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Research Article

Functional Outcome of Distal Femur Fractures Treated with Locking Compression Plate

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Abstract

Distal femur fractures have always posed a beneficial challenge to orthopedic surgeons. Variety of implants and modalities of fixation have been established over the years for management of these fractures. The aim of this study was to analyse the complications and clinical outcomes following fixation with locking compression plate as the treatment for distal femoral fractures. This is a prospective study in which 30 consecutive cases of the fracture of the distal femur, between the age of 18 -74 years, irrespective of sex were subjected to open reduction and internal fixation with locking compression plate and followed up for 1 year. Meantime for fracture union was clinically 16 weeks and radiologically 20 weeks. At the latest follow, up ROM > 110 is noted in 18 patients, 90-110 in 9 patients, and 75-90 in 3 patients. In our study, 19 patients had an excellent result; 6 had good; 4 had fair, and 1 had poor result according to Neer's Scoring system. Locked plating of Distal Femur fractures allows stable fixation and early mobilization. However, careful understanding of its basic principles and identification of suitable fracture pattern for use of locking compression plate is essential to avoid complications like malalignment, infection and non-union and delayed union.

Introduction

Approximately 37 per 1,00,000 person-years is the incidence of distal femur fractures [1]. They are usually sustained by high energy trauma, especially in road traffic accidents. Open injuries with significant comminution of condyles and metaphysis are frequently seen. In low energy trauma, seen in elderly patients with severe osteoporosis frequently presents as a peri-prosthetic fracture. In high-energy trauma, the difficulty of restoring the function in a destroyed knee joint is a major challenge. In addition, complex ligament injuries are frequently present. In elderly patients, extreme osteoporosis also creates a hurdle for anchoring the implant [2]. In olden days, such fractures were managed with Thomas splint [3]. Most of the surgeons, in today's era, believe that distal femur fractures need an operative intervention to achieve optimal patient outcomes [4]. Though good internal fixation results have already been reported with these fractures over 30 years ago; the number of revisions for non-union, implant failure and loss of reduction is also high [2]. The operative interventions available are conventional plating techniques that require compression of the implant to the femoral shaft (blade plate, Dynamic Condylar Screw, non-locking condylar buttress plate), antegrade nailing fixation, retrograde nailing, sub muscular locked internal fixation, and external fixation [4]. Double plating, and more recently, locked plating techniques have been advocated. However, double plating results in extensive soft tissue and periosteal stripping on both sides of the femur, resulting in decreased blood supply and increased chances of non-union and failure of the implants [2,5,6]. Most commonly preferred implant for distal femur fractures fixation are Fixed angle devices, usually in the form of Dynamic Condylar Screw (DCS) system, which is a supracondylar plate combined with a lag screw. This two-piece construct is more lenient and allows correction in the sagittal plane after the lag screw is inserted [7,8].

The locking compression plate is a single unit device whose biomechanical principle is splinting rather than compression which results in flexible stabilization, thus avoiding stress shielding and induces the formation of a callus. In addition, when it is applied via a minimally invasive technique, it allows rapid healing, fewer chances of infection and decreased bone resorption as the blood supply is preserved [9]. Internal fixation with locking plates

creates a toggle free, fixed angle construct [10]. The institution of plates with the option of locked screws offers the means to increase the rigidity of fixation in osteoporotic bone or in the presence of periarticular or juxta-articular fractures with a small epiphyseal segment [10]. The implant provides multiple points of fixed-angle contact between the plate and screws in the distal part of the femur, theoretically reducing the tendency for varus collapse that is seen with traditional lateral plates [10]. The DF-locking compression plate is a further advancement from the LISS in which the shaft holes are oval on the DF- locking compression plate, thus allowing for the options of a compression screw or a locking screw. This leads to more precise placement of the plate, as it can be compressed more closely to the bone [2,11].

The study is justified for the fact that it will be one of the solutions for the age-old complications associated with the treatment of supracondylar fractures with traditional fixed angle plates and nails, postoperative loss of reduction (varus collapse) and malalignment due to their inherent lack of rigidity and in some cases, eventual implant failure. Since there have been no published studies focusing specifically on the locking compression plate condylar plate. This study will help us in defining the role of locking condylar plate in the treatment of distal femur fractures in terms of functional outcome, effectiveness and complication of distal end of the femur treated with locking compression plate based upon infection rate, rate of union, time taken for union, varus and valgus malalignment and failure of fixation.

