



Plate and Screw Osteosynthesis of Distal Femur Fractures

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7.1 Indications for Plate and Screw Fixation of Distal Femur Fractures

Distal femur fractures make up <1% of all fractures and approximately 3–6% of femoral fractures [1]. Patients who sustain such fractures have a primarily unimodal distribution. A small number of patients are young individuals who sustain accidental high-energy trauma. However, the primary group is elderly patients, usually female with poor bone stock and multiple medical comorbidities following low-energy mechanisms of injury [2].

Following this injury, goals of treatment are threefold: (1) anatomic restoration of articular

surface; (2) functional restoration of the articular unit to shaft restoring length, alignment, and rotation; and (3) stable fixation to allow for early range of motion and mobilization [1, 3]. In the vast majority of patients, this means surgical intervention is indicated. Other treatment options may be indicated in nonoperative candidate patients, patients with non-displaced fractures, non-ambulatory patients, or patients with spinal cord injury. However, even in these patients, non-operative management has been shown to lead to increased risk of stiffness, decubitus ulcers, wound complications, pulmonary complications, deep vein thrombosis, and deconditioning as compared to operative management [1, 4, 5].

Open reduction with plate and screw fixation of distal femur fractures has been shown in many studies to come with a high risk of wound and healing complications; this led to the introduction and subsequent popularity of the retrograde femoral nail [6–9]. However, more recent advancements in locked plating technologies with minimally invasive or less invasive surgical techniques have led many to reconsider indications for plate and screw fixation of these types of fractures [9].

When considering the use of plate and screw fixation for distal femur fracture stabilization, a few factors must be taken into account: anatomy/geometry of the fracture, desired immediate post-operative activity level, previously placed

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hardware, and surgeon ability/familiarity with equipment and techniques [4].

A distinct advantage of locked plating fixation over intramedullary device utilization is the ability to adequately address very distal fractures of the femur. Locked plating devices allow for fragment-specific fixation in, and reduction of, intra-articular distal femur fractures such as in the case of AO/OTA 33-C3 fractures still amenable to fixation. Locking plates also allow one to provide a stable construct for extremely distal fractures, something that is difficult to provide with IM devices [10]. When a fracture is more proximal and anatomic reduction of fracture fragments is not necessary for optimal functional outcomes, this advantage is lost over intramedullary fixation techniques.

Plate and screw fixation of distal femur fractures have historically been too weak a construct to have the mechanical strength to bear the full weight of a patient, especially those with osteoporosis/osteopenia [11, 12]. All patients treated with such devices would consequently then be restricted to toe touch or non-weight-bearing on the operative extremity [11–13]. This was a marked disadvantage as compared to intramedullary nails or acute total knee arthroplasties performed for these fractures. However, newer plate and screw technologies are made of materials durable enough to potentially allow patients to bear weight immediately following operative fixation [13].

In the case of periprosthetic distal femur fractures, previously implanted hardware must be taken into consideration when choosing a stabilization technique [14]. In the case of total knee prosthesis, many femoral implants do not have an “open box” or sufficiently large enough opening to allow for access to the medullary canal through the prosthesis, while others have stemmed hardware which have already occupied the same space [14]. Techniques have been described in which the opening in the prosthesis is widened using a diamond-tipped burr to allow for supracondylar nail entry or an antegrade nail is utilized for fractures >8 cm superior to the femoral con-

dyles [15, 16], although newer nail designs allow their use in fractures more distal. Some hip arthroplasty stems may also prohibit intramedullary fixation of such fractures. If the knee prosthesis is loose as in the case of Rorabeck III fractures, revision TKA is the appropriate choice for fixation [14, 17]. In cases other than those described previously, plate and screw fixation vs revision of arthroplasty hardware are the options remaining [14].

Surgeon skill and familiarity with the surgical technique has a significantly larger effect of outcomes after plate and screw fixation of distal femur fractures as compared to intramedullary nail fixation [18]. It has been shown that the low-volume surgeon has comparable success rates with intramedullary nailing of distal femur fractures as compared to higher-volume surgeons with greater experience [19]. However, in the case of minimally invasive locked plating fixation of distal femur fractures, surgeon experience has a major moderating factor on patient outcomes [19]. Patients treated by less experienced surgeons have more variable and overall worse outcomes when compared to highly experienced surgeons using the same systems for treatment of similar fractures [20].

