
COMBINED USE OF INTRAMEDULLARY NAIL AND AUGMENTATION PLATE FOR TREATMENT OF COMPLEX FEMORAL DIAPHYSEAL FRACTURES

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Abstract

Complex acute fractures of the femoral diaphysis such as severely comminuted and segmental fractures are the results of massive traumatic insults and together with old fractures presented with nonunion or implant failure from previous internal fixation are difficult to treat. Various problems arise in the management of these fractures and in the patient's final functional outcome. A prospective study of 30 patients with such complex femoral fractures was conducted at Basrah General Hospital from January 2007 to June 2008. The technique of open reduction and simultaneous combined internal fixation by intramedullary Kuntscher's nail and derotation plate was performed. The nail was left in situ, and was augmented with a short AO plate and screws applied to lateral or anterior surface of the femur. Cancellous bone graft was harvested from ipsilateral or contralateral proximal tibia and was added to fracture site in every case.

There were 28 males and 2 females. Their age ranged from 17 to 37 years. The majority of the fractures were closed occurring in 23 patients (77%). There were 18 acute fractures (60%), 6 (20%) nonunited, and 6 (20%) with metal failure complicating previous internal fixation by conventional plates and screws. Fresh comminuted fractures were the most frequently reported fractures in this study, they occurred in 18 patients (60%), followed by oblique fractures in 9 patients (30%), and transverse fractures in the remaining 3 patients (10%). The oblique and transverse fractures belong to the group of 12 patients with old fractures more than 6 months since injury (6 patients with non-united fractures, and 6 patients with implant failure both complicating previous surgical fixation by long conventional plate and screws with or without cancellous bone grafting). For acute fractures, surgery was performed 2 to 10 days from the time of injury. Clinical and radiological signs of union were achieved in 27 patients (90%). The average time for solid callus to become evident on radiographic examination was 6 months. Deep seated infection which failed to respond to local wound care and parenteral antibiotic administration had developed in one patient whose initial injury was compound fracture from bullet injury. Revision surgery with removal of the whole implant and exchanging to external fixation was required in that patient. Loosening of the most proximal screw from the plate without affecting the mechanical stability of the combined implant construct had occurred after the 20th week following surgery in 5 patients (16.3%), and was the result of excess stress on that screw following full weight bearing after achieving clinical and radiographic evidences of fracture union. Proximal migration of the Kuntscher's nail developed in 4 patients (13.3%) and was also the result of full weight bearing following fracture union. This migration was well tolerated by patients and was treated by nail removal leaving plate in situ. Significant limb shortening of about 3 cm had developed in one patient who presented initially with severe comminution and bone loss from bullet injury. Limitation of knee joint movements prior to surgery was present in 12 patients from the group of old fractures. True postoperative knee stiffness following combined fixation had developed in only three patients (10%).

Composite implant construct using combined nailing and augmentation plate appears to give an acceptable outcome, in terms of union and function in treating complex femoral shaft fractures. It gives more rigid and stable fixation than conventional plate and screws alone or nail alone with relatively few complications.

Introduction

Femoral shaft fractures are among the most common fractures in orthopedic practice. These fractures are usually caused by high energy trauma like road traffic accidents and missile injuries. Stress fractures and pathological fractures due to osteoporosis and metastatic tumors can also develop.

The femur has abundant blood supply both endosteal and periosteal. A nutrient artery usually enters along the linea aspera posteriorly and proximally on the femur and supplies the endosteal circulation which is responsible for supplying the inner three fourths of the cortex. The periosteal circulation serves only the remaining outer fourth of the cortex. However, the periosteal circulation is critical to fracture healing in the diaphysis¹. When a fracture is displaced, the medullary vessels are disrupted and the periosteal vessels predominate as the vascular supply to the fracture site during early healing. The significance of periosteal blood flow in healing also emphasizes the importance during surgery of avoiding extensive periosteal stripping especially along linea aspera².

Currently femoral shaft fractures in adults are best treated by surgery because of the high rates of union, low rates of complications, and the advantage of early fracture stabilization which decreases the morbidity and mortality rates in the injured patients³. Different types and modalities of surgical fixations are used such as interlocking nails, conventional long plates and screws, and external fixation. Currently, antegrade reamed interlocked intramedullary nailing with entrance through the piriformis fossa is the golden standard treatment for diaphyseal femur fractures⁴. Because of increased complication rate with the use of conventional compression plate and screws compared with intramedullary nailing, plate fixation of acute femoral

shaft fractures is reversed to cases with distal metaphyseal-diaphyseal junction fractures, ipsilateral femoral neck and shaft fractures, small intramedullary canal, associated major vascular injury, and peri-prosthetic fractures about intramedullary implants^{5,6}. External fixation is reserved mainly for patients with compound fractures (Gustillo IIIB or IIIC), and when time is of essence necessitating short time of operation such as in medically unstable patient, polytrauma patient, and in mass casualty situations^{5,7}.

