

REVIEW ARTICLE**Operative Treatment of Acute Distal Femur Fractures: Review of literature**

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Date Received: April, 2019

Date Accepted: May, 2019

Online Publication: August 15, 2019

Abstract

Fractures of the distal femur may be extra articular or have an intra articular component. Mismanagement of any of these fractures can result in abnormalities of alignment of the load-bearing axis of lower limb and/or rotational deformities. Essentially all supracondylar femur fractures require operative intervention because of the severe potential risks of prolonged bed rest. Yet, despite their proven track record and benefits over older implants, technical errors are common and must be overcome with proper preoperative planning and intra-operative attention to details. The goal of this study was to present an update on the management of these fractures.

Keywords: Distal femur, Fracture, Surgery

Introduction

Fractures of the distal femur are rare and usually severe. The estimated frequency of distal femoral fractures is 0.4% of all fractures and 3% of femoral fractures. The incidence rate is approximately 37 per 100,000 person-years (1). Typically, these fractures are caused by a high-energy injury mechanism in young men or a low-energy mechanism in elderly women. Managing these fractures can be a challenging task. Most surgeons agree that distal femur fractures need to be treated operatively to achieve optimal patient outcomes (2). Fractures of the distal femur may be extra-articular or have an intra-articular component. Mismanagement of any of these fractures can result in abnormalities of alignment of the load-bearing axis of lower limb and/or rotational deformities. These can have profound biomechanical consequences (3). In the past, supracondylar femur fractures were treated with skeletal traction. However, results were not satisfactory and complications such as angular deformity, knee stiffness, and delayed mobilization persisted after non-operative management. With advancements in orthopedic implant technology, current consensus among orthopedic surgeons is to treat supracondylar femur fractures surgically. Essentially all supracondylar femur fractures require operative intervention because of the severe potential risks of prolonged bed-rest.(4,5)Patients in whom surgery is contraindicated include patients who are bedridden or non-ambulatory with non-displaced or minimally displaced fractures in which a brace may provide acceptable stability and alignment is not an issue. (Patients with displaced unstable fractures in this group still may require surgery to improve nursing care, reduce pain, and prevent further soft-tissue injury by mobile bone fragments.) Patients with severe life-threatening or other medical problems in which the risks of anesthesia are high may also be treated non-operatively (2,6,7). The goal of this study was to present an update on the management of these fractures. Fractures of the distal part of the femur are difficult to treat and bring up considerable challenges in management. Pain, decreased range of motion and compromised function of the knee joint are common problems resulting from articular incongruity and improper fixation of articular fragments in

such fractures.(3,5,6) For early mobilization, recovery of the axis, length and rotation in the dia- and metaphyseal area and proper fixation of the condylar region are of major importance.(7) During the last decade, a series of new implants have been developed, in particular, locking plates and nailing systems.(1,8) Fractures of the femur are challenging to treat despite new fixation options. Currently, intra- medullary nails (both antegrade and retrograde) and the minimally invasive implantation of plates are the two main osteosynthesis strategies for surgical treatment of extra-articular distal femoral fractures. Nevertheless, the optimal choice of surgical treatment device for these fractures remains unclear (6,9,10). With the newest generation of poly-axial plates with angular stability, promising extramedullary fixation devices are now available for treatment of supracondylar femoral fractures. Locking plates have been developed along with a minimally invasive biologically friendly insertion technique which allows the plate to be placed without excessive soft tissue-stripping and with minimal disruption of the bone blood supply (3, 4). Intramedullary nails have many advantages similar to locking plates such as percutaneous placement without disruption of blood supply, indirect fracture reduction, success in osteoporotic bone and have been reported to result in high healing rates in fractures of the distal femur. Nevertheless, opening of the knee joint can be problematic.(11) Retrograde intramedullary nails allow minimally invasive fracture fixation due to their anatomic design and the surgical approach.(5,8) Antegrade interlocking nailing avoids the retrograde nailing complications such as stiffness and infection of the knee. As the canal at the metaphyseal-diaphyseal junction widens suddenly, the nail is modified in the form of multiple, multi-directional locking bolts at the distal end. This provides extra stability and enables early mobilization (12). The aim of this study is to systematically summarize and compare the results of different fixation techniques in the operative management of acute non-periprosthetic distal femur fractures (Orthopedic Trauma Association (AO/OTA) type 33A and C) and the characteristics of the fractures for each treatment (articular/ non-articular and open/closed). Supracondylar

