Management Options and Decision Making Algorithm for Distal Femur Fractures

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Abstract

Distal femur is a complex fractures and most of times a personalized approach is needed for these fractures. Over a period of time variety of approaches and implants have been used for these fractures. The guiding principles for achieving good prognosis is meticulous surgical technique, preservation of fracture biology, restoration of articular surface and overall alignment of the limb. In case of geriatric fractures factors like long terms health and functional goals also need to be taken into consideration in planning treatment. This review focusses on providing an overview of the management options and lay down the premise for the symposium

Keywords: .Distal femur fractures, surgical management, decision making

Introduction

Distal femur fractures have been reported to account for between 4% and 6% of all femoral fractures[1, 2]. The distribution of fractures of this region is bimodal both in terms of age and mechanism. Distal femur fractures can result from either high-energy trauma or low-energy trauma. High-energy trauma such as road traffic accidents and sports accidents are more likely in men ages 15–50, whereas low-energy trauma such as falls from standing height at home are more likely to lead to distal femur fractures in women aged 50 and above. There is also the addition of the peri-prosthetic fracture group in the geriatric population with osteoporosis. In both cases axial loading of the leg is the most common mechanism of injury[2]. The fractures can be open or closed, due to their peri-articular location, can also have associated injuries of the patella and tibia. Proper antibiotic prophylaxis is essential to reduce the rate of infection in open fractures[3]. In cases of high energy trauma there can be associated neurovascular injury. Hence the neurovascular status of the extremity should be monitored closely in the perioperative and postoperative period. For evaluation of the fractures AP and Lateral X-Rays are obtained. Where articular comminution is present CT (computerized tomography) can aid in better understanding of the fracture geometry. 3D reconstruction images can further clarify complex articular injuries and coronal plane fractures[4]. As for all peri-articular fractures the restoration of articular surface and joint alignment requires thorough assessment of the fracture character and proper preoperative planning. Failing to do so can result into severe permanent disability specially if there is loss of knee stability and function[5]. Classically, the treatment of choice for management of femoral fractures, including supracondylar fractures, was with different types of splints. In 1907 and 1909, Steinmann and Kirschner, respectively, developed the first traction treatment modalities with the use of pins or wires under tension. A single pin is usually placed in proximal tibia when applying skeletal traction for treating these fractures[6]. Retrospective reports during the 1960's by Stewart et al. (1966) and Neer et al. (1967) favored simple non-operative methods of treatment. However, in the next decade the pendulum started to shift as new surgical methods and materials improved the results of surgery according to Miiller et al[1].

Progressively with time better understanding of anatomy and fracture characteristics led to improved implant designs and improved outcomes. The modalities for fixation of distal femoral fractures can be broadly classified into external fixation, Conventional plating (sliding screws, blade plates and Dynamic compression plates), Locked plate fixation, Intramedullary nailing and arthroplasty.

Non Operative Management

The options of non-operative management are splint, cast and traction. Thomas and Meggit compared different non operative modalities and observed that there was no significant difference in the malunion rates between the splint versus the cast brace treatment. Although there was delayed union associated with splints[7]. Butt et al. evaluated operative (dynamic condylar screw) versus conservative (skeletal traction) treatment in a randomized control trial for displaced distal femur fracture in elderly patients. Good or excellent results were obtained in 53% of the operative patients versus 31% in the conservative group. The non-operative group had an increased risk for deep vein thrombosis (despite anticoagulation therapy), pulmonary and urinary tract infections, non-unions, mal-unions, knee joint stiffness, skin related complications and pin tract infections[8]. Therefore the application of the non-operative treatment is limited to only certain conditions like non-displaced fractures, bed bound patients, patients unfit to undergo surgery due to comorbidities[9].

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Operative Management

Fractures of the distal femur can be managed successfully with surgery. A good result depends on identification of all fragments, adequate repair of soft tissue, appropriate bone grafting, meticulous inter-fragmentary compression, and complete reduction of the joint space[10].
Indications for operative management include open fractures, displaced fractures, intra-articular fractures, fractures associated with neurovascular compromise, ipsilateral lower extremity fractures, irreducible fractures, pathologic fractures and non-unions.
The implant and technique used is determined by fracture pattern, bone quality, the hemodynamic stability of the patient, and the skill and experience of the surgeon[11].

Surgical Techniques

ORIF Approaches

Surgical approach usually depends upon the character of the fracture and the choice of the implant. Most commonly performed approach is the lateral approach.