7.2 Choice of Implants for the Plate and Screw Fixation of Distal Femur Fractures

As discussed above, the nature—or classification—of the fracture at the distal femur will help guide the choice of fixation. For intra-articular fracture components, absolute stability with anatomic reduction of articular fragments is paramount, followed by applying absolute versus relative stability principles to the extra-articular fracture components depending on the fracture patterns [21]. Conventional plating, fixed-angle plates with or without additional screw fixation, and locked plate fixation are three major options [19, 22]:

7.2.1 Conventional Plate Fixation

Despite many technological advances in plate and screw engineering, there remain some fracture geometries, like simple medial condyle fractures and Hoffa fragments, which are best managed via interfragmentary compression screws supplemented with a plate and screws in a position where they provide neutralization or a buttress function (Fig. 7.1).

7.2.2 Fixed-Angle Plate Fixation

As implied by the name, fixed-angle plates are implants that are “precontoured” with a constant



Fig. 7.1 Femur with medial condyle fracture and compression screw fixation supplemented by a conventional plate utilized as a buttress. Image art by Ivan Zapolsky, MD



Fig. 7.2 Femur with extra-articular distal fracture and compression screw fixation with blade plate for neutralization. Image art by Ivan Zapolsky, MD

angle between the plate blade or screw designed to fit the anatomy of the distal femur [4, 23] (Fig. 7.2). In most cases, they are used for simple fractures with metaphyseal comminution, extra-articular fractures, fractures in the supracondylar/intercondylar region, or fractures involving only one femoral condyle [4, 21–23]. With the advent of fixed-angle plates, there is a significant improvement in the success of treatment of distal femur fractures [19].

There are two main variants of the fixed-angle plate, the blade plate, and the dynamic condylar screw/compression plate. Blade plates are stable, rigid, and fixed-angle constructs that provide compression at the site of fractures [4, 23]. One of the most commonly used blade plates is the 95° plate [19, 22]. Given the shape of the plate, once inserted laterally, it will provide medial compression

sion due to the valgus nature of the femur's articular surface [23]. In order to be effective, the blade must be positioned approximately 2 cm proximal to the femoral joint line along the diaphyseal axis of the femur and over the anterior half of the femoral condyles [23]. Although a very good fixation device, there are disadvantages to its use, particularly in osteoporotic bone or cyclic stress loading situations, and due to the extensive surgical exposure required for insertion and less than optimal ability to address coronal plane fracture lines [4, 23]. From the blade plate design, dynamic condylar screw/compression plates (DCS) evolved with ability to provide epiphyseal lag screw fixation for fracture compression, particularly when there are intercondylar fracture lines [4, 23] (Fig. 7.3). The advantage was the less-extensive exposure needed

and easier insertion technique [4, 23]. However, disadvantages are similar to the blade plate in terms of cyclic stress loading tolerance [4].

7.2.3 Locked Plate Fixation

As designs evolved in plate fixation, the use of minimally invasive techniques became more popular. Within distal femur fracture fixation, this led to the use of precontoured locked plates [4, 24]. An advantage of locked plate fixation is that constructs provide improved stability, which is particularly important when addressing osteoporotic bone (Fig. 7.4). Specifically, by locking the screw directly on the plate, the stability of the construct becomes independent of the interaction between



Fig. 7.3 Femur with medial condyle fracture and dynamic condylar screw fixation. Image art by Ivan Zapolsky, MD

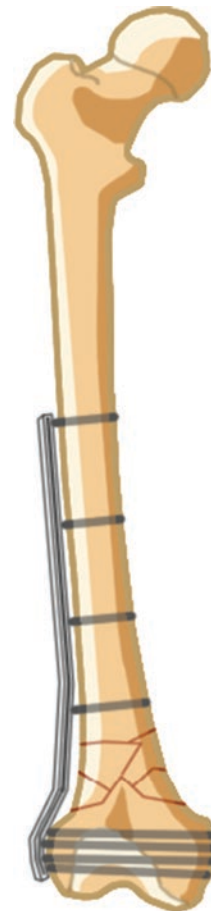


Fig. 7.4 Femur with comminuted very distal fracture and locking bridge plate fixation. Image art by Ivan Zapolsky, MD

the bone and the plate—a feature of fixed-angle devices [23]. Not only does this improve stability but also spares the devitalization of periosteum beneath the plate [19, 23]. Locked plates tend to have a precontoured design so as to allow reduction during insertion; in other words, the plate can be used as a reduction tool in the form of a mold [19, 23]. Additional advantages of novel locked plate designs are their ability to be inserted open or via minimally invasive approaches, all dependent on fracture pattern, degree of articular involvement, and experience of the surgeon [23]. Generally, longer plates are preferred so as to distribute stress and strain over long lengths of fixation constructs [19, 23]. Nevertheless, as in fixed-angle devices, plate placement is of utmost importance, with locked plates ideally placed parallel to the bone cortex and close to bone on AP view and aligned on lateral views with the intramedullary femoral canal [19, 23].