With complex acute fractures of the femoral diaphysis such as severely comminuted and segmental fractures significant injury to the bone and surrounding soft tissues occur imposing more difficulties in selecting the best surgical procedure and in the rate of possible postoperative complications. Similar difficulties are faced with in the management of previously operated upon and internally fixed fractures complicated by implant failure and/or nonunion. This prospective study was conducted to evaluate the union rates, complications, and the functional results of treating such complex fractures by open reduction and combined internal fixation using retrograde intramedullary Kuntscher's nail augmented by short derotation plate applied to the surface of femoral diaphysis.

Patients and Methods

Thirty adult patients with complex femoral shaft fractures were included in a prospective study conducted at Basrah General Hospital between January 2007 and June 2008. There were 28 males and only 2 females. Age ranged from 17 to 37 years (the working age). Involvement of left femur was the predominant and was reported in 22 patients, right thigh involvement in 8 patients. There were 23 closed fractures and 7 open fractures (Gustillo A and B). The cause of the

fracture was road traffic accidents in the majority, 22 patients, bullet injuries in 7, and fall on the ground in one patient. Other associated injuries (skeletal and non skeletal) occurred in 10 patients, with head injuries being the most frequent associated injury reported in 7 patients. Sciatic nerve palsy from bullet injuries was reported in 2 patients. There were 18 acute fractures. The remaining 12 were old complicated fractures from previous open reduction and internal fixation using conventional AO plate and screws alone with or without cancellous bone grafting: 6 were nonunited fractures, and 6 with metal failure (plate loosening, breakage, or bending).

For acute fractures, surgery was performed on 2nd to 10th day since the injury. Under general anesthesia using ordinary operating table, the patient is operated upon in lateral decubitus position with the fractured limb up. Prophylactic antibiotics, intravenous Cefotaxime 1gram, was used in every patient. The first dose was initiated at time of induction of anesthesia and was continued 8 hourly for a total of 5 days. The fracture site is exposed using the posterolateral approach to femur. Reflection of the vastus lateralis muscle (with as minimal as possible soft tissue dissection) is done. Very minimal stripping of periosteum on both sides of the fracture is done. No stripping is performed at region of linea aspera. Very minimal reaming of the medullary canal (to just 1mm larger than the diameter of the isthmus of the involved femur) is done using manual reamers. An ordinary Kuntscher's nail is then inserted in a retrograde manner reducing the major fragments of the fracture and restoring the length and alignment of the injured limb. The knee joint is then examined in every patient to be sure that the nail does not penetrate and thus damages the knee. Depending on the geometry of the fracture, an AO metal plate (6-10 holes) is finally applied and fixed to the lateral

or anterior surface of the femur. Cancellous bone graft from ipsilateral or contralateral tibia was used in all patients. Redivac drain was used in every patient and was removed after 48 hours. Average time required to complete surgery was 90-120 minutes. Above knee plaster of Paris back slab was applied in every patient for pain relief and to aid soft tissue healing. Postoperative hospital stay was 5-7 days in most cases. On removal of back slab in the seventh postoperative day, a program of quadriceps muscle exercises and gentle knee flexion of the injured limb was started and increased progressively afterwards.

Follow-ups visits were arranged at 2 weeks interval for the first month and then every 4 weeks. Both clinical and radiographic assessments of the fracture were monitored in each visit with special emphasis on the following parameters: quadriceps muscle efficiency, range of knee movements, fracture healing, and possible occurrences of complications like infection, implant failure. Visible callus at fracture site was usually radiographically evident in x-rays taken 8-12 weeks postoperatively in most patients. Partial weight bearing with the aids of two axillary crutches is allowed 6-8 weeks postoperatively and increased gradually as the bridging callus become more evident and much stronger on follow up x-rays examination. Full weight bearing is started 16-20 weeks following surgery taking in considerations the fracture geometry, associated other injuries and co morbidities, and of course the clinical and radiographic progress of fracture union.

Results

The majority of the fractures were closed and occurring in 23 patients (77%). Fresh comminuted fractures were the most frequently reported fractures in this study, they occurred in 18 patients (60%), followed by oblique fractures in 9

patients (30%), and transverse fractures in the remaining 3 patients (10%). The oblique and transverse fractures belong to the group of 12 patients with old fractures more than 6 months since injury (6 patients with non-united fractures, and 6 patients with implant failure both complicating previous surgical fixation by long conventional plate and screws with or without cancellous bone grafting). Fractures of the middle portion of femoral shaft was the most frequently reported fractures in this study accounting for 53.4% of cases (16 patients), followed by proximal third fractures in 8 patients (26.6%), and lower third fractures in 6 patients (20%).

