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Functional outcome of fixation of distal femoral fractures with DF-LCP: a prospective study

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ABSTRACT

Background: Management of supracondylar fractures is a real challenge to the orthopaedician due to its extensive soft tissue injury, boneloss, comminution, articular extention and instability. Open reduction and internal fixation with anatomical distal femoral locking plate permits early mobilization. Stable anatomical fixation is necessary to avoid complications and disability.
Methods: 25 patients with Type A and Type C closed supracondylar femoral fractures were followed up from November 2013 to November 2015. All the patients underwent ORIF with DF-LCP. Clinical and radiological follow up were recorded for 24 months.
Results: Mean time for fracture union was 4.02 months. Average duration for full weight bearing was 122 days (range 90-180days). The average range of movement for Type A fractures was 105.71 degrees, for C fractures average ROM was 93.64 degrees. Average ROM for patients <50 was 103 degree and for patients>50 ROM was 98.66 degree.
Conclusions: Locked plating of DF fractures permits stable fixation and early mobilization which avoids disability and ensures good joint function.

Keywords: Distal femoral fracture, DF-LCP, Functional outcome, Neer's score

INTRODUCTION

Fractures of the distal femur are complex injuries that can be difficult to manage. They are serious injuries having the potential to produce significant long-term disabilities. Distal femoral fractures are much less common than hip fractures and account for about 7% of all femoral fractures. If fractures of the hip are excluded, 31% of femoral fractures involve the distal portion.[1] These fractures are defined as those fractures involving the distal 15 cm of the femur including the metaphysis and/or the articular surface. Because of severe soft tissue damage, extensive comminution, intrarticular extension and injury to quadriceps mechanism, the management of these fractures has presented significant challenge to orthopaedic surgeons since the beginning of this speciality. However, for proximal fractures of femur, orthopaedic literature is embellished with extensive experience with specific methods. The distal femur is not well suited for internal fixation. A widening canal, thin cortex and poor bone stock make open reduction in this area a great challenge. Watson Jones noted that "Few injuries present more difficult problems than supracondylar fracture of the femur".[2]

Most studies regarding the management of distal femoral fractures in the past have attempted to compare the results of non-operative with surgical interventions. Before the development of techniques and implants to provide stable fixation, most fractures of this region were treated with skeletal traction.

Studies done in the 1960s documented better outcomes for patients treated non-operatively than for those treated

operatively. However, complications of non-operative treatment included angular deformity, joint incongruity, knee stiffness, and delayed patient mobilization.

In the 1970s, the AO (Arbeitsgemeinschaft fur Osteosynthesefragen) principles and the use of the angled blade plate revolutionized the treatment of these injuries. Over the past 30 years, implants and techniques have improved. It is now recognized by most orthopaedic surgeons that distal femoral fractures are best treated with reduction and surgical stabilization. Anatomic reduction of the articular surface, restoration of limb alignment, and early mobilization have been shown to be effective ways of managing most distal femoral fractures. Despite the advances in techniques and the improvements in surgical implants, treatment of distal femoral fractures remains a challenge in many situations. Long term disability can still occur in patients with extensive articular cartilage damage, marked bone comminution, and severe soft tissue injury.[3,4]

METHODS

The patients evaluated in this study include prospective groups. For a fracture to be included in this series, fracture line should be within 15cm from the distal articular surface of the femoral condyles.

- Prospective groups- includes those newly admitted cases following the fracture within the time period, November 2013 to November 2015 in our institution.
- Sample size- 25 patients

Inclusion criteria

Patient of both sexes in the age group more than 18 years, closed fractures, extrarticular distal femur fractures with or without intra-articular extension based on AO/OTA classification (A1, A2, A3, C1, C2 and C3).

Exclusion criteria

Age group less than 18 or more than 80 years, pathological fractures, patients with other associated injuries like head/ chest/ abdominal/ major vascular injuries which precluded early surgery.

Patients satisfying the above criteria were admitted in our ward through casualty and initial x-rays were taken to define the type and extent of fracture according to AO/OTA classification system. A general anaesthetic work up was carried out and those who were fit for surgery were subjected to immediate fixation of the fracture, at the earliest. Those patients who needed further evaluation for surgical fitness were sent to the orthopaedic ward with upper tibial skeletal traction done under local anaesthesia and operated as an early elective procedure, once they were fit for surgery.