It is important to note that modern plating techniques have developed the ability to combine fixed-angle device features with locked plating advantages, thus creating hybrid constructs [19, 23]. By locking certain screw holes and utilizing nonlocking screws in others, a hybrid fixation with advantages of both constructs can be achieved to dial in appropriate stability to fractures based on bone quality and fixation construct [23]. Additionally, by using same plates, one can provide improved mechanical performance under torsional loads, particularly when using polyaxial locked screw fixation [19, 23].

7.3 Surgical Approaches to the Distal Femur for Plate and Screw Fixation

There are three main surgical approaches available for the insertion of plates for distal femur fracture fixation: (1) lateral, (2) medial, and (3) posterior approach [1, 4, 21, 25]. Some surgeons describe an anterior approach, which is usually a medial or lateral parapatellar approach and is discussed in the respective medial or lateral sections. Of note, minimally invasive submuscular

approaches are also possible and are generally modifications of the above approaches.

7.3.1 Lateral Approach

A majority of distal femur fractures are addressed utilizing the lateral approach, usually combined with a lateral parapatellar arthrotomy (Fig. 7.1). This approach is particularly helpful if there is involvement of the articular surface and for the application of most plate constructs [1, 4, 21]. The approach involves the split of the iliotibial (IT) band in line with the skin incision, and the internervous plane between the vastus lateralis muscle and the lateral intermuscular septum overlaying the hamstring muscles [1, 25]. The vastus lateralis is elevated anteriorly which reveals the distal femur [1]; however, care should be taken with this maneuver, as the profunda femoris perforators lie in the region depending on the extent of proximal dissection. Perforators should be tied off carefully prior to continuing dissection. The minimally invasive modification generally involves an incision over the anterior half of the lateral femoral condyle in line with Gerdy's tubercle over the joint line and through the IT band. If the incision is performed about the epicondyle, little vastus lateralis should be encountered, which is retracted anteriorly to expose the lateral aspect of the distal femur.

7.3.2 Medial Approach

The medial approach should be strongly considered for the plating of fractures on the medial femoral condyle [21]. The interval is between the vastus medialis and sartorius muscles (Fig. 7.1). Vastus medialis is elevated and sartorius is generally retracted posteriorly to reveal the adductor magnus muscle and its insertion to the adductor tubercle. Adductor magnus can then be retracted posteriorly to reveal the distal femur [1, 21]. During this approach, care should be taken, as the neurovascular bundle comprising the superficial femoral artery (transitioning to popliteal artery),

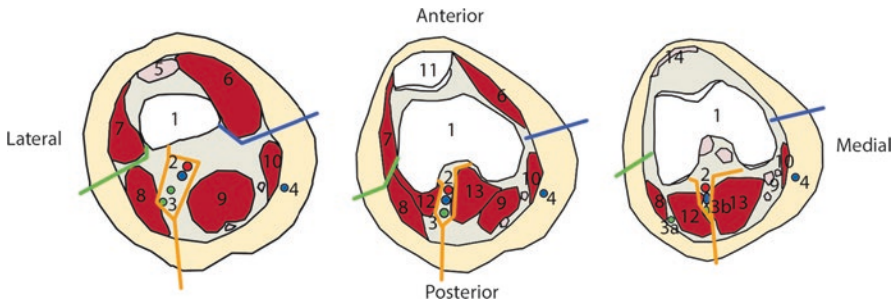


Fig. 7.5 Approaches to the distal femur. Green, lateral; blue, medial; orange, posterior; (1) femur; (2) popliteal a. and v.; (3) sciatic n. (3a common peroneal n., 3b tibial n.); (4) great saphenous v.; (5) quadriceps tendon; (6) vastus medialis; (7) vastus lateralis; (8) biceps femoris; (9) semi-

membranosus/semitendinosus; (10) gracilis; (11) patella; (12) lateral head of gastrocnemius; (13) medial head of gastrocnemius; (14) patellar tendon. Image art by Ivan Zapolsky, MD

femoral vein, and sciatic nerve (transitioning to common peroneal and tibial nerves) is encountered just posterior to the femur and beneath the adductor magnus [21].

This approach can be modified to fit the standard medial parapatellar approach to the distal femur/knee, such as in total knee arthroplasty, to help in the exposure of intra-articular fracture fragments [1].