Materials and Methods

A prospective study was carried out where all the patients enrolled in the hospital were included in the study based on the inclusion and exclusion criteria during the period of February 2016 to February 2017. The study involved both male and female patients with a supracondylar femur fracture. In present series 30 consecutive patients of supracondylar femur fracture operated with locking compression plate, satisfying the inclusion criteria were included. The study included those above 18 years with stable or unstable, comminuted or intra-articular fractures of the distal femur with no distal neuro-vascular complication and managed surgically. The Locking compression plate and screws are manufactured from 316 L stainless alloy with gun drilling technique were used. They are anatomically pre-contoured plate. Pre-operative work-up was done as required for fitness and anesthetic evaluation. Fractures were classified with the help of radiographs according to the AO-ASIF classification. Preoperative calculation was done on radiographs to ascertain the size of the plate, accurate size of locking, cortical and cancellous screws after subtraction of the magnification factor. The limb to be operated was prepared. One gm of third generation cephalosporin was injected 10 minutes before surgery.

Surgery was carried out in a supine position on a radiolucent table with a pillow below the knee, the entire injured extremity and ipsilateral iliac crest are prepared and draped. Tourniquet applied and inflated. The lateral approach to distal femur was taken. Minimal Stripping of soft tissue necessary for the application of the plate and reduction of the articular surface was done. Firstly, the condylar reduction was made with the aid of a Steinmann pin and levering it to restore the articular surface and patella-femoral groove. They were fixed with a 6.5 mm cancellous screws from lateral to medial, taking care not to interfere with the subsequent path of other cancellous screws of locking compression plate. Secondly, the condyles were reduced with respect to the shaft. When using the plate as a reduction aid, the compression screw draws the bone towards the plate and uses the contour of the plate to reduce the fracture in the coronal plane. Once the fracture was reduced, supplemental locking screws were then added to create a fixed-angle construct. Post-operatively, the patient's vitals were monitored. Splints were removed, and mobilization was started on 3rd or 4th day post-op which included non-weight bearing walking till 8 weeks, followed by partial weight bearing was recommended after signs of early callus till fracture union. All patients were followed up at 4th 10th 14th 18th week, 6 weeks, 6th month, 9th month and 1 year. During the follow up patients were assessed clinically, radiological and functionally by NEERS criteria.

Results

In our study which was prospective; consisted of 30 supracondylar femur fractures treated with locking compression plate. Patient follow-up for 12 months. Twenty-one patients were males and nine were females (Table 1). The patients' ages ranged from 18 to 74 years with a mean age of 44 years (Table 2). Twenty fractures involved the right side, and ten involved the left side. The causes of fractures were motor vehicle accident in nineteen patients and a domestic fall in remaining eleven (Figure 1). All of them had acute fresh fractures. According to Muller's classification of distal femur five were Muller's type A1; nine Muller's type C1; ten Muller's type C2; and six Muller's type C3. Twenty-six of them had closed fracture and four open type fractures.

Sex	Lower End Femur	Percentage
Male	21	70%
Female	9	30%

Table 1: Gender Distribution.

Age in Years	Lower End Femur	Percentage
18 - 30	9	30%
31 - 40	4	13%
41 - 50	6	20%
51 - 60	3	10%
Above 60	8	27%
Total	30	100%

Table 2: Age Distribution.

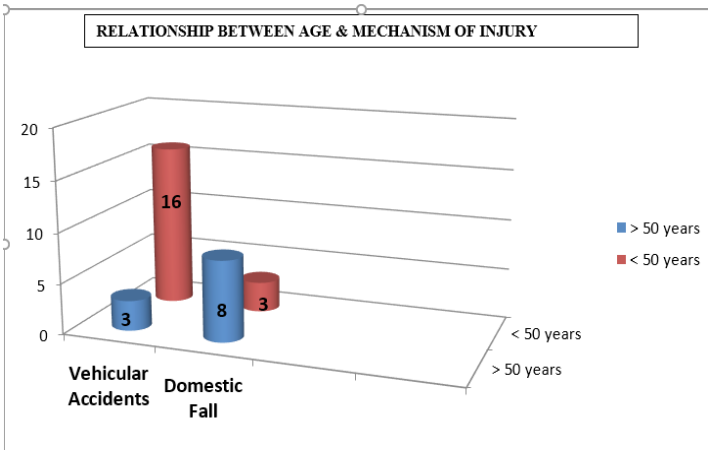


Figure 1: Relationship between Age and Mechanism of Injury.

