# Discussion

Distal femoral fractures represent 0.4% of all fractures and about 6% of femoral fractures. Supracondylar intercondylar fractures are difficult to treat successfully as they are often comminuted, unstable, and associated with injury to the quadriceps mechanism. Not only the articular but also the non-articular supracondylar fracture requires anatomical reduction in order to restore the functional and the mechanical axis of the extremity. Moreover, a stable internal fixation that allows early function is required in order to avoid stiffness of the knee joint. [(67)]

Historically, the majority of supracondylar fractures were treated conservatively where traction achieved acceptable results but exposed the patient to the risk of prolonged bed rest, persistent angular deformity, knee joint incongruity, and loss of knee motion. [(37)]

With the improvement of internal fixation devices, operative treatment is now recommended for most fractures of the distal femur. The goals of operative treatment are anatomical alignment, stable fixation, rapid mobilization and early functional rehabilitation of the knee. [(41)]

The locking compression plate (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 in unlocked plates. Thus, it acts as an internal fixator which prevents crushing of the periosteal vessels. Its unique biomechanical function is based on splinting rather than compression resulting in flexible stabilization, avoidance of stress

shielding and induction of callus formation. When applied via a minimally invasive technique, it allows for prompt healing, lower rates of infection and reduced bone resorption as blood supply is preserved. [80]

The locking head screws distally have prevented varus collapse, even in cases of osteoporosis. Locking head screws both proximally and distally have made loss of fixation rare. [80]

The choice of implant is likely to depend on several factors, including bone quality, fracture type, fracture pattern, degree of comminution, articular involvement and surgeon preference. [90]

Plating techniques remain the mainstay for managing most periarticular and selected long bone fractures. However, movement toward more biologically appropriate plating techniques is occurring in an attempt to minimize soft-tissue stripping, decrease the need for bone grafting, and improve union rates. Internal fixation with locking plates creates a toggle-free, fixed-angle construct. [90]

Early data on the biomechanical and clinical performance of these implants are encouraging. Current indications for locked plating include periarticular fractures, typically those with metaphyseal comminution.[90]

Although impressive union rates have been reported, malunion remains a concern, especially when percutaneous techniques are used. Further clinical and biomechanical research on locking plate technology is needed to define its place fully alongside existing technology in orthopedic trauma. [90]

Provided it is applied with proper understanding of biomechanics, LCP is one of the best available options for management of challenging peri- and intra-articular fractures. [90]

The LCP can be used in either an open, or a minimally invasive manner. When inserted in an open manner, a lateral approach is used. This is most commonly done for an A-type or C1/C2-type fracture. [80]

The aim of our study was to assess the results of the treatment of distal femur fractures using the distal femoral locking compression plate (DF-LCP) through the standard lateral approach to the distal femur and direct reduction of the fracture under vision.

In our study, DF-LCP was a suitable method of treatment not only for simple distal femoral fractures but also for complex fracture, with good functional results. Its complication rate was low, probably because our patients were relatively young, and both the bone quality and the surgical technique were good.

Our results compare well with other series, in terms of postoperative functional scores and complication rates.

There is no statistical significant difference between our results compared with those reported in most recently published series [58, 67, 69, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100] in terms of postoperative functional scores and complication rates.

In our study, 20 distal femoral fractures were fixed by a DF-LCP through the same standard lateral or antero-lateral approach. The patient's ages ranged from 25 to 92

years with a mean age of 59 years which is slightly different than the comparative studies. The causes of fractures were sever high energy trauma in twelve patients either due to RTA or fall from height and eight patients sustained low energy trauma, The average number of days from injury to surgery was 4.5 days with a range of 1 to 15 days. Patient follow-up ranged from 6 months to 12 months with an average of 9 months which is almost similar the comparative studies.