Fracture union was achieved in 27 patients (90%). Solid callus on x-ray examination was evident at 4-8 months post operatively (average 6 months) in these patients (figs.1 and 2). Absence of clinical and radiographic signs of union at 4 months postoperatively was regarded as a sign of union failure, this had occurred in 3 patients representing 10% of all fractures.

Postoperative wound infection was reported in 4 patients (13.3%). In 3 of these cases the infection was superficial wound infection, occurred early within 3 weeks after surgery and responded fully to frequent wound dressings and the use of intravenous Cefotaxime 1gm 8 hourly for 7-10 days. The remaining one patient had developed deep seated infection which failed to respond to local wound care and antibiotics. The initial injury in that patient was compound fracture from bullet injury. Revision surgery with removal of the whole implant and exchanging to external fixation was required in that patient.

Plate avulsion or loosening was not reported in this study, but loosening of one screw from the plate and extrusion

into the surrounding soft tissues had occurred in 5 patients (16.3%). This screw avulsion (usually the most proximal one) had occurred after 20 weeks following surgery, and was the result of excess stress on that screw following full weight bearing after achieving clinical and radiographic evidences of fracture union. Treatment was by removal of the avulsed and remaining screws together with the derotation plate, leaving the nail in situ.

Proximal migration of the intramedullary nail had occurred in 4 patients (13.3%) and was also the result of full weight bearing following fracture union. This migration was well tolerated by patients and was treated by nail removal leaving plate in situ.

Significant limb shortening (about 3cm) was reported in one patient (3.3%). The cause of shortening was the presence of severe comminution with bone loss and gap prior to surgery from bullet injury. After achieving fracture union, the use of a raised heel in the shoe greatly helped that patient and had compensated to a great extent his limb shortening.

Limitation of knee joint movements prior to surgery was present in 12 patients (6 with non-union and 6 with metal failure from previous conventional plate fixation). True postoperative knee stiffness following combined fixation by intramedullary nail and derotation plate had developed in only three patients (2 with sciatic nerve injury and one with compound comminuted fracture from bullet injury extending to lower third of femur). Intensive course of physiotherapy and quadriceps muscle build was practiced in all these patients who had improved the range of motion of knee joint to at least 110° of knee flexion.

Figure 1: Acute comminuted femoral fracture

A-Preoperative x-ray.

B-Seven months after combined fixation showing complete fracture union.

(A)



(B)



Figure 2: Failed previous internal fixation and non-union left femur

A-Broken plate with no signs of union 5 months since first surgery.

B- Six months after combined fixation showing complete fracture union.

(A)



(B)



Discussion

Complex acute diaphyseal femoral fractures (comminuted, segmental, compound, and those with bone loss) are the results of high energy trauma like from road traffic accidents, fall

from height and missile injuries. Occurrence of other associated injuries (both skeletal and non skeletal) are common⁸. In these complex fractures both the bone and the overlying soft

tissues are severely traumatized, imposing many problems both in their surgical management and in the final functional outcomes. Similar problems are encountered after surgical treatment when initially simple fractures fail to unite (nonunion) or are complicated by implant failure from previous internal fixation. The usual victims are mainly young men in their working age resulting in substantial loss in both manpower and economy⁹.

Currently diaphyseal femoral fractures in adults are best treated by surgery because of high rate of union, low rate of complications, and the advantage of early fracture stabilization which decrease the morbidity and mortality rates in patients¹⁰. Each patient's treatment must be selected with careful clinical considerations of the patient's health status at presentation, the level of emergent treatment needed, the available materials, and the surgeon's personal experience¹¹. Different types and modalities of surgical fixation were used. Compression plating and screws were extensively used in the past for fixation of diaphyseal femoral fractures but because of the extensive approach, periosteal stripping, potential blood loss, stress shielding (load sparing), and higher rate of complications (infections, nonunion and implant failure) associated with this type of fixation, other modalities of fixation especially interlocking nails are favored¹². Currently, antegrade reamed interlocked intramedullary nailing is the treatment of choice for diaphyseal femur fractures in adults, and is superior to plates fixation because the location of the rod in the medullary canal virtually guarantees proper axial alignment⁴.

In the literatures, the combined fixation (intramedullary nail augmented with derotation side plate) was used in proximal third fractures of tibia treated with intramedullary nail. Unicortical

plates had been used as a form of supplemental fixation to reduce the frequency of malalignment¹³. In the femur, Choi and Kimhad¹⁴ treated 15 patients with femoral nonunion after interlocking intramedullary nailing with AO plate augmentation on the lateral aspect of the femur and bone grafting leaving the nail in situ. All patients achieved radiological solid union at an average of 7.2 months.

Up to our knowledge, no article was found in the literatures about using this combined fixation technique in fresh fractures of femoral diaphysis.