Nine patients had associated injuries. One patient had same side 5th rib fracture and 5th - 6th ribs fractures was seen in three patients. One patient each of ipsilateral mandible fracture, both bones i.e. radius and ulna fracture, humerus fracture, patella fracture, ulna fracture. One patient had associated head injury. All associated injuries were treated at the same timing accordingly. Twenty-six patients were operated within 7 days of injury. Of the four patients for whom surgery was delayed more than 7 days, are those patients who had an open wound which was managed initially with AO External Fixator then ORIF with locking compression plate done on 11 POD. The operative time ranged from 90 minutes to 240 minutes with an average of 140 min. This is because few patients had associated injuries like mandible fracture, humerus fracture, patella fracture and radius and ulna fracture. In addition, anesthetist gave in few patients Fascia Iliaca block for post-operative pain management after the surgery which added to surgical time. The size of the plate used for fixation varied from 4 holed to 12 holed depending on fracture pattern. But commonly used size was 7-9 holed plates. Average blood loss was 200 ml.

Four patients had primary bone grafting at the time of surgery of which one patient had allogeneic bone graft. We did primary bone grafting in 4 elderly patients who had severe intra-articular comminution with osteoporosis. Of 30 patients, 26 Patients (87%) showed radiological union within 20 weeks. Mean time for Radiological union was 16 weeks (Figure 2). Partial weight bearing was started at an average 6-8 weeks after surgery when there were early signs of callus formation. Full weight bearing was started on an average 12-14 weeks after surgery as per union seen on roentogram and patient's tolerance (Figure 3). Average flexion in this study was 115 degrees with more than 63% patients having knee range of motion more than 110° (Figure 4). In our study, two patients (7%) had superficial infection which was managed conservatively with intravenous antibiotics. We observed one patient each with varus and valgus malalignment.

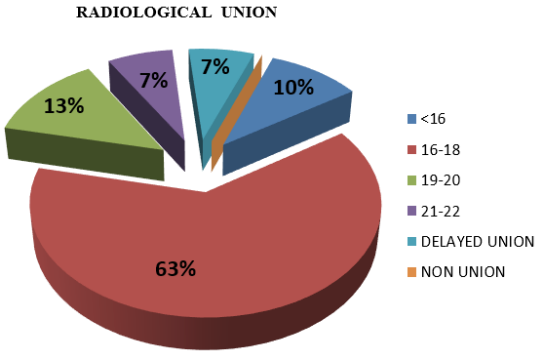


Figure 2: Mean Time of Radiological union.

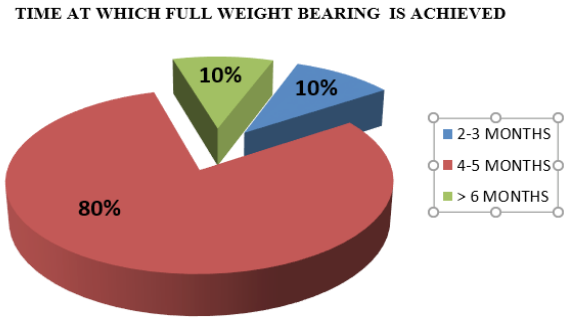


Figure 3: Achievement of Full Weight Bearing (in months).

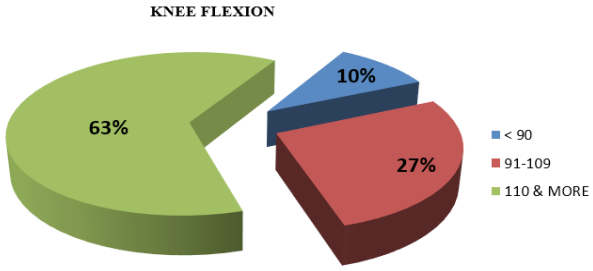


Figure 4: Knee Range of Movement.

The functional outcome was assessed at the end of one year using Neer's scoring system as excellent in 19 (64%), good in 6 (20%), fair in 4 (13%) and poor in 1 (3%) (Figure 5). Out of 30 patients, twenty-eight patients had an excellent to fair results with no major complications. Only one patient had a poor outcome which contributed for 3% of varus malalignment.

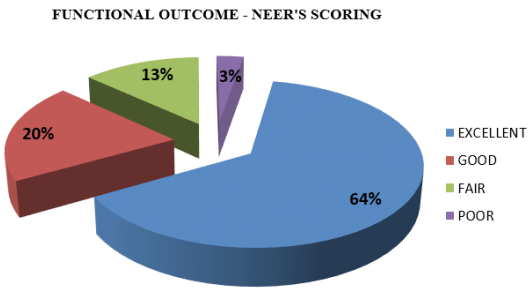


Figure 5: Functional Outcome using Neer's Score.