Technique

We used fixation of fracture with 4.5 mm DF-LCP locking plate through lateral approach. A fracture table with traction was not used as the resulting muscle tension would make exposure and reduction more difficult. Instead a knee roll assisted the procurement and maintenance of reduction with patient on a radiolucent table in supine position. Under appropriate anaesthesia as decided by the anaesthetist adequate draping done. A convenient long incision was made over the lateral femoral condyle curving distally to the tibial tuberosity. Iliotibial band incised along the same plane. Vastus lateralis is elevated or split through the rent in the muscle developed due to trauma and lateral arthrotomy performed. Care taken not to injure the lateral collateral ligament.

Figure 1: Intraoperative photograph showing the surgical approach.

Figure 2: Intraoperative photograph showing elevation of vastus lateralis.

Figure 3: Intraoperative photograph showing fixation of plate.

Intercondylar type fractures were converted to a single condylar block under direct vision and temporary fixation was achieved by using Krischner wires. Fracture site reduced under direct visualization using bone holder and manual traction and fixed with 4.5 mm DF-LCP locking plate of adequate length. The intraarticular fracture reduction, plate length, axial and rotational alignment were checked and confirmed using image intensification. Fixation of fracture attained adhering to AO - LCP technique. Per op ROM, stability, alignment and limb length checked and recorded. Incision closed in layers after attaining haemostasis and keeping drain *insitu*.

We routinely used intravenous broad spectrum antibiotic pre-operatively and continued the same till 5th day of surgery. Drain kept was removed 24 hours after the procedure, check X-ray to assess reduction was taken and patients were put on static quadriceps exercises from the next day of surgery. Active assisted and active ROM along with active quadriceps and hamstring strengthening exercises were added from the 5th – 7th day of surgery, sutures were removed between 10-14 days and patients were allowed non-weight bearing crutch walking for 6 weeks.

All patients in our series were evaluated clinically and radiologically at frequent intervals of 6 weeks, 12 weeks, 18 weeks, 6 months, 1year and finally at 2 year or more frequently, if there was any complication. Patients were allowed partial and full weight bearing based on the radiological assessment of union at those follow ups. Functional outcome of our patients were assessed at final follow up with Neer's criteria as well as Knee Society Score. Statistical analysis was done using SPSS V.10.

RESULTS

Sex distribution

Out of 25 patients, 11(44%) were males and 14(56%) were females. Of the 11 males 6 got excellent result, 3 satisfactory, 1 unsatisfactory and 1 failure. Of the 14 females 4 got excellent, 9satisfactory, 1 unsatisfactory and no failures.

This shows that results were good in male than female. But on statistical evaluation using SPSS V.10. Chi-square value (χ^2) was found to be 4.10 and p value was 0.25 which is insignificant.

Laterality

Out of 25 fractures, 12 (48%) fractures were of right side and 13 (52%) belong to left side.

Age distribution

The youngest patient was 21 and the oldest was 78 years old. The average age was 51.24 years. The average age for male patients was 43.27 years and that of the female patient was 57.5. The peak incidence of whole series was 50-69.

In the final evaluation of 25 patients, in the age group 20-29, 3 excellent results were present. In the age group 30-39, there was 1 excellent and 1 satisfactory result. In the age group 40-49, there were 2 excellent, 1 satisfactory, 1 unsatisfactory and 1 failure. In the age group 50-59 there were 3 excellent, 2 satisfactory and 1 unsatisfactory result. In the age group 60- 69 there were 1 excellent, 5 satisfactory results. In the age group >70 there were 3 satisfactory results.

Result analysis shows outcome was better in 3rd and 4th decade when comparing age with outcome. But on statistical evaluation using SPSS V.10. Chi-square value (χ^2) was found to be 17.278 and p value was 0.303 which is insignificant.

Mode of injury

9 (36%) patients sustained fractures as a result of RTA, most commonly as either passengers or pedestrians in motor vehicle accidents, 6 (24%) from fall from height and 10 (40%) from domestic injuries.

Associated injuries

An injury to knee was associated with many of the 25 fractures; of these include 3 patellar fractures, 2 ACL injuries, 2 PCL injuries, 3 LCL injuries and 3 meniscal injury. Most of the ligamentous injuries were avulsion injuries (5 out of 7). Ligamentous repair was attempted at initial injury and all of them produced minor instability.

There were 3 patellar fractures, 2 of them being comminuted, ended up with patellecomy and 1 was treated by tension band wiring. The 2 calcaneal fractures and 1 spinal fracture were treated conservatively.

Pre-operative radiological classification

The AO/OTA classification system was used to classify the fractures. Out of the 25 fractures we had for final evaluation, Type A was 14 (56%) and Type C was 11 (44%).

