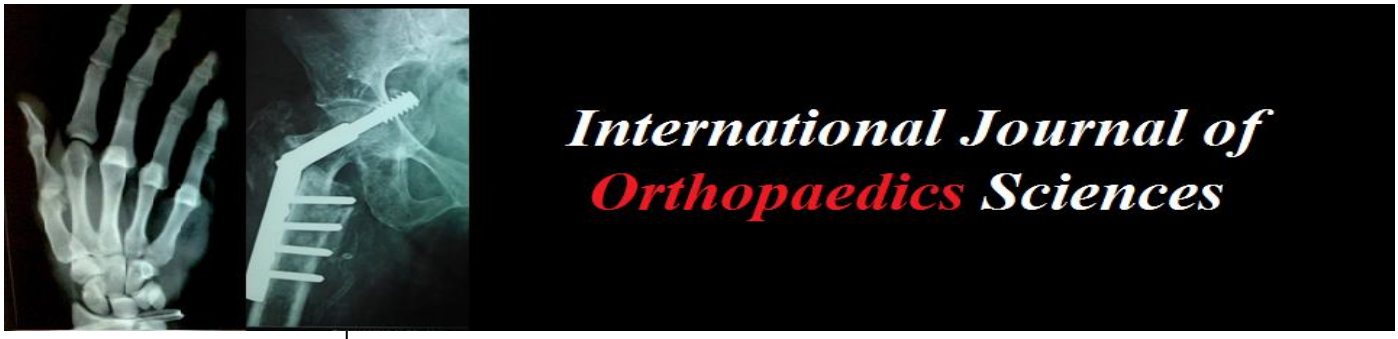

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Distal femur fracture, a comparative study of locking compression plate versus distal femur nail

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Abstract
Background: Distal femoral fractures reportedly account for less than 1% of all fractures and comprise between 4%–6% of all femoral fractures. The current method of open reduction and internal fixation has become evident in the recent years with good results being obtained with the AO blade plate, dynamic condylar screw and other implant systems like intramedullary retrograde nails and recently locking compression plate. Controversy still remains regarding the optimum device for distal femur fixation.
Objectives: To compare functional outcomes of fractures of distal femur operated with distal femur locking compression plate and distal femur nail using range of motion at knee and Neers knee scoring system and to compare rate of complications associated with both treatment modalities.
Materials and methods: In this retrospective study, 60 patients with displaced distal femur fractures presented to our hospital were studied from January 2012-june 2017. 30 patients underwent fixation with locking compression plate and rest 30 underwent distal femur nailing. Outcomes were measured and assessed at 1 months, 3 months and 6 months using Neers knee scoring system.
Results: Union was achieved in all patients with mean time to radiological union being 20 weeks in retrograde nailing patients and 24 weeks in locking compression plating. Neer scores were graded as excellent in 51.7 % in retrograde nailing patients and 56.6 % in plating patients. Mean range of motion was more (115 degree) in retrograde nailing patients compared to locking compression plating patients (114 degree) at the end of follow up.
Conclusion: There were no statistically significant differences found in functional outcome of the patients between the two surgical methods. Locking compression plate is better implant in comminuted intra-articular fractures of distal end of femur, particularly in elderly patients with osteoporotic bone. Retrograde intramedullary nailing is a good operative technique for extra-articular distal third femoral fractures. However, both techniques require sufficient surgical experience and appropriate preoperative planning.

Keywords: Distal femur fracture, locking compression plate, retrograde femur nailing, range of motion, Neers knee scoring system

1. Introduction
Distal femur fractures are defined as fractures that affect the lower nine to fifteen centimetres of the femur, down to the articular surface of the knee [1-3] Distal femoral fractures reportedly account for less than 1% of all fractures and comprise between 4%–6% of all femoral fractures [4] Supracondylar femoral fractures occur commonly among two populations, young patients involved in high-energy accidents (including motor vehicle and motorcycle accidents and sports trauma) and older patients, often osteoporotic, sustaining low-energy fall fractures. Because of its biomechanical specifics, the treatment of distal femur fractures has historically been associated with a high incidence of complications, including non-union or delayed union, malalignment of the femur, infections of the bone and soft tissues, chronic pain and decreased range of motion and function of the knee joint [5-7]
The osteosynthesis in the distal femur could be difficult because of thin cortex, comminution, osteopenia, complex injuries associated soft tissue injuries, a distal wide medullary canal and involvement of the knee joint. Most surgeons agree that distal femoral fractures need to be treated operatively to achieve optimal outcomes [8] the current method of open reduction and internal fixation has become evident in the recent years with good results being obtained with the AO blade plate, dynamic condylar screw and other implant systems like intramedullary supracondylar nails and recently locking compression plate.