7.3.3 Posterior Approach

On rare occasions, a Hoffa fragment that is very posterior might need to be addressed. In these cases, a posterior approach to the knee is warranted for fragment fixation. The incision is centered midline at the popliteal fossa but is made in an S shape beginning proximal-laterally over the biceps femoris, then diagonally across the fossa and medial-distal over the medial gastrocnemius [25]. There is no formal interval, but once deep fascia is incised, extreme caution should be observed due to the number of important neurovascular structures encountered, including the tibial nerve medial and posterior to the semi-membranosus and medial gastrocnemius, the common peroneal nerve lateral and posterior to the biceps femoris, and the popliteal artery and vein, both deep and medial to the tibial nerve [25] (Fig. 7.1). The approach can be extended proximally, with the important note that from proximal

to distal, the sciatic nerve lies anterior to the biceps femoris, which runs in a medial to lateral course across the posterior thigh [25]. Therefore, for proximal posterior femur approaches, the biceps and sciatic should be retracted medially, whereas for more distal incisions, the biceps and sciatic should be retracted laterally [25] (Fig. 7.5).

7.4 Postoperative Course and Follow-Up After Plate and Screw Fixation of Distal Femur Fractures

Following plate and screw fixation of a distal femur fracture, a strict postoperative activity protocol is an important facet of success. Articular fractures require strict non-weight-bearing, while some types of fixation may allow weight-bearing immediately after surgery [26, 27]. Though rehabilitation after distal femur fractures has been poorly studied, literature suggests that postoperative protocols should include early mobilization and range of motion to reduce postoperative complications secondary to prolonged immobilization; low-force loading associated with immediate postoperative ROM has a beneficial effect on the healing of articular cartilage [3–5, 13, 26, 28]. Weight-bearing restrictions following plate and screw fixation of distal femur fractures depend on fracture geometry and patient factors. If the articular surface is involved in the fracture,

a patient must have protected weight-bearing for 8–12 weeks with close follow-up and radiographic evidence of healing prior to advancement [26].

If the fracture is extra-articular, the surgeon should strive to provide a stable enough construct to allow a patient to be weight-bearing as tolerated immediately after surgery [18]. Provided that adequate length, alignment, and rotation were obtained, and the patient demonstrated minimal postoperative pain, immediate weight-bearing is recommended [18]. If the construct cannot provide this level of stability, a patient should be instructed to have protected weight-bearing. The patient may then be advanced after 6–8 weeks, as long as there is radiographic evidence of bone healing or callus formation [27, 29].

Gait training and knee motion with a hinged knee brace on postoperative day 1 with physical therapy has been shown to improve motion and

function [1]. Utilizing a continuous passive motion machine may be necessary for patients unable to ambulate or incapable of moving the knee [3, 30]. Full knee extension should be emphasized during rehabilitation to prevent flexion contracture [1].

7.5 Clinical Case: Plate and Screw Fixation of a Distal Femur Fracture

A 24-year-old man was struck by an automotive, sustaining multiple injuries including an intra-articular distal femur fracture (Fig. 7.6). He was initially placed in a knee and ankle spanning external fixator (Fig. 7.7). The intra-articular component was addressed first through a medial parapatellar arthrotomy. Articular fragments were mobilized and reduced to form a single articular block. Once the articular block was