Time delay between injury and surgery

The interval between injury and surgery varied between 10 hours to 14 days with a mean of 4 days. A delay in operation of more than one week is attributable to control of medical illness, or late transfer of patient from another institution.

Out of the 14 fractures treated on day 1, 6 had excellent, 7 had satisfactory and 1 unsatisfactory results. In the 1-5 days group there were 4 patients of which 1 had excellent, 2 had satisfactory and 1 failure as results. In the 6-10 days group there were 2 patients of which 1 had

excellent and 1 had satisfactory result. Of the 5 patients in 11–15 days group, 2 excellent, 2 satisfactory and 1 unsatisfactory results were obtained. On statistical evaluation using SPSS V.10. Chi-square value (χ^2) was found to be 7.03 and p value was 0.634 which is insignificant.

Type of anaesthesia

All 25 cases were done under spinal anaesthesia.

Position of patients and surgical approach

All patients were positioned supine and all cases were approached laterally.

Per-operative assessment of fracture

All the fractures were again classified after exposure. No change in fracture type noted compared to pre-operative radiological assessment. Inter condylar comminution noted in 2 cases. Out of the 14 Type A fractures, 7 had excellent 6 had satisfactory, 1 had unsatisfactory result. Out of the 11 type C fractures, 3 had excellent, 6 had satisfactory, 1 had unsatisfactory and 1 had failure as result.

Usual expectation is greater the comminution of the articular fracture, poorer is the outcome. But on statistical evaluation using SPSS V.10. Chi-square value (χ^2) was found to be 2.27 and p value was 0.518 which is insignificant.

Fixation device used

All 25 patients were treated by using 4.5 mm DF-LCP locking plate of same make by Lateral approach.

Per operative assessment of reduction and stability

Out of 25 cases, 15 (14+1→A1/A2/A3/C1) cases obtained anatomical reduction without any articular incongruency and fracture fixation was stable and rigid throughout the range of movement of knee (0-120). In 10 (C2/C3) cases there was minimal articular incongruency, but both fracture fixations (inter condylar and supra condylar) were stable and rigid throughout the range of movement of knee.

Skin closure

In all cases surgical wound was fully closed without tension with drain *insitu*, which was removed after 24 hours. Sutures were removed between 10-14 days.

Postoperative wound infection

There were 2 cases of superficial wound infection which responded to antibiotics and regular dressings. The only disadvantage of this was longer hospital stay. This has not prevented early mobilization.

There was 1 case of deep infection in our series, whose immunological status was compromised. With prolonged antibiotic therapy infection was controlled, but the fracture went for delayed union and plate bending.

Period of postoperative rehabilitation

The next day after surgery, patient was put on static quadriceps exercises. Active assisted and active ROM along with active quadriceps and hamstring strengthening exercises were added from the 5-7th day of surgery. Non weight bearing bilateral axillary crutch walking was taught for first 6 weeks. Partial weight bearing started at 6 weeks when X-ray showed callus formation. Full weight bearing started after 3-5 months when fracture was radiologically united.

Postoperative neurovascular complications

There was no case with neurovascular complications.

Duration of hospital stay

The average hospital stay was 14 days with a minimum of 10 days and maximum of 27 days. Most of the cases were discharged on 10th day after suture removal. Delayed hospital stay was due to associated medical illness or infection which needed inpatient care. Duration of hospital stay did not have any influence on the final outcome of the treatment.

Follow up

The mean follow-up time was 24 months. The average duration for fracture healing was 4.08 months. The average duration for full weight bearing was 122 days (range 90-180 days).

Pain

18 patients had no complaint of pain either at rest or during activity. 6 patients had pain during activity. 1 patient had pain throughout the range of motion.

Deformity and disability

10 patients who were graded excellent did not have any disability. Out of 12 patients who were graded as satisfactory, 7 had minimal disability due to limitation of extreme movement. Both the patients with unsatisfactory results have disability due to restriction of movement and intermittent pain. The 1 failure case had severe disability due to knee instability and severely restricted painful range of movement.

Deformity was not a major problem in this series. Out of the 25 patients treated, only 2 had a varus angulation of

>5 degree. Both had bend implant due to premature full weight bearing.

Limb length discrepancy

Out of the 25 cases, 21 patients had no significant LLD (</= 1), 2 patients had <2 cm LLD and 2 patients had >2 cm of LLD.