fractures occur within the distal 9 cm of the femur. Fractures were classified according to the AO system (11). Where type A fractures are extra-articular and Type C are intra-articular fractures. Fracture types are numbered 1, 2, or 3 based on the degree of comminution: A1 being a simple, two part fracture of the metaphysis and A3 having severe comminution. Intra-articular fractures are similarly classified: C1 fractures are a simple T or Y split of the femoral condyles, C2 fractures have metaphyseal comminution, and C3 have comminution of the articular surface (2,3).

Operative management

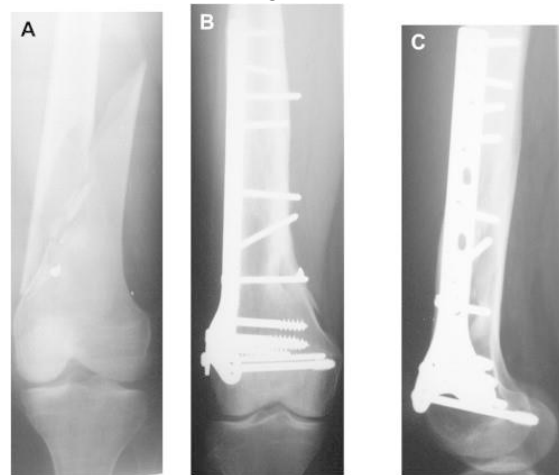
Developments in implants and improvements in surgical techniques have made surgical fixation the treatment of choice in most distal femoral fractures. Open reduction, in skilled hands, allows the articular surface accurately to be reconstructed. Other benefits include early ambulation and mobilization of joints, although protected weight-bearing is usually required until the fracture has united. The main disadvantage of operative intervention is the potential for additional damage to the local blood supply that may lead to non-union and infection. There has been a slow evolution of implants and techniques in attempts to minimize these problems (1,2,13).

Surgical options

Condylar buttress plate (CBP)

This plate was designed to be used when the fracture is too fragmented. It has an expanded distal end, contoured to the distal femur, which allows multiple lag screws to be passed across the condyles. The condylar buttress plate requires a more extensive surgical exposure to achieve proper placement and avoid varus or valgus malalignment, which leads to extensive soft-tissue trauma and higher rates of infection and pseudo-arthritis. The screws can toggle independently at the screw-plate interface and may lead to implant loosening. This device is no longer widely used because of these concerns and the development of locking plate devices (14). George Petsatodis et al. investigated Condylar

buttress plate versus fixed angle condylar blade plate versus dynamic condylar screw for supracondylar intra-articular distal femoral fractures. Authors resulted Outcomes in patients treated by the dynamic condylar screw were significantly superior to those treated by the condylar buttress plate ($p=0.016$) or fixed angle condylar blade plate. Complication rates were lower in the dynamic condylar screw group than other 2 groups (4,14). In Essoh J.B. study, it was indicated that the main drawback of the CBP, which is not a fixed-angle device, is varus deformity. Therefore this implant is not frequently used. The main finding of this study was the ensuing knee stiffness after a prolonged immobilization and delay in performing surgery and rehabilitation program due to socioeconomic and logistic reasons (15).