We think that by combining intramedullary nailing with plate augmentation, the advantages of these two modalities of fracture fixation are obtained, and at the same time their potential complications and drawbacks will be avoided. The intramedullary nail will act as load sharing device, neutralizing the shear forces on the fracture, and maintain the general alignment of both the fracture and the limb. The augmented plate fixation will control continuous excess motion at the site of this complex, comminuted unstable fractures and thus provide stability of the fracture. With the use of short augmentation plates, the surgical approach is much less extensive when compared with the conventional plate technique and so avoiding the disadvantages of conventional plating such as, long operative time, excess blood loss, bone loss under the plate, fractures at the ends of the plate, re-fracture through the original fracture site and plate breakage or loosening.

The nonunion rate of 10% reported in this study after the use of combined fixation technique is comparable to the results of other studies using a single modality of fixation. Ricci et al¹⁵ retrospectively compared 104 diaphyseal femur fractures treated with retrograde intramedullary nailing and 94 treated with antegrade

intramedullary nailing. The nonunion rate was 6% for each. With conventional plate fixation the rates of nonunion are very variable, while Bostman et al¹⁶ reported 5% non union rate in their patients, a much higher nonunion rates of 46.7% were reported in a study performed by Seligson et al¹⁷.

Several points have to be stressed in performing such combined fixation in this current study. First there is still a place for using the classic Kuntcher nail in treating femoral fractures although the trend is towards interlocking nails. Botchu et al¹⁸ in their study of 100 patients with femoral shaft fractures managed with intramedullary nailing (either by Kuntscher nails or interlocking nail depending on the financial status of the patient) concluded that Kuntscher nails are cost effective and give an acceptable results in the management of femoral shaft fractures in a developing country. Our study also stressed that open nailing of Kuntscher nail in a retrograde direction can still be utilized in contrast to closed reduction and antegrade intramedullary fixation under fluoroscopy. The concept of open nailing was also stressed by Meenal et al¹⁹ in a study published in 2003 in India, open nailing without fluoroscopy was done in 62 and closed nailing under fluoroscopic control done in 46 patients. The union rate at 12 months period was 93% in closed nailing and 87% in open nails locked distally. Complications were the same as seen with closed interlocking nail involving limb length discrepancy, malrotation, infection, with added complication of failure to lock distal end in few cases. The authors concluded that results derived from open nailing of long bone fractures are comparable to that of closed nailing and have benefits on surgeons and patients. Third point is

the question of possible interference with the medullary and periosteal blood supply of the fractured bone by simultaneous application of intramedullary nail and augmentation plate. To minimize injury to vascular supply of the femur, this operation demands attention to important technical details; an essential point is to handle the tissues delicately with avoidance of all unnecessary trauma. We think that doing minimal stripping of soft tissues and periosteum on both sides of the fracture to a distance sufficient only to allow reduction of fractures and insertion of a short plate to the lateral or anterior sides of the bone, together without disturbing the attachment of periosteum to linea aspera will preserve some of the periosteal blood supply to the fractured bone. For restoration of medullary blood supply, extensive reaming of the bone should be avoided, reaming to allow passage of nail with a diameter of just 1mm larger than the diameter of isthmus of the injured femur should be used. Manual reamers rather than powered ones should be used to minimize damage to medullary blood vessels. The use of Kuntscher's nail (which is hollow throughout its length), rather than a solid nail will allow a space for medullary revascularization of the bone in the process of fracture healing.

Other complications reported in this study included infection, loosening or extrusion of single screw from the plate, and proximal migration of the Kuntscher nail. Deep seated infection had occurred in one patient (3.3%), treated by removal of the combined implant construct and exchange to external fixation. Most studies utilizing interlocking nailing in femoral fractures report less than 1% infection rate in contrast to 7% rate of deep seated infection following the use of conventional plate and screws¹⁶.

Implant failure or loosening of the augmentation plate was not reported in this study, in contrast to higher rates of implant failure of 3.5-12% (plate loosening, avulsion or breakage) reported in other studies using conventional plate and screws alone in the fixation of diaphyseal femoral fractures¹⁶⁻¹⁷. Loosening of a single screw from the augmentation plate (usually the most proximal one) but without affecting the mechanical stability of the composite fixation had been reported in 16.3% of cases in this study as a result of full weight bearing following fracture union. Even with the

use of interlocked nail fixation reports of loosening or breakage of locking screws had been reported²⁰.

In conclusion, the composite implant construct using combined nailing and augmentation plate is a reasonable alternative to interlocking nail for fixing complex and nonunited fractures of femoral diaphysis fractures. It gives more rigid and stable fixation than conventional plating and screws alone or nail alone with relatively few complications, this rigidity is crucial for early weight bearing and rehabilitation of patients following such difficult fractures.

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