Range of movement

The average range of movement for Type A fractures was 105.71 degrees, for C fractures average ROM was 93.64 degrees. Average ROM for patients <50 was 103 degree and for patients>50 ROM was 98.66 degree. Average range of motion of the knee during follow up was 100.4 degrees (range 0-120 degrees)

Union of fracture site

Union of the fracture site at the intercondylar region and supracondylar region was complete at last follow up. 1 case had gone for scanty callus formation at the metaphyseal region. The patient was treated at 3 months by autogenous iliac crest bone graft and was united at 6th month.

Average time taken for radiological union was 18 weeks. No implant removal was done. We do not advice routine removal of them.

Complications

There were 2 cases of implant bending in our series. Final result of which was 1 unsatisfactory and 1 failure. There were 4 patients showing features of early post traumatic osteoarthrosis and all 4 of them were having type C3 fracture. Their results were 2 satisfactory, 1 unsatisfactory and 1 failure.

The knee society score was used to quantitate the final functional outcome of the knee. Neer's criteria was used for overall functional rating.

- Excellent >85
- Satisfactory >70
- Unsatisfactory >55
- Failure <55

Though at follow-up Type A fractures has resulted in better knee functional outcome than Type C. On statistical analysis using SPSS V.10 Chi-square value (χ^2) was found 17.42 and p value was 0.294 which is insignificant.

Overall rating

The cause of insignificance on statistical analysis in our study may be due to, either the technique and the implant used for surgery gives good result irrespective of other variables or the study group was inadequate for each individual fracture pattern.

DISCUSSION

Current fracture patterns veer towards complex comminuted types due to the prevalence of high speed vehicles. Improved healthcare results in a longer lifespan and subsequently presents us with more osteoporotic fractures which were previously treated using conservative methods. The LCP is a single beam construct where the strength of its fixation is equal to the sum of all screw-bone interfaces rather than a single screw's axial stiffness and pullout resistance as in unlocked plates. Its unique biomechanical function is based on splinting rather than compression resulting in flexible stabilisation, avoidance of stress shielding and induction of callus formation.[8] When applied under proper technique, it allows for prompt healing, lower rates of infection and reduced bone resorption as periosteal blood supply is less impaired. The 4.5 mm DF-LCP is a further development from the Less Invasive Stabilisation System (LISS), which was introduced in the mid to late 1990's.[9,10] The main difference between the 4.5 mm DF-LCP and the LISS is that the LISS utilises an outrigger device for shaft holes, functioning essentially as a locking guide JIG, which is attached to the distal part of the plate and guides the placement of the proximal locking screws. The shaft holes on the 4.5 mm DF-LCP are oval combiholes allowing the options of a compression screw or a locking screw. This leads to a more precise placement of the plate, as it is able to be compressed more closely to the bone.

Our cases did not demonstrate any irritation of the ilio-tibial tract which caused pain so severe that it necessitated removal of the implant.[8,11] This could be because we did not use the outrigger device, and are therefore better able to approximate the distal portion of the plate to the bone, ensuring that prominent hardware did not become an irritation to the ilio-tibial tract. Comparable studies utilizing the LISS demonstrate similar short term results.

Although the follow-up period of our series was short, studies have shown that early function is comparable to final long term outcome. The outcome seems not to correlate with aetiology, bone quality, fracture severity, length of time elapsed from injury to surgery and concomitant injuries, if fracture is well stabilized with good articular reduction and early mobilization.[12]

The definitive long term prognosis remains unknown as of today, as the earliest LISS was implanted in the mid to late 1990's. Furthermore, the initial severe concomitant cartilage damage may predispose to early osteoarthritis.[13]

In osteoporotic bones, use a longer plate and bicortical anchoring on the shaft.[12,14,15] Loosening of the plate is

usually due to misjudgement of the lever-arm or bone quality, but can also be due to improper positioning of the plate or screws.[12]

Recent attention has been directed to the concept and benefits of a biologic fixation technique in which the emphasis is on soft-tissue sparing, preservation of vascular attachments to fractured bony fragments, maintenance of fragment viability, and the use of specific implants and reduction aids to enhance operative treatment and healing characteristics of fractures.[16-18]

With the correct application of LCP fixation techniques, early fracture callus has been shown to occur, and the need for supplemental bone grafting often is avoided.[19,20] If the soft tissues are preserved, bone grafting may be unnecessary even in fractures with large defects. Even though we have limited numbers in this series, the favorable results were achieved without bone graft in all cases except one. Ostrum et al reported a union rate of greater than 86% without primary bone grafting.[21] Leunig et al recommended bone grafting for large metaphyseal defects to prevent the loss of articular reduction and for open fractures with extensive traumatic devascularization or segmental bone loss and a questionable healing potential.[22] We believe that it also is reasonable to perform a secondary bone graft procedure when a certain area of fracture does not show evidence of healing on routine plain radiographs over several consecutive weeks, because patients can commence passive and active range-of-motion exercise just after the operation.