Locking compression plate (LCP)

The indications are extra-articular fractures, sagittal unicondylar fractures or supra and inter-condylar fractures. The goal of the locking plate is to provide better stability in fragile bone (12). Primary stability of the plate is independent of the friction effect as the screw presses the plate, and is obtained by locking the screw into the plate. Plate design is usually anatomical which allows it to be used as a “reduction mold”, molding the bone to the plate.

Its main disadvantage is lack of epiphyseal compression with locking screws, requiring prior placement of standard additional screws. The locking plate can be used during an open

procedure when there is intra-articular involvement, or with mini invasive surgery using the ancillary less invasive stabilization system (LISS) in case of an extra-articular fracture or in presence of a simple non-displaced fracture (13). Combination use is possible, with mini-invasive proximal diaphyseal fixation combined with open distal internal fixation. Mini invasive surgery reduces postoperative pain, and facilitates functional recovery (5,9,13).



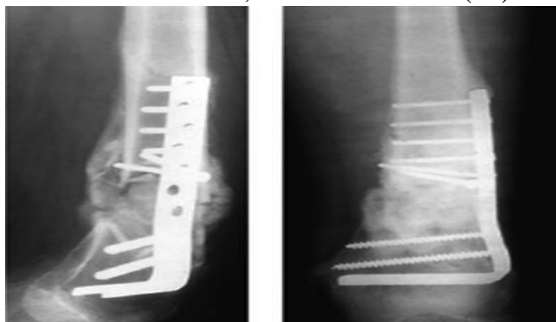
In a study by Shih-Hao Chen, they concluded that both retrograde intra-medullary (IM) nailing and locked plating might be adequate treatment options for distal femur fractures. There was no difference between implants regarding fracture healing, non-union and infection. But the LCP group had better outcome after 2 years of follow-up. IM nailing may provide favorable intra-medullary stability and stable callus, and may be successfully implanted in bilateral or segmental fractures of the lower extremity. Persistent knee pain and inability to use in type C fractures are the main limiting factors of retro-grade nailing. In type A fractures, LCP plating was associated with less morbidity than retrograde nailing in terms of persistent knee pain and better range of movement after 2 years of follow-up. Locked plating may be utilized for all distal femur fractures including complex type C fractures and osteoporotic fractures (16). Bottlang et al. propose using a standard screw at the end of the plate in case of a fracture in osteoporotic bone to limit strains and prevent a stress fracture. This type of system increases strength during bending without changing strength under compression or torsion (17). In retrospective studies of

AO/OTA Type 33-A and C1 distal femur fractures, Hierholzer et al. reported that 90% of fractures in both groups healed within 6 months and there was no significant difference between the two groups in terms of fracture healing (18). In prospective study of intra/extra-articular distal femur fractures, Mark Miller et al found no significant difference between the two groups in terms of infection, malalignment or nonunion (20). Marti et al compared less invasive stabilization system (LISS) using mono-cortical screws with angular stability and two conventional plate systems, CBP and dynamic condylar screw (DCS) for treatment of distal femoral fractures with respect to biomechanical properties. Their results suggested an enhanced ability to withstand high loads when using the mono-cortical screw fixation technique with angular stability like in LISS. They reported less irreversible deformation in LISS in comparison to DCS and CBP and explained their results saying that irreversible deformation of the construct comprised of two main contributions, the first of which is bone destruction (plastic deformation) in the anchoring region caused by excessive stress between bone and screw leading to irreversible sinking of the screws into the supporting bone (21). Hierholzer et al confirmed these results in a retrospective series of 115 fractures comparing retrograde nailing ($n = 59$) and mini-invasive locking plate ($n = 56$). Statistical results for rate of surgical revision and rate of malunion are better for retrograde intramedullary nailing. The rates of infection and nonunion were higher in the open internal fixation group (22,23). Kao et al. demonstrated in their clinical study that minimally invasive percutaneous plating with the DCS or the LISS provides good outcome with few complications in treatment of distal femoral fractures and LISS seems to have a lower risk of early implant loosening than the DCS (24).