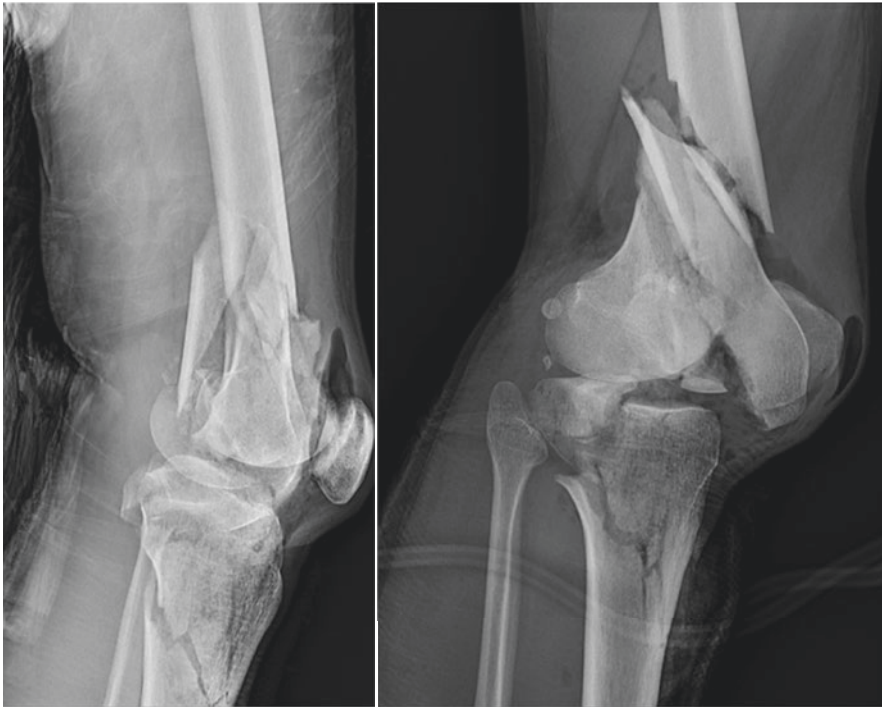


Fig. 7.6 Initial injury films. Comminuted intra-articular fractures of the distal femur and proximal tibia are evident. This was an open injury; intra-articular gas can be

seen on AP and lateral images. Images courtesy of Derek Donegan, MD MBA



Fig. 7.7 Preoperative 3D ghost reconstruction of right femur utilizing CT images obtained following placement of a knee spanning external fixator. Images courtesy of Derek Donegan, MD MBA

restored, it was reduced as a unit back to the intact metadiaphysis utilizing the previously placed external fixation system and strategically placed bone clamps, restoring length, alignment, and rotation. An 18-hole variable angle curved condylar plate was placed on the lateral aspect of the femur in a submuscular fashion via a lateral approach. The plate was balanced and secured in

place using k-wires. The plate was then secured with a nonlocking screw distally, and nonlocking screw proximally, just distal to the lesser trochanter, to compress the plate to bone and restore coronal and sagittal planes. The plate was then further secured utilizing hybrid fixation with locking screws distally and nonlocking screws proximally (Figs. 7.8 and 7.9).

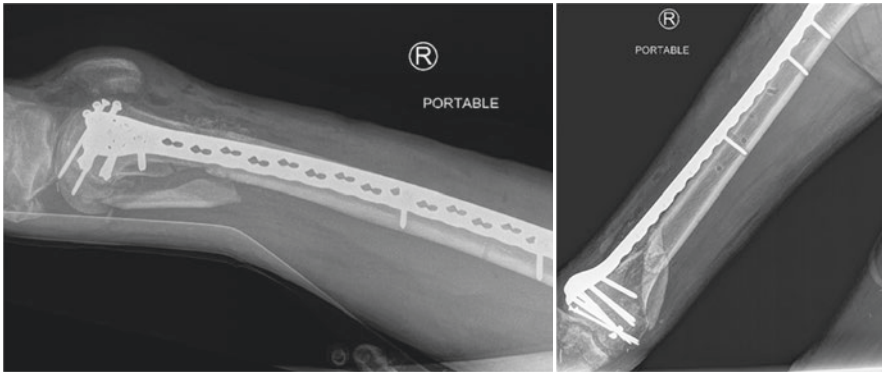


Fig. 7.8 Postoperative x-ray images of the distal and diaphyseal femur demonstrating restoration of distal femoral length alignment and rotation with anatomic reduc-

tion of the articular block. Images courtesy of Derek Donegan, MD MBA

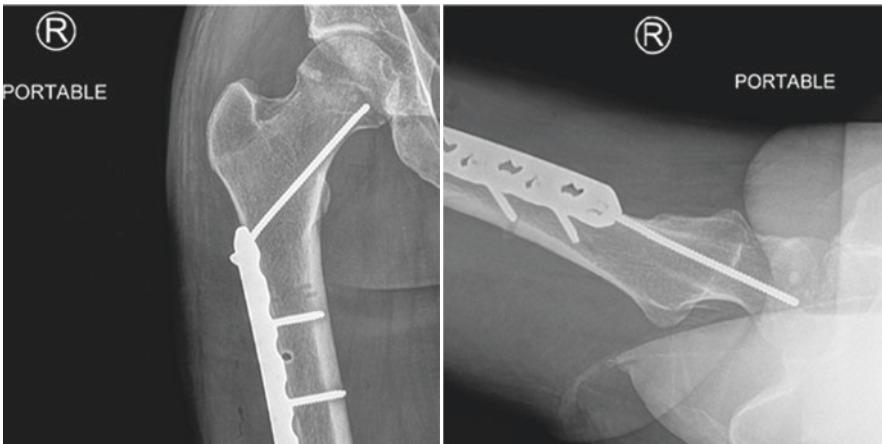


Fig. 7.9 Postoperative x-ray images of the proximal femur demonstrating plate and screw placement. Anterior-posterior (left). Cross table lateral (right). Images courtesy of Derek Donegan, MD MBA

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