Even though the restoration of early and complete function by internal fixation is important, the optimum requirements needed for bone healing now take precedence. This is also an important fact in distal femoral fractures, which need a certain amount of stability to start early controlled mobilization of the knee. Using the LCP, we could start early mobilization of the knee joint without early mechanical implant failure. Most patients showed flexion over 90 degrees, with good functional outcomes. As expected, the functional knee range of motion was related to the intra-articular fracture.

Before LCP, the less invasive stabilization system (LISS) has been introduced for the treatment of complex fractures of the distal portion of the femur, and Kregor et al showed a high rate of union and a low rate of infection with its use.[8] The LISS also allows for percutaneous placement of self-drilling cortical shaft screws, locked fixed-angle screws, and submuscular placement of the plate.[23] It is also known to have an enhanced ability to withstand high loads.[24] But clinicians found that this technology was too restricted in most cases and that an all purpose implant system would offer greater flexibility and resulted in evolution of LCP.[6,7]

On comparing our study with that of Yeap et al, Study group included 11 patients within age group 15 to 85 years treated with 12 DF-LCP.[25] Follow up period was from 6 to 15 months, average time taken for union was 18 weeks, average flexion attained was 107.7 degree thus the results were comparable.

Table 1: Comparing different studies of distal femoral fractures treated with LISS.

Author	Cases	Age	Follow up	ROM
Kregor et al	66	49	9 months	2-103
Schandelmaier	54	NA	6 months	104
Schutz et al	99	54	13.7	0-107
Fankhauser et al	30	57	20	4-105
Kregor et al	103	52	14	1-109
Markmiller et al	20	57	12	0-110
Weght and Collinge	22	44	18	5-114
Shutz et al	66	52	12	112
Wong et al	16	75	23	104
Yeap and Deepak	11	44	9.7	1-107.7

On comparing our study with LCP and a study by Jeon et al using DCS, there were several limitations with use of the DCS compared with the LCP.[26] First, the straight plate of the DCS sometimes did not match the anatomic anterior bowing of the femur. This made screwing the proximal diaphyseal area difficult and sometimes resulted in decreased anterior bowing of the femur. However, major malalignment did not occur in their study and results were comparable.

Retrograde intramedullary interlocking nailing is another biologic treatment tool for selected supracondylar femoral fractures.[5,27,28] But drawback is it may damage articular cartilage in the injured knee joint.

Thus plating with the 4.5 mm LCP condylar plate is a feasible and worthwhile method of fixation that provides promising results with few complications in the treatment of distal femoral fractures.

CONCLUSION

Results are good even in elderly with early internal fixation using 4.5 mm DF- LCP plate for distal femoral fractures. Surgery within first two weeks yields good results. Comminution of the intra articular fracture adversely affects the results. Per operative intraarticular reduction, alignment and stability is an important factor in determining the end result. Intra articular comminution is not unsuitable for internal fixation. Unstable and incongruent reduction resulted in poor outcome. LCP technique of fixation offers good compression for intra articular fragments and adequate stability. Surgeon must be well versed in the AO–LCP technique and should adhere to the principles throughout fixation. The 4.5 mm

DF-LCP is designed to achieve the rigidity of a fixed angle device without sacrificing flexibility. Less bone is required to implant 4.5 mm LCP condylar plate when compared with traditional fixed angle devices and has tremendous advantage in extensively comminuted fractures and in patients with osteoporotic bone. Conventionally it is said that undisplaced fractures have good results comparing displaced fractures. Displaced fractures with intra-articular extension also have fair prognosis. Incidence of complication is less, when displaced fractures are treated operatively. Primary or secondary bone grafting may be necessary with severely comminuted fractures. Rigid flexible internal fixation and early post op rehabilitation are the key factors for a better functional outcome. Complications like neurovascular injury, nonunion, traumatic arthritis, significant malunion etc. are rare. Incidence of infection can be taken care off with proper antibiotic prophylaxis and aseptic theatre precautions. So finally to conclude the 4.5 mm DF-LCP is a good implant to use for fractures of the distal femur. However, accurate positioning and fixation are required to produce satisfactory results. We recommend use of this implant in Type A and C and also in osteoporotic fractures. Our early results are encouraging but long term studies are needed to prove comparable or better outcome so that the technique can become a part of the armamentarium of the orthopaedic trauma surgeon.

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