Lateral Approach

This approach is employed for fractures without articular involvement or simple articular extension. It is performed in the supine position with the knee flexed to 30 degrees. Flexing the knee releases the traction caused by gastrocnemius muscle and prevents extension of the distal fragment. This approach can be extended as required proximally to mid-thigh and to the lateral parapatellar region distally. The approach relies on an atraumatic elevation of the vastus lateralis from the lateral aspect of the distal femur, and a lateral arthrotomy for joint access. Articular reduction and lateral plate placement can both be achieved with the same approach. When extended proximally this approach can provide access to the entire length of the femoral shaft. Fractures of the medial femoral condyle and more complex fractures can also be handled with a lateral approach[12]. Occasionally a medial para-patellar approach may be utilized to provide good view of the articular surface of the distal femur.

Medial parapatellar

A medial approach to the distal femur may be used for a medial distal femoral fracture or in case of a coronal split (Hoffa-type fracture) of the femoral condyles. It can also be used in conjunction with lateral exposure when double plating of the distal end of the femur is indicated for severe supracondylar comminution or for bone defects requiring additional medial stabilization and in patients with complex combined supracondylar and intracondylar fractures. The vastus medialis is reflected anteriorly to expose the distal medial shaft of the femur. Structures to be protected in this approach are medial collateral ligament, the medial meniscus and the femoral artery and vein as they leave the adductor canal[13].

Surgical Algorithm

For extra articular distal femur fractures a minimally invasive surgical approach can be utilized, this approach preserves the fracture biology. This can be achieved by minimal invasive plate osteosynthesis or retrograde intramedullary nailing. Either approach allows for bridging of the fracture. This approach is superior to open reduction and internal fixation of intermediate fragments where blood supply may be impaired. Compression mode plating has been found superior to bridging mode and should be performed where feasible[14].
For simple articular fractures open reduction of the affected femoral condyle is required to achieve anatomic reduction. Lag screws can be used to reduce the articular fragments followed by a plate for osteosynthesis.
In case of the comminuted articular fractures visualization of the knee joint is required in order to reduce and anatomically reconstruct the articular surface. Temporary k-wire fixation can be performed followed by placement of lag screws using 3.5 mm screws. Afterwards the articular bloc is fixed to the femoral shaft. No matter which kind of fixation is performed it is imperative to restore axial alignment, length and rotation of the lower limb for good functional recovery[15].
In severely comminuted fractures a spanning external fixator may be used as a salvage procedure. The external fixator may be applied for several weeks in order to achieve adequate conditions for later total knee arthroplasty[16].

External Fixation

External fixation is commonly used as a temporary measure of these fractures, in particular for displaced intra-articular fractures. Mainly used when there is an open fracture, significant comminution, bone loss, vascular compromise or extensive soft tissue damage. A bilateral fracture or a floating knee are also examples of complex fractures requiring external fixation. Proper placement of pins away from the zone of injury will reduce the risk of infection and maintain the integrity of the soft tissue for definitive management at a later stage[17].
With Monolateral fixators, it is difficult to control alignment, the stability is often poor, there is no fixation of the articular component and stabilization of the fracture requires bridging the knee, which increases the risk of stiffness. As a damage control measure external fixation provides opportunity for medical management, reduction in pain and facilitates nursing care till definitive treatment can be performed. Severely comminuted fractures can also be treated definitively with tensioned external fixation devices such as the Ilizarov fixator. Oh et al. reported results of a series of 59 complex intra-articular fractures with temporary bridging external fixation. There were seven complications including four that developed in distal femoral fractures which were infection and the unsuccessful control of leg length[18]. Parekh et al. reported good results in staged management of complex intra-articular fractures around the knee, with 16 distal femoral fractures in a series of 47 cases[19]. Zlowodzki et al. reported an average 7.2% nonunion rate, 1.5% rate of fixation failure, 4.3% rate of deep infection, and 30.6% need for secondary surgical procedures when distal femoral fractures were treated with external fixation[20]. Arazi et al. evaluated 14 complex fractures treated with Ilizarov external fixator and found that union occurs around 16 weeks with a mean ROM of 105 degrees at the knee. With the only complication being an infected nonunion, they concluded that the fixator is a safe option that provides adequate stability[21]. Kumar and colleagues examined the outcomes of the Ilizarov fixator in open supracondylar fractures and found that union occurred much later at 39 weeks, with at least 4 cm of shortening noted in 40% of fractures and pin-track infections in 21% of patients[22].

Conventional Plate Systems

After the 70s, better results to support ORIF in fractures of the distal femur were reported in literature[1, 23] Shahcheraghi et. al. compared ORIF with closed reduction directly, preferred ORIF with good or excellent clinical results registered, 81% open versus 42% closed and a significantly reduced malunion rate, 3% open versus 37% closed[15]. With the availability of the fixed angle blade plate the care for the distal femur fracture got transformed. This construct provided polyaxial stability and inherent rigidity. Earlier designs constituted an angled side plate that could be impacted into the distal femur and fixed to the distal femur by the precontured region of the plate across the metaphyseal flare. The angle of the blade was commonly 95 degrees and careful implantation ensured that length and alignment could be restored even in injuries with metaphyseal comminution. The major drawback of this design was that it required a large exposure. Furthermore, it could not be used in cases of osteoporosis and was unable to address the coronal plane fractures[5]. Later another implant was designed on the fixed angle concept with a sliding screw and was called the Dynamic Condylar Screw (DCS). This implant provided the ability to compress the intercondylar fragments. This design was adopted for the ease of application and smaller exposure. But it still did not address the coronal fracture limitation of the angled blade plate and also resulted in more bone loss upon insertion which made revisions difficult[24].