Healing was achieved in 100% of cases with satisfactory clinical outcomes in 11 cases (55%) achieved excellent and good score. The average time of union was 14 weeks with a range from 10 weeks to 22 weeks. No bone graft was used in any patient. The average time for full weight bearing in our study was 4 months. The mean knee flexion was 118.25°.

On comparison with the series presented by Yeap and Deepak [(90)] included 11 distal femoral fractures fixed by a distal femoral locking compression plate (DF-LCP) through a standard lateral approach. The patients' age ranged from 15 to 85 years with a mean of 44 years. The causes of fractures were motor vehicle accident in seven patients and a fall in four patients. One patient sustained multiple fractures including lung injury.

The average number of days from injury to surgery was 9.9 days with a range of 4 to 19 days. Patient follow-up ranged from 6 months to 15 months with an average of 9.7 months. They reported an average time to union of 18 weeks with a range from 6 weeks to 36 weeks. Bone graft

was used in two patients only. The average time to full weight bearing was 4.5months. The mean knee flexion was 107.7° (range 40° to 140°). [90]

Haidukewych et al. [58] presented another series reported 56 periarticular knee fractures (including only 25 in the distal femur) treated by using the Polyax locking compression plate; fracture healing was achieved in 94 % of the cases with satisfactory clinical outcomes for most of patients.

Compared to another prospective observational study presented by Pawasuttikul and Chantharasap [91] which was conducted with 40 patients (24 males and 16 females), average age 48.7 years (range 20-81), with distal femoral fractures AO/OTA type A2 (5 cases), A3 (17 cases), C2 (8 cases) and C3 (10 cases) who were treated using an open indirect reduction technique and fixation with LCP. Clinical results were evaluated using the Neer score six months after surgery. Follow-up periods ranged from 12 to 36 months (average 18.35).

Thirty eight of the fractures (95%) healed completely without a secondary procedure. The average time to union was 14.45 weeks (range 12-24). The average knee range of motion was 2° (0-5) to 110° (20-140). Two patients had an implant failure which required revision and secondary iliac bone grafting. There were no varus or valgus deformities, no limb shortening and no deep infections. Neer scores were excellent in 18 cases (45%), good in 14 (35%), fair in 6 (15%) and poor in 2 (5%). The mean Neer score was 83.60 (range 50-100). [91]

On comparison with another series reported by Jain et al. [92] of a twenty case with distal femoral fracture were fixed with LCPs. The types of femoral fractures were A1 (4 cases), A2 (3 cases), A3 (2 cases), C1 (1 case), C2 (7 cases) and C3 (3 cases). All patients were followed up for up to 18 months (mean 12 months). Fourteen patients with distal femoral fractures underwent surgery using a minimally invasive percutaneous plate osteosynthesis (MIPPO) technique. The others were treated by open reduction. The average time of fixation was 8 days after injury (0-31 days). Knee Society scores were used for clinical and functional assessment.

All fractures, except one united. The mean union times for distal femoral was 15.2 weeks. One patient with a distal femoral fracture had implant failure. One patient was quadriplegic and did not recover the ability to walk. The average Knee Society scores of the remaining 18 patients were 82.66 (excellent) and 77.77 (good). There was one case of implant failure and one of screw breakage in distal femoral fractures. [92]

The results obtained also were found comparable to results of other studies that used other locked plates and techniques for the treatment of distal femur fractures like the less invasive stabilization system (LISS).

Kayali et al. [93] conducted prospective observational study to 26 patients with 27 supracondylar fracture femur, the mean age of the patients was 49 years (range 26–80 years) There were 14 supracondylar (AO type A) and 13 intercondylar (AO type C) fractures, Clinical assessment

was conducted at least 6 months post-operatively using the Schatzker scoring system , the results were excellent in six (22%) cases, good in 15 (56%) cases, fair in four (15%) cases, and poor in two (7%) cases.

These results were found to correlate with the results reported by other authors, Syed et al. [(94)] conducted prospective study on 29 patients, four patients were excluded from the study as three of them died and one had quadriplegia while the remaining 25 patients were classified into acute (18 patients) and salvage (7 patients who were tertiary referrals from other hospitals in whom the primary fixation had failed) groups. The average age of the patients was 60.9 years (range 16-94 years). Clinical assessment was conducted at least 12 months post-operatively using the Schatzker scoring system. The results of the acute group (18 patients) were excellent in four (22%) patients , good in nine (50%) patients, fair in three (17%) patients and poor in two (11%) patients.

These results were found to correlate with the results reported by Fankhauser et al. [(95)] who treated 30 distal femoral fractures (type A and C) using the LISS and patients were followed up for a mean period of 20 months. They reported a mean period of union of 12 weeks with a range of 8-23 weeks and the time till full weight bearing ranged from 6 to 18 weeks. The mean knee range of motion was 113° (90° -140°) in type A fractures and 101° (60° - 130°) in type C fractures.

Schutz et al. [96] treated 66 distal femoral fractures using the LISS and patients were followed prospectively for 12 months. Complete fracture healing was achieved in 85% of the followed-up patients. The LISS implant was positioned correctly in 89% of the cases. Malalignment of valgus/varus angulation occurred in 26% of the cases. Flexion of the injured limb was on average 80% of the range of the uninjured limb. An extension deficit of more than 5° was measured in 3 cases. Fourteen patients underwent further operations during the course of follow-up. Of these, 6 required bone grafting and 3 re-fixation of the implant due to implant loosening.

Kanabar et al. [97] reviewed records of 6 men and 11 women who underwent LISS plating for complex distal femora fractures from September 2001 to August 2005 .The mean age of the remaining patients was 61 years and the mean follow-up period was 12 months. Eight fractures were type A and nine fractures were type C. The mean time to union was 17 weeks. Two patients with non-union underwent a second LISS plating and bone grafting, resulting in a satisfactory final outcome. Delayed radiographic union was observed in one patient, but clinically he was asymptomatic and mobile. The fracture finally united at 9 months.

As regards the postoperative complication rates, It was found no difference between LISS and LCP plate in infection, plate failure, or nonunion in a comparative retrospective study of postoperative complications rates for open and closed 339 distal femoral fractures of which 185

(54.6%) were repaired with a LISS plate and 154 (45.4%) were repaired with a LCP, Multivariate analysis revealed only open fractures to be a risk factor for nonunion (Odds ratio 2.42, *P* = 0.01) and infection (Odds ratio 3.47, *P* = 0.02), regardless of device used. [98]

Tank et al. [99] conducted a comparative retrospective study of 67 distal femur fracture (OTA/AO 33-A, B, C) for early mechanical implant failure , 21 fractures were treated with LISS plates, 10 fractures treated with LCP and 36 fractures treated with variable angle LCP, Average age was 54.6 ± 17.5 years.

Results showed no statistically significant differences between groups for age, gender, open fracture, mechanism of injury, or medial comminution. When all fractures for all 3 groups were compared for failure rate, there was no statistically significant difference (*P* = 0.23). However, when only 33-C fractures were compared, there was significantly greater failure rate in the VA group (*P* = 0.03). The mean time to failure in group VA was 147 days (range 24–401 days) and was significantly earlier (*P* = 0.034) when compared with group LISS (mean 356 days; range 251–433 days).

They concluded that early mechanical failure with the VA distal femoral locking plate is higher than traditional locking plates (LCP and LISS) for OTA/AO 33-C fractures, and they caution practicing surgeons against the use of this plate for metaphyseal fragmented distal femur fractures.

As regards the factors that may affect the final outcome of surgically treated distal femur fractures:

The results of our study showed that the younger the age of the patients the better were the results. However the relation between the age and the final score was statistically insignificant. Mean age of the patient with excellent results was 35.16. Mean age of the patients with good results was 58.6.

As regards the mechanism of trauma, 5 out of 12 of the high energy fractures achieved excellent outcomes (41.5%)while 1 out of 8 of the low energy fractures achieved excellent outcomes (12.8%) which can probably be attributed to the older age group and the poor bone quality of the low energy patients.

There was a mean time lapse to surgery of 4.66 days in cases that achieved excellent outcomes and 4.9 days in cases that achieved good outcomes.

Regarding fracture classification 6 patients (30%) had AO type A (extra-articular) fractures and 14 patients (70%) had type C (intra-articular) fractures, 4 out of 14 patients who had Type C fracture achieved excellent results (28.5%), while 1 out of 6 patients who had type A fracture achieved excellent result (16.6%).

Our results reveal no statistically significant relationships between the patients' age, mechanism of trauma, BMI, time lapse before surgery, the presence of

associated medical condition, the fracture classification and the final outcome

Fankhauser et al. [95] reported that the outcome depends primarily on the aetiology of the fracture, the severity of the injury, concomitant trauma, bone quality and the time elapsed from injury to surgery. He also reported that intraarticular type C fractures tend to have poorer results as regards pain and function.

Likewise, Schutz et al. [96] looked at the relationship between fracture type, patient's age, mechanism of trauma, type of reduction, or soft-tissue injuries and the outcome parameters that he measured (fracture healing, weight-bearing, axial relationships and range of motion) and found no statistical significance to it.

Rademakers et al.[67] and Thomson et al. [100] assessed the factors that might influence knee function and the development of secondary osteoarthritis at long-term and the results showed that age at the time of trauma does not seem to be of any significance despite the fact that older patients have a prolonged hospital stay period.

Commenting on their series, Kregor et al. [69] stated that early surgical intervention was performed in an attempt to maximize eventual range of motion. The eventual range of motion was limited in their series in a special group of patients, who were characterized by delayed reconstruction secondary to multisystem trauma, associated extensor mechanism injury, head injury, open fractures, complex

articular fractures, and/or infection. This special group of patients contributed significantly to the decreased range of motion in the overall group.

The DF-LCP plate used with appropriate surgical principles provides adequate fracture fixation, permits early mobilization and high union rate. However, optimal implant choice is dictated by the type, level of fracture, and the familiarity and experience of the surgeon with biological and locking plate principles.

Though our study sample size is small, we recommend the DF LCP plate as a suitable fixation device for fixation of distal femoral fractures, high union rates can be achieved with a good function and patient satisfaction when respecting biologic and biomechanical principles.

## Summary and Conclusion

Locking plates offer more advantages than conventional plates specially when dealing with complex distal femoral fractures or osteoporotic bone. It is recommended to use locking plate whenever an elderly patient is indicated for internal fixation.

Although no agreement exists on management of complex distal femoral fractures, locking plates represent an advance for fixing different fracture patterns in this region. These include either high-energy fractures with severe bone comminution that may be further complicated through open injury and fractures in older people with poor bone quality.

Anatomically contoured locking compression plates provide multiple locking screw options distally, angular stability, help to preserve periosteal blood supply, provide better purchase and stability in osteoporotic bone, decrease the need for primary bone grafting and also allow for the possibility of the use of minimally invasive surgical techniques.

We recommend the use of DF-LCP with respect of biologic and biomechanical principles as a suitable device for fixation of challenging distal femoral fractures with high union rates, good functional outcome, and low complication incidence achieved.

Analysis of the complications in the studied patient sample revealed that the causes were not related to the implant or approach itself but could be attributed to the severity of the initial injury, inadequate surgical technique and the individual patient’s overall condition and compliance.

Our results are comparable to recent published series with some limitations, most importantly is heterogeneity in the sample; there is a large number of differing variables in patient, injury characteristics and treatment pathways that make determination of factors that influence healing and clinical outcome difficult.

Long term studies with more heterogeneous sample sizes are needed to prove definitively acceptable outcomes.

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