Discussion

Our study consists of thirty patients with distal femur fractures who underwent surgery using a locking compression plate. The overall outcome was evaluated in terms of regaining the lost knee function using NEER'S Score. In our study, 30 supracondylar femur fractures were treated. All cases were fresh trauma. 21 patients were males and 9 patients were females. The median age was 44 years; ranging from 18 to 72 years. Out of these, 11 of the fractures were caused by domestic fall and 19 were due to road traffic accidents. Road traffic accident as a mechanism of injury was observed more commonly in younger males and domestic fall was seen commonly in elderly females. 20 patients were with a fracture on right side and 10 on left side. The Epidemiology of group is consistent with previous studies. We compared our outcomes with standard studies, and found the following similarities. In a retrospective evaluation of Less Invasive Stabilization System plate (LISS) fixation for 103 distal femur fractures, Kregor, et al. [9] reported a 93% union rate without secondary bone grafting. The remaining 7 cases went on to uneventful union after bone grafting procedures. At a mean follow-up of 14 months, the mean knee range of motion in this cohort was 1 to 109 degrees. Implant failure in the form of proximal screw loosening occurred in 5 cases, each requiring revision surgery.

In a study by Schutz M, Muller M, et al. [12], Internal fixation using the Less Invasive Stabilization System (LISS) was performed at an average of 5 days (Range: 0-29 days) after the injury. 48 fractures underwent surgery within the first 24 hours. Revision operations were required for 2 cases of implant breakage. 4 cases had implant loosening and 7 debridement's were needed to deal with infections. Their study showed clearly that when working with LISS, primary cancellous bone grafting was not necessary. The total follows up rate was 93%. Vallier, et al. [13] in his study concluded that locking plates should only be used when conventional fixed-angle devices cannot be placed. They noted the significant added cost of locking plates. To decrease the risk of implant failure with locking plates, they recommended accurate fracture reduction and fixation along with judicious bone grafting, protected weight bearing, and modifications of the implant design. Zlowodzki, et al. [4] combined these series (n=327) and evaluated the outcomes as part of a systematic literature review. Average nonunion, fixation failure, deep infection, and secondary surgery rates were 5.5%, 4.9%, 2.1%, and 16.2% respectively. Some of the technical errors that have been reported for fixation failure have involved waiting too long to bone graft defects, allowing early weight bearing, and placing the plate too anterior on the femoral shaft.

Yeap E.J. and Deepak A.S [14] conducted a retrospective review on eleven patients who were treated for Type A and C distal femoral fractures (based on AO classification) between January 2004 and December 2004. All fractures were fixed with titanium distal femoral locking compression plate. The patient's ages ranged from 15 to 85 with a mean of 44. Clinical assessment was conducted at least 6 months post-operatively using the Schatzker score system. Results showed that four patients had excellent results, four good, two fair and one failure. Min BW, et al. [15] demonstrated that the radiological and clinical results of MIPO with locking compression plate were not inferior to ORIF and resulted in fewer intraoperative complications than ORIF. Similarly, Xing W, et al. [16] showed that 90% of the distal femur fracture fixation had an excellent outcome using a locking compression plate through a posterolateral approach. In our study, we treated 30 cases of distal femur fractures with an average age of 44 years. The average union time was 16 weeks. The time required for surgery ranged from 90 to 240 minutes. This is because few patients had associated injuries like mandible fracture, humerus fracture, patella fracture and radius and ulna fracture (Master Chart: Case number 10, 18, 21, 24, and 28) which were fixed at the same time with distal femur fixation. In addition, anesthetist gave in few patients Fascia Iliaca block for post-operative pain management after the surgery which added to the surgical time. We did primary bone grafting in 4 elderly patients who had severe intraarticular comminution with osteoporosis. The size of the plate used for fixation varied from 4 holed to 12 holed depending on the fracture pattern. But commonly used size was 7-9 holed plates. 7% had superficial infections, 3% each of varus and valgus malalignment. We had two cases of delayed union. On analyzing it retrospectively we believe the reason for a delayed union was due to preexisting anemia and diabetes. In our study, partial weight bearing was started at an average 6-8 weeks after surgery when there were early signs of callus formation. Full weight bearing was started on an average 12-14 weeks after surgery as per union seen on roentogram and patient's tolerance. At a follow-up of 12 months, the mean knee range of motion in our study cohort was 0 to 115 degrees. Functional outcomes at the end of one year were assessed using Neer's scoring system. Results were excellent in 19 patients (64%), good in 6 (20%), fair in 4 (13%) and poor in 1 (3%). In our studies, functional results are close to the functional results achieved in other studies, but the rate of complications is less (Table 3).