In general open reduction and internal fixation requires extensive dissection and can therefore lead to devascularization of fracture fragments, hence there is an increased risk of delayed union, non-union and infection[25]. To decrease these complications, concepts evolved applying indirect reduction techniques to restore length, rotation, and the mechanical axis without direct exposure of the fracture site and therefore maintaining the blood supply to the fracture region. Indirect reduction techniques were shown to have a biological advantage. Bolhofner et al. treated 57 patients with distal femoral fractures with conventional plates using only indirect reduction techniques. The average time to fracture union and full weight bearing was 10.7 weeks with no non-unions or hardware failures reported. These results could be achieved although 11 patients with open fractures were included[26].

Keeping in view the problems with open reduction and internal fixation and advantages of indirect reduction and preservation of vascularity of fracture fragments evolution occurred to wards minimally invasive surgery[27]. Studies have shown the preservation of soft tissue perforators and specially of the periosteal blood supply while using minimally invasive plate osteosynthesis (MIPO) techniques. Furthermore it decreased the incidence of infection, implant failure and led to earlier callus formation and decreased the need for subsequent bone grafting[20].

Locked Plate Fixation

With the development of different options in plate osteosynthesis, the locked pre-contoured plates have become widely used in orthopedics for many different fractures. Unlike the previously used (conventional) plates, which required friction between the plate bone interface for stability, the locking plates have mechanisms to secure the screw heads to the plate. This allows for the screws to be placed at different angles. The major advantage is that the plate doesn't not have to be in contact with the bone. This allows for preservation of the periosteal blood supply[27].

Locking plate can be used in an open reduction and internal fixation procedure when the fracture is intraarticular, or with minimally invasive surgery using the less invasive stabilization system (LISS) in case of an extra-articular fracture or a simple non- displaced fracture[28]. One of the disadvantages of locking plate is the lack of interfragmentary compression with locking screws, this requires fixation of fragments with placement of lag screws prior to plate fixation. Extra care while insertion is required to prevent the interference of lag screws with the locked screws. There is a learning curve associated specially when using LISS in order to achieve union and prevent malunion and mechanical failure[29].

Although locking plates provide the biological advantage, at the same time they create rigid constructs which can suppress fracture union. As micro motion across the fracture site has been long known to cause stimulation of healing across the fracture fragments. Making the construct too rigid can affect the callus formation[30]. Choice of material also affects rigidity, stainless steel being more rigid, whereas titanium and associated alloys provide more flexibility[31].

In locking plates there are variations that exist based on the locking mechanism of the screws. One type has the unidirectional screws and the other has polyaxial screws. Polyaxaial system allows for more accurate screw placement, especially in the peri-articular regions. As a further development, a hybrid locking plate was made known as the Locked compression plate (LCP) which contains holes for both locking screws and cortrical screws. This system allowed for interfragmentry compression similar to a dynamic compression plate (DCP)[32].

In the literature there are many biomechanical studies that evaluate locking plate fixation systems. Beingessner et al. compared titanium plates to steel plates as well as unicortical to bicortial screws. They concluded that strength under torsion is reduced in titanium plates and strength is improved with bicortical screws. Whereas there is no difference for axial compression strains and plastic deformity[33].

Lujan et al. demonstrated that titanium plates favor the formation of callus due to elasticity in fixation material[31]. Stoeffel et al. when comparing LCP, DCP and Hybrid fixation showed that locking system results in less loss of reduction under axial compression with less plastic deformity and the DCP system provides better strength under torsion. The conclusion was that Hybrid fixation is preferred[34]. Wilkens et al. showed that the placement of polyaxial screws increased strength under axial compression and torsion and reduces deformation when loaded[35]. Freeman et al. compared load to failure, axial stiffness, and screw extraction torque for distal femoral locking plates with locked or cortical screws. Results demonstrated that locked fixation was superior in the osteoporotic model only[36]. Buckley et al. brought forward the issue of mal-rotation following MIPO if careful intra operative assessment is not done[37].

Recently, Tank et. al. concluded that early mechanical failure with the variable angle distal femoral locking plate is higher than traditional locking plates (LCP and LISS) for comminuted intraarticular distal femur fractures. They advised against use of this plate for metaphyseal fragmented distal femur fractures[38].