95 Degree Angled blade plate (ABP)

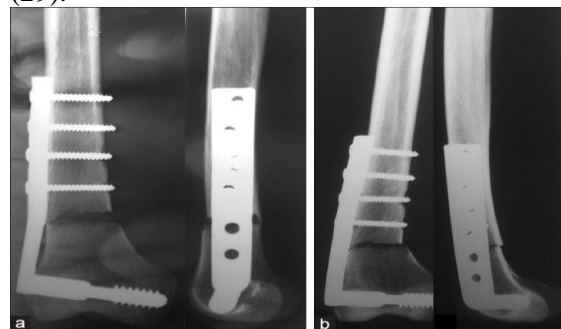
This implant was a major step forward in treatment of supracondylar fractures of femur. This one-piece device had great strength so rigid internal fixation became achievable. However, insertion of an angled blade plate is

technically demanding. The entry point and direction of insertion of the blade are critical. Once the seating chisel has prepared the blade insertion, it is impossible to adjust. Careless insertion risks damage to the lateral collateral ligament, articular surface, or cruciate ligaments and may create malalignment. Although technically difficult, this procedure can provide good results in skilled hands. The 95-degree-angled blade plate is also an effective reduction aid and fixation device for aseptic nonunions of the proximal and distal femur with acceptable healing rates in one surgery alone (25,26,27). In the study designed by Marco Antonio et al for comparing the 95° blade plates and dynamic condylar screws (DCS), there was no statistically significant difference in relation to load resistance under flexion and compression, or in relation to the type of failure, i.e. whether it occurred in the bone (fracture) or in the material (loosening or breakage of the implant) between blade plates and DCS. However, there was an indication ($p = 0.066$) that blade plates might present greater rigidity in flexion than seen with DCS (25). In Vallier H A study the 95-degree angled blade plate was compared to the locking condylar plate for treatment of distal femoral fractures. This study concluded in fractures that could be treated with either implant, patients treated with locking plates had more complications and nonunions, requiring more secondary procedures to treat complications and to remove prominent implants. Furthermore, locking plates are significantly more expensive than conventional fixed-angle devices. Further investigations are needed in form of a large randomized prospective study to clearly define clinical differences, functional outcomes, and costs of care (27).



Dynamic condylar screw (DCS)

Its two-piece configuration makes it more forgiving and less technically demanding than the angle blade plate (ABP), as the position of the plate can be determined after the lag screw has been inserted. Intercondylar fractures are fixed prior to insertion, using intercondylar lag screws, but compression can also be applied by the condylar lag screw. The condylar screw is less likely to split the condyles than the blade of an ABP, but a large volume of bone is reamed out to accommodate the lag screw. This may make the construct less rigid in those with poor bone quality (28,29). In Ashutosh Kumar et al. study which is about biomechanical comparison of dynamic condylar screw and locking compression plate fixation in unstable distal femoral fractures, distal femoral locking plate (DFLP) fixation of the distal femur fractures resulted in a stronger construct than the DCS fixation in both cyclic loading and ultimate strength in biomechanical testing of a simulated A3 distal femur fracture (29).



Intramedullary femoral nails

Antegrade femoral nailing has been used to stabilize supracondylar fractures. This method is most suitable for high extra-articular fractures, but some authors also recommend IM nailing for intra-articular fractures. Any intra-articular fracture is reconstructed with percutaneous lag screws prior to nail insertion. The advantages of this technique are that it is closed with conservation of hematoma and that the implant is extra-articular which is relatively easy to remove. The nail should descend as deeply as possible into the condyle for maximum stability (10). Although retrograde femoral nailing may also be used for supracondylar fractures, retrograde femoral nails have been used in selected cases,