During application of AO blade plate or dynamic condylar screw, the shaft of femur is often pulled laterally displacing the line of weight bearing, lateral to the anatomic axis of condyle. This creates rotational movements at the fracture site that causes pulling off the blade plate or condylar screws leading to fatigue fracture of the plates. Also, the presence of osteoporotic bone leads to fixation failures with screws and plates cutting of the soft bone.

Retrograde nails have proved to be very useful in extra-articular and partial articular distal femur fractures, but fixation of comminuted articular fractures is still a grey area with such an implant. To address these issues, locking condylar plate was designed. A locking condylar plate decreases screw- plate toggle and provides more stable fixation which is one of the key factor in the successful treatment of these fractures. These devices create a fixed angle at each screw hole where the individual screw head is secured to the plate by a locking mechanism [9-11]. But, the obvious advantage of an intramedullary device is that it aligns the femoral shaft with condyles reducing the tendency to place varus movement at the fracture site. The reduced bending movement of an intramedullary device has substantially reduced failure of fixation in osteoporotic bone.

Controversy still remains regarding the optimum device for distal femur fixation. The type of device depends on variables, fracture personality and soft tissues. This study is undertaken to compare the functional and radiological outcome using two different surgical modalities like distal femur locking compression plate and retrograde femur nailing.

2. Objectives

1. To compare functional outcomes of fractures of distal femur operated with Distal Femur Locking Compression Plate and Distal Femur Nail using Range of motion at knee and Neers Knee scoring system.
2. To compare of rate of complications associated with both treatment modalities.

3. Materials & Methods

3.1 Source and type of the study: This study is a retrospective study of 60 cases that were admitted and operated in the dept. of orthopedics, at R. L. Jalappa hospital, Tamaka Kolar from january 2012 - june 2017. 30 patients underwent LCP fixation and 30 patients underwent distal femur nailing. Our institutional ethics committee approved the study & informed consent was obtained from all patients when called for follow-up. All surgeries were conducted at our institute.

3.2 Inclusion criteria

1. Patients of age group > 16 years.
2. All patients with closed displaced fracture of distal femur.
3. Open fractures of Gustilo-Anderson classification type I, type II, type IIIA.
4. Polytrauma patients.

3.3 Exclusion criteria

1. Gustillo Anderson open type IIIB, IIIC fractures.
2. Pathological factures.
3. Non-union.
4. Associated neurovascular injury.
5. Crush injury.

3.4 Follow-up: Based clinically and radiologically using Neer's knee scoring system.

3.5 Analysis: The estimated sample size is 60 and the the collected data were coded in excel format, all the quantitative measures, categorical variables like functional outcome, sex, age, side of fracture and fracture type were compared using percentages. Student t test and chi square test were used as the test of significance. P value <0.05 will be considered as statistically significant. Statistical analysis will be carried out using SPSS version 20.

3.6 Operative procedure of LCP fixation: Procedure using lateral approach, where the plane between vastus lateralis muscle and lateral intermuscular septum was developed, was used for closed fractures of distal femur. Intra articular comminuted fracture fragments were reduced and held in place with K-wires and then lag screws. The distal femur locking compression plate was placed 1.5 to 2 cm proximal to the distal femoral articular surface in the middle third of anterior hail of the lateral femoral condyle. Then the femoral condyles were reduced with the femur shaft. Primary bone grafting was done wherever necessary. Static quadriceps exercises were started after 3 days of surgery. After 1 week, considering the pain tolerance, active and passive quadriceps strengthening exercises were started. The fracture pattern, bone quality and severity of injuries were considered while mobilising. Non weight bearing mobilisation with walker was started at post-operative day 10 and continued till 6 weeks. Suture removal was done and patients were discharged on post-operative day 12. Patients were followed up at 1, 3 and 6 months. Full weight-bearing ambulation without any aids was started at approximately 3 months in majority of the cases with radiographic evidence of fracture union.