In a randomized prospective multicenter controlled trial comparing the Less Invasive Stabilization System (LISS) with the minimally invasive Dynamic Condylar Screw System (DCS) published by the Canadian orthopedic trauma society, they concluded that there was no statistically significant difference between LISS and DCS in terms of the number of fractures healed, time to union, or functional scores. Complications and revisions were more common in the LISS group. Only 52% of the LISS group healed without intervention by 12 months compared with 91% in the DCS group[39].

Interlocked IM nail

Intramedullary nailing is a good surgical option for distal femur fracture. It helps avoid extensive soft tissue dissection and minimize secondary damage of devascularization of fracture fragments[40]. This method has been recommended for non-comminuted fractures with intact distal femur to allow for interlocking. Both ante- and retrograde nailing have successfully been applied in the treatment of even comminuted and intraarticular fractures, but antegrade nailing has lost appeal[41]. Antegrade nailing has now been reserved for extraarticular fractures with fracture line > 5 cm proximal to the articular surface to allow for adequate distal fixation. The only advantage of antegrade nailing is the avoidance of an arthrotomy[32].

Retrograde nailing prevailed due to availability more options of distal fragment fixation. As with minimally invasive plate osteosynthesis, indirect fracture reduction and a minimally invasive approach were adopted for nailing as well.

Handolin et. al. reported in a series of 44 patients with 46 distal femur fractures with retrograde nailing, that the final union rate was 95% and a mean union time was 17.5 weeks. However, there were three patients with a loss of reduction and two of them had to undergo a re-operation[42]. Henry et al. compared open versus percutaneous reduction techniques for retrograde nailing of distal femoral fractures. The authors concluded improved post-operative knee function with decreased operative time, blood loss, bone grafting, and non-union rates without differences in malunion rate[43]. Hartin et. al. compared nailing vs plate fixation in fractures of the distal femur. They demonstrated high union rates in both groups without any statistically significant difference between groups. They observed that the deep infection rate, knee range of motion and healing time was better in the nailing group but was not statistically significant[44].

Disadvantages of the nailing technique may be a lack of alignment control, posterior angulation, perforation of joint cartilage and intra-articular distribution of reaming debris. Stability is limited if small diameter and short nails are inserted[45].

Arthroplasty

Complex peri-articular fractures can be a challenging to treat especially in the elderly. Even after achieving anatomic reconstruction and rehabilitation, posttraumatic arthritis and knee pain are complaints that commonly arise in addition to any baseline osteoarthritis. In younger patients the use of primary arthroplasty or distal femoral replacement may not be a viable option but in elderly it can be a valuable consideration, especially in the presence of primary osteoarthritis and comminution of the femoral condyles. Thin cortices, wide intramedullary canal and osteoporosis can make stable primary fixation difficulty to achieve, especially in the presence of multiple medical co-morbids[46]. Preservation of knee function and early weight bearing should be the objectives of management in the geriatric population[47]. Careful pre-operative planning and imaging is required to gauge the extent of injury. Radiography of the contralateral limb can act as a template in planning. Depending on the extent of the fracture and its pattern implant choice can be made. Primary total knee arthroplasty implants for non-comminuted fractures, revision TKA implants in the presence of metaphyseal extension, distal femoral replacement in cases of significant metaphyseal comminution and hinged implants where there is ligamentous instability. Addition of plates, lag screws, cables and cement can be done to achieve the required stability[48]. Choi et. al. performed TKA with the Medial Pivot prosthesis in 8 patients with ages between 65 and 89 who had primary osteoarthritis along with a distal femur fracture. They reported a mean time of 15 weeks to union and a good clinical result for all patients. They concluded that primary TKA can be considered as an option for the treatment of minimally comminuted distal femoral fractures in elderly patients who have advanced osteoarthritis of the knee with appropriate bone stock[49]. Appleton et. al. reported results of hinged total knee replacement in treatment of 54 fractures in 52 patients with a mean age of 82 years. Within the first year after implantation 22 of the 54 patients had died, six required further operation and two required revision surgery. They concluded that hinged total knee is useful alternative treatment to internal fixation in elderly patients and has a high probability of surviving as long as the patient[50]. Arthroplasty for peri articular fracture may not be seen as a paradigm shift but instead as a good alternative, for a certain patient group, that requires a strict indication and an experienced surgeon[51].

Conclusion

With the evolution of techniques and implants over time the treatment of the distal femoral fracture has improved. Although the advantage of one system of fixation over the other cannot be absolutely concluded, the main dependence of the surgical decision remains more on the fracture pattern and familiarity of the surgeon with the use of a certain implant and technique. The guiding principles for achieving good prognosis is meticulous surgical technique, preservation of fracture biology, restoration of articular surface and overall alignment of the limb. In case of geriatric fractures factors like long terms health and functional goals also need to be taken into consideration in planning treatment.

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