to a limited number of periprosthetic femoral fractures. The main cause of this limitation is the small box size and the design of some currently available prostheses on the market, rendering the insertion of classic retrograde intramedullary nailing impossible. Also, in the coronal plane, the entry point of the femoral nail shifts far posterior, limiting the insertion of a larger-diameter femoral nail [1,7,33]. Posterior stabilized knee designs are not amenable to retrograde nailing. Other pitfalls with intramedullary devices are that they are limited with regard to distal purchase and fixation [8], the approach is articular, not all types of TKAs accept a nail and it might be difficult to be aware of the precise type of TKA, a very distally located fracture or a homolateral total hip arthroplasty [13]. Large *et al.* [34] concur with the superiority of the LCP compared with conventional treatments such as retrograde intramedullary nailing and nonlocking plates, with fewer complications of malunions or pseudarthroses.

Locking plates (internal fixators) have numerous advantages, including the ability to be placed through limited exposure, the ability to be applied submuscular, thus preserving the vascularity, and the advantages of a multiple fixed-angle construct [8]. They are well adapted to fractures on TKA [11,17,34–39], improve the stability of plate osteosynthesis significantly [10,11], permit good fixation in osteoporotic bones [7,27,40,41] and comminuted fractures [27], and can be used to fix extreme distal periprosthetic femoral fractures when the distal fragment is small with good results [11].

In the current study, for the osteosynthesis with LCP, we followed specific mechanical guidelines as much as possible: long assembly to obtain a long construct with at least five holes beyond the fracture on the proximal femur, and the screws applied bicortical with maximal fixation in the distal fragment, as well as alternating locked screws with free holes (in most of the cases). Recent studies have confirmed this type of assembly [13,18–22]. Interest in anatomical plates resides in the possibility of multiple anchoring by locked screws in the distal fragment with angular stability of the converging screws [13]. We also limited the gap between the plate and the bone and we placed the plate properly on the lateral femoral condyle. Ahmad *et al.* [23] underlined the importance of the position of the plate on the lateral view to avoid having the screws tangent to the cortex and compromise the fixation. To have a stiffer, more homogenous assembly, it is necessary to limit the gap between the plate and the bone. They concluded that a gap less than 2 mm allows maximal fixation in compression and torsion [23]. We used the combination of both the internal fixator mode and the compression mode. A recent study compared the three ways of using the plates in cases of distal femoral fractures [24]. The internal fixator mode has the best axial compression stiffness, but shows less plastic deformation. The compression mode better resists torsion. Therefore, the authors recommend using a combination of both techniques [24].

The results in the current study are satisfying, encouraging and comparable to other reports from the literature [8,10,11,13,17,34,35,37–39,42–44]. The union rate was excellent (91%). There were no mechanical complications due to the failure of the implant. No general, decubitus or infectious complications were noted in this study. The nonunion rate was 9% (in one case). Three fractures were supplemented with nonstructural allograft (bone substitute).

Series specifically reporting results of locked plating brought together 57 patients including five series: Kregor *et al.* [17], Althausen *et al.* [42], Wick *et al.* [35], Raab and Davis [43], Ricci *et al.* [37]. The nonunion rate was 5.3% (three cases), failure of fixation 3.5% (two cases), the deep infection rate 5.3% (three cases), and the revision rate 8.8% (five cases). These complication rates are clearly greater than ours. Kregor *et al.* [17] reported a 100% union rate in 13 periprosthetic fractures using locking plate; only one patient needed bone grafting. Zlowodzki *et al.* [44] reported only one failure with the LCP construct in 16 cases. Raab and Davis [43] reported their results of using locking plate in 11 fractures, which included two nonunions. Eight fractures were supplemented with nonstructural allograft. They achieved union in all nine acute fractures and in one case of nonunion with satisfactory alignment. Ricci *et al.* [37] reported their results of treating 22 periprosthetic fractures by indirect reduction methods without bone graft using a locking plate. Nineteen (86%) of 22 fractures healed within 12 weeks (range 8–12 weeks). All three patients who failed to heal were insulin-dependent diabetes mellitus patients. Fulkerson *et al.* [38] reported delayed union in two (11%) out of 18 fractures and nonunion in three (17%) fractures. Large *et al.* [34] reported that among 29 patients treated with locked plating, there were five malunions (20%) and no nonunions. Complication rates were 12%. In the Norrish *et al.* [39] series, 11 out of 12 patients who completed the follow-up showed radiographic union. Kolb *et al.* [10] reported only two (11%) fractures of delayed union in their series of 23 fractures. Fracture healing was achieved in an average of 14 weeks (range 9–21 weeks). In the Streubel *et al.* [11] series of 89 fractures, delayed healing and nonunion occurred, respectively, in five (18%) and three (11%) of more proximal fractures, and in two (6%) and five (15%) of the fractures with distal extension. Four (14%) construct failures occurred in more proximal fractures, and three (9%) in fractures with distal extension. Of the two deep infections that occurred in each group, one resolved after surgical debridement and antibiotics, and one progressed to a nonunion.

In the Ehlinger *et al.* [13] series, the consolidation rate was 93.8%, which was obtained within 10 weeks (range 8–12 weeks). There was only one case of nonunion (out of 16 fractures). There were no mechanical or infectious complications.

This study has several limitations. The number of cases was small. The follow-up duration was limited. Unfortunately, these limitations are inherent in an aged study population and considering the rarity of the pathology. However, there are many series in the literature with a comparable number of cases [13,17,38,39,44]. Also, there were limitations in the clinical evaluation and the functional recovery in comparison with the prefracture ones owing to the difficulty to obtain the prefracture clinical data.

Conclusion

The management of periprosthetic fractures of the femur above a TKA depends on the displacement at the fracture site, the bone quality, the size of the distal fragment, and the condition of implants. If the fracture is displaced and implants are well fixed, surgical fixation of the fracture is indicated. Periprosthetic femoral fractures above a total knee replacements without component loosening can be managed by a variety of methods. Locked compression plating technique is an effective and well-adapted method for the treatment of such fractures. It is more effective for osteoporotic bones, and it provides good fixation, stable satisfying reduction through time, and a high rate of fracture healing.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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