predominantly for extra-articular fractures extending from the supracondylar area into the diaphysis, when a supracondylar nail would be too short to allow adequate fixation. Passing a nail near the fractured trochlea can deteriorate the situation by opening the fracture site. Thus, if there is an intra-articular fracture line, initial screw fixation is indicated. Retrograde nailing has the advantage of being a closed technique, but because it is intra-articular, there is a risk of septic arthritis in case of infection. The nail should be inserted deep enough to avoid any impingement of patella and should not be used as a lever to prevent creating an intercondylar fracture line (30,31). For nailing, patients were positioned supine with the injured extremity draped free. For the extra-articular fractures, an anterior, midline incision was made that extended from the inferior pole of the patella to the tibial plateau, similar to the approach for intramedullary nailing of the tibia. The patellar tendon was split centrally and retracted to provide access to the intercondylar notch. Using image intensification, either a sharp awl or a 0.25-inch drill was advanced into the notch, with the knee flexed 30° to 40°, just anterior to the femoral attachment of the posterior cruciate ligament. For Type C1 intra-articular fractures, a closed reduction and fixation of the condyles with percutaneous, cannulated lag screws placed anterior or posterior to the path of the intramedullary nail was attempted. If reduction of the articular surface was not anatomic, an open reduction through a formal medial parapatellar arthrotomy was performed. All Type C2 and C3 fractures were reduced open. Direct exposure of the intercondylar fracture allowed provisional fixation with Kirschner wires or inter-fragmentary screws. Once the condyles were reconstructed, a guide wire was advanced past the fracture site into the proximal shaft of the femur. Sequential reaming up to 1 to 2 mm greater than the selected nail was performed and a supracondylar nail that allowed at least 2 bicortical screws to gain purchase in the proximal shaft was placed over the guide wire. The distal tip of the nail was positioned deep to the cortical bone in the notch to prevent impingement on the tibial plateau or patella. The nail was attached to an insertion jig that allowed placement of the interlocking screws proximally and distally through lateral stab incisions. It was imperative to obtain at least 2

screws distally in the condyles to prevent rotation at the fracture site. Accurate measurement of the distal interlocking and lag screws was important to prevent impingement and pain resulting from prominent screws (22,30). Acharya et Rao [40] reported a prospective series in 28 patients treated with retrograde nailing with union in 93%, malunion in 14% and excellent or good functional results in 75% of cases. There was no difference between results for retro- and antegrade nailing (31). For Salem et al. results in length, torsion, alignment and function were comparable. The only reported difference was in hip range of motion which was more limited with antegrade intramedullary nailing, and knee range of motion which was more limited with retrograde nailing (32). Hartin et al. did not report any difference in functional recovery in a randomized comparison of the treatment of extra-articular fractures by retrograde intramedullary nailing and blade plate. The only element observed was more frequent pain in the knee in the retrograde nailing group, so that fixation material had to be removed in 25% of the cases (33). SPS Gill et al in their Comparative Outcome Study discussed the extra articular supracondylar femur fractures managed with locked distal femoral plate or supra condylar nailing. They concluded Nailing proved more cumbersome intraoperatively due to escalated operating time and blood loss and successive anterior knee pain necessitating implant removal but this detriment may be offset by an inclination towards earlier union. With Less Invasive Stabilization System (LISS), technical errors are more common and less forgiving and must be overcome with proper preoperative planning and intraoperative attention to details (34).



Conclusion:

The quality of the surgical technique is the primary factor, and the only guarantee of obtaining good radiological and clinical results in distal femoral fractures. The ultimate goal of the treatment of distal femoral fractures is to provide a stable construct that restores leg length and alignment while allowing early motion of the knee joint. The surgical technique must be rigorous and the biomechanical qualities of these implants must be understood to prevent the development of

major complications. Proper choice of implant must take into consideration not only the indications of the implants, but especially their limits, since the situations when complications are attributed to the implants might be, in fact, cases of miss-usage of a certain device.

Conflict of interest

Authors declare no conflict of interest.

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