AUTHOR	NUMBER	OPEN # (%)	MEAN AGE (YRS)	F/UP (MON)	ROM	BONE GRAFT (%)	UNION (WKS)	INFECTON (%)	IMPLANT FAIL (%)	MALALIG-NMENT (%)
Schutz, et al. [6]	99	29	54	13.7	0 -107	6	N/A	7	6	1
Schande-Lmaier, et al. [2]	54	18.5	N/A	6	104	-	14.3	1.9	7.4	13
Kregor, et al. [5]	66	N/A	49	9	2 - 103	5	11	3	1.5	5
Fankhauser, et al.	30	46.7	57	20	4 - 113	-	12	-	10%	-
Schutz, et al. [6]	66	32	52	12	112	9	N/A	3	4.5	37
Markmiller, et al. [17]	20	N/A	57	12	0 - 110	-	13.8	-	10	15
Kregor, et al. [9]	103	34	52	14	1 - 109	7	12	3	5	6
Wong, et al.	16	-	75	23	N/A	-	30	-	12.5	-
Yeap, et al. [14]	11	36	44	9.7	1 - 107	18.2	18	9	-	9
Our Study	**30**	**13**	**44**	**12**	**0 - 115**	**13**	**16**	**7**	**-**	**7**

Table 3: Comparison of Our Study with Previously Published Study on Distal Femur Fractures.

The institution of locking compression plates with the option of locked screws has provided the means to increase the rigidity of fixation in osteoporotic bone or in the presence of periarticular fractures. Operative time has drastically reduced when using Locking Compression Plate as surgical dissection is kept to a minimum. Surgical time can further be reduced if Less Invasive Stabilization System (LISS), Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique is used this may be initially difficult and needs expertise. The device offers good angular stability based on the principle of triangular reconstruction and thus allows early mobilization, even in comminuted fractures where other modes of fixation often tend to delay the process of mobilization because of lack of stability. Perhaps one of its greatest applications is in osteoporotic fractures, where it may offer an answer to the age-old problems of screw cut out, late collapse, and malalignment since the stability of the construct does not entirely depend on the quality of the bone. In contrast to other studies where locking compression plate was used, our study used the plate through open reduction technique. However, when compared with other techniques of plating through open reduction technique the soft tissue damage is considerably less since periosteal stripping and soft tissue exposure can be kept to a minimum. Use of Locking Compression Plate through Less Invasive Stabilization System (LISS) and Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) would probably further decrease the amount of soft tissue trauma. It must be kept in mind that careful intraoperative attention should be given to restoring alignment in all planes. Restoration of both medial and lateral columns is necessary to prevent complications. Possible reasons for implant failures include technical errors in plate placement and early weight-bearing in the presence of delayed fracture union. In our practice, we use bi-cortical, non-locked screws in the proximal portion of the locking compression plate which might improve pull-out strength compared with that provided by the uni-cortical locked screws of the LISS. Former studies involving LISS do not recommend primary bone grafting. In our opinion, sensible use of bone graft or bone-graft substitutes would enhance the healing response and decrease the potential mechanical failure and varus collapse, especially in elderly patients. In our institution, we also practice use of nail in supracondylar femur fracture. But the major challenge is difficulty in correcting rotation, varus and valgus malalignment. With the introduction of locking compression plate, this difficulty has been overcome.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

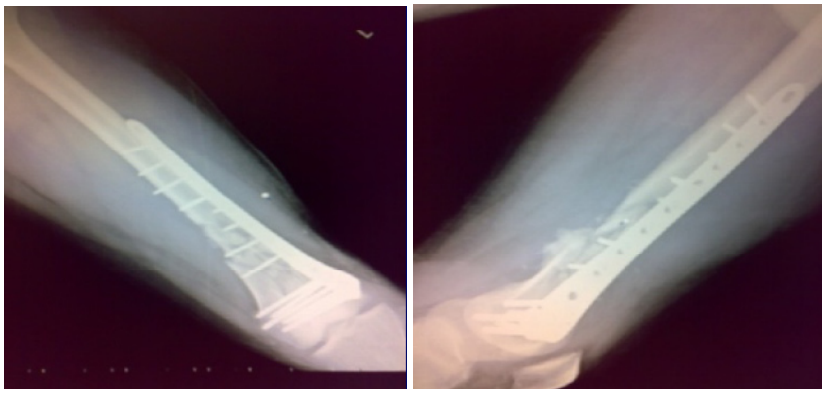
Data Availability

All data generated or analyzed during this study are included in this article.

Supplementary Materials

(Muller Type C 3 Lower End of Femur Fracture)

Pre-Op X-Ray **Post-Op X-Ray**



6 Weeks Follow Up

1 Year Follow Up X-Ray **Clinical Photo at End of 1 Year**

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