3.7 Operative procedure of DFN fixation: The patient was supine on a radiolucent table with the knee in 30° flexion. A midline skin incision of 4 cm was made between inferior pole of patella and tibial tuberosity. The patellar tendon was split in the midline along the direction of the fibers. Entry point was made through the inter-condylar notch. The fracture was reduced under image intensifier guidance and guide wire passed from distal fragment to proximal fracture fragment. After reaming, an appropriate size and length nail was inserted through the entry point through distal and proximal fragment over the guide wire. Its position was confirmed with image intensifier. Then the proximal and distal holes were locked with interlocking bolts passed from lateral to medial cortex. Open reduction was done wherever necessary. Postoperatively, static quadriceps and active or active assisted bedside knee mobilization was started from 2nd postoperative day. Patients were discharged and were followed-up after 1, 3 and 6 months post-operatively. Toe touch walking was allowed by the 2nd week. Further, weight bearing was allowed depending on the clinical and radiological features of the patient.

4. Results

All the patients were available for follow-up and they were followed up till 6 months. Results were analyzed both clinically and radiologically. Majority of the injury occurred in male patients in both groups - 28 cases (93.3%) and 2 patients were female (6.7%) in both LCP and DFN groups. The distribution of age reveals that majority of cases lie between 20-40 years i.e.17 (56.7%) in LCP and 16 (53.3%) in

LCP group with 8 patients in 21-30 and 9 patients in 31-40 years in LCP group and 8 patients in 21-30 years and 8 patients in 31-40 years in DFN group, 5 patients each in 40-50 years and 50-60 years group in LCP group and 7 patients each in 40-50 years and 50-60 years group in DFN group. 3 patients in LCP group and no patients in DFN group are more than 60 years.

Majority of the cases i.e. 23 cases (76.7 %) in LCP and 28 (93.3 %) in DFN occurred as a result of road traffic accidents, 5 cases (16.7%) in LCP and 2 cases(6.7%) in DFN as a result of self fall, 2 cases (6.7%) in LCP group and no cases in DFN group due to assault. In this study, there were a total of 19 cases (63.3%) had right sided fracture, and left side was affected in 11 cases (36.7%) had left sided fracture among both LCP and DFN group.

23 patients had open fractures and 7 patients had closed fractures in LCP group and 25 patients had closed fracture and 5 patients had open fractures in DFN group. In LCP group, 1 patient had open Muller C1, 20 patients in open Muller C2, 2 patients in open Muller type C3, 2 patients had closed Muller C1, 4 patients had closed Muller C2 and 1 patient in closed Muller C3. In DFN group, 23 (76.7%) patients had closed Muller type A1, 1 (3.3%) patient each had closed Muller A2 and closed Muller A3, 4 (13.3%) patients had open Muller A1 and 1 (3.3%) patient had open Muller type A2. Open fractures were treated initially with external fixator application if needed, and then definitive fixation with plate or retrograde nailing after infection subsides.

Mean range of motion was 99.6, 100 and 114 degrees at 1, 3 and 6 months respectively in LCP group and mean range of motion was 96.9, 111 and 115 degrees at 1, 3 and 6 months respectively in DFN. Average fracture union rate was 24 weeks in LCP group and 20 weeks in DFN group with one patient undergoing open reduction. In LCP group, excellent outcomes were seen in 17 (56.6%) patients and good outcome in 9 (30%) patients. Average to poor results were observed in 4 (13.33%) patients. These patients had severe comminuted fractures. In DFN group, 15 (51.7%) had excellent results, 6 (20.6%) showed good results, 7 (24%) had fair results and 1 (3.4%) had poor result and 1 patient expired.

With comparison of complications, surgical site infection was seen in 3 patients in LCP group and no patients had surgical site infection in DFN group. 3 patients had shortening of limb in both LCP and DFN groups. 4 patients had knee stiffness and 3 patients having extensor lag in LCP group and 3 patients had knee stiffness and 3 patients had extensor lag in DFN group. 3 patients had delayed union each in LCP and DFN group. No patients had pulmonary embolism in LCP group and 3 patients had pulmonary embolism in DFN group with 1 patient expired in DFN group. 1 patient had implant failure in LCP and 2 patients had implant failure in DFN group.

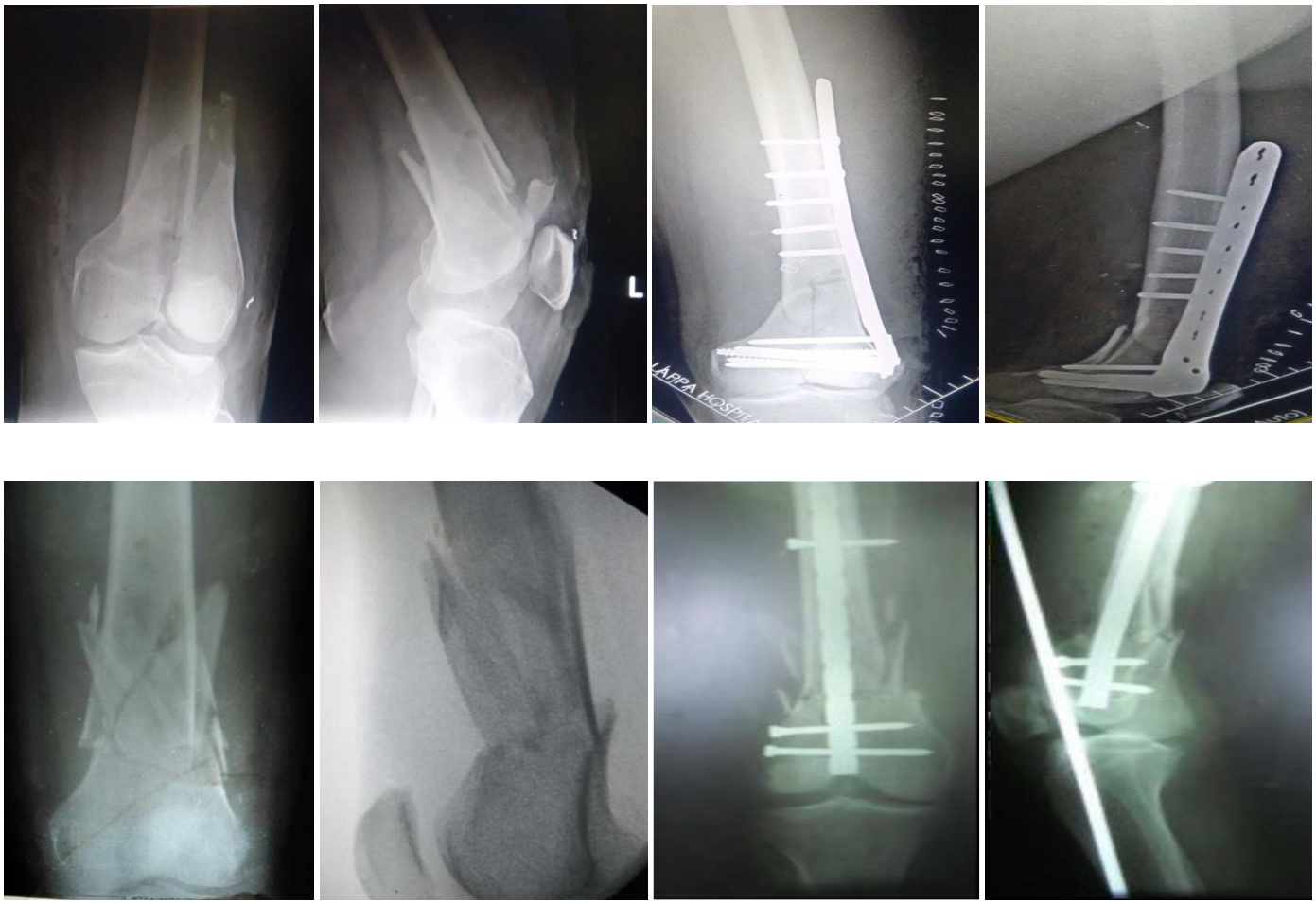

Fig 1: Pre Op and Post Op x-rays of the patients.

5. Discussion

Distal femur fractures are challenging injuries, despite improvements of fixation techniques and implant designs. For the treatment of distal femoral fractures, retrograde IM nailing or locking plate osteosynthesis are used as major therapeutic principles [12]. Some authors have demonstrated the ability of locked plates to absorb more energy before failure compared with angled blade plates or retrograde intramedullary nails, thereby having a lower incidence of loss of fixation [13, 14] Successful operative treatment of distal femoral fractures

requires the surgeon to know fracture anatomy and advantages and limitations of implants used. It is important to protect soft-tissue envelope based on the concept of biological osteosynthesis and minimally invasive approaches that resulted in decreased complication rates. Minimally invasive technique of osteosynthesis can be achieved by using two concepts: minimally invasive plating with an internal fixator - the LCP and also by intramedullary nailing [12].

LCP system is an extramedullary, anatomically contoured internal fixator. Locking plate provides good fixation in osteoporotic bones in elderly patients [15-17]. Previously, implants were selected depending on fracture type, whereas the LCP system can be universally applied for the treatment of all distal femoral fractures AO type A to C with the exception of AO type B Hoffa fractures, which are preferentially stabilized using lag screw osteosynthesis. Fracture stabilization with the LCP system may render adequate reduction more difficult since the plate and the locking screws are not designed to approximate the fracture toward the plate. The concept of bridging osteosynthesis implicates that the final fracture construct should be elastic and not too stiff to prevent formation of non-union. The non-union rates following LCP plate osteosynthesis ranges from 1.6% to 6.1% [18]. In our study, the high rate of delayed union in the LCP group found may be due to more number of open and comminuted C-type fractures in the study population. Inappropriate size and contour of the plate may cause pain by irritation of the iliotibial tract. Symptomatic hardware has to be removed [19].

Nailing provides favourable load bearing intra medullary stability and can be successfully implanted in bilateral or multisegmental fractures of the lower extremity. In addition, a variety of distal femur fractures ranging from extra-articular, metaphyseal, supracondylar, as well as intra-articular AO type C1 fractures can be stabilized. In these fractures, retrograde intra medullary nailing may be used and closed indirect fracture reduction is achieved leaving the soft tissue envelope intact. In our series we excluded type C2 and C3 fractures for the use of retrograde nail osteosynthesis. In contrast to the position of the distal screws in LCP plating which have to be positioned perfectly parallel to the joint line, distal interlocking screws of the retrograde nail have to be inserted at a valgus angle of approximately 7 degrees to the joint line. Major advantages of retrograde nailing include soft-tissue protection due to small incision, decreased blood loss following limited exposure and the increased stability by load-sharing type of implant. The snug intramedullary nail-bone fit improved the mechanical interaction between the femoral diaphysis and the nail.[20] In our series, predominant indications for osteosynthesis using the retrograde nail included distal femur fractures AO type A and C1. The nailing technique has disadvantages of lack of alignment control, intra-articular distribution of reaming debris and the intra-articular insertion [12].

Age incidence: In present study, the mean age was 41.4 years which is comparable to the observations of Daroch M S *et al.* [21]. With mean of 45 years, Jillala S R *et al.* [22] and Pascarella R *et al.* [23] reported mean age as 51 and 62 years respectively. Virk J S *et al.* [24], reported it as 36.64 years and Batchelor E *et al.* [25] as 64.7 years, Acharya K N *et al.* [26] as 41 years and Rathi N B *et al.* [27] as 41.27 years. Distal femur fractures occur following high energy impact in young patients resulting in comminuted and open fractures and in elderly patients with osteopenic or osteoporotic bone. In current study, mean age group was 41.4 years with male predominance.

Table 1: Age Distribution of Patients.

AGE	No. of Patients		Percentage	
	LCP	DFN	LCP	DFN
21-30	8	8	26.67	26.7
31-40	9	8	30	26.7
41-50	5	7	16.67	23.3
51-60	5	7	16.67	23.3
>60	3	0	10	0

Gender predilection: In our study, males were 56 (93.3%) and females were 4 (6.7%). In the studies conducted by Jillala S R *et al.* [22], there were 31 (54.38 %) males and 26 (45.61 %) females, Daroch M S *et al.* [21] reported as males are more commonly involved with 25 males (83.33%) as compare to females with 5 Cases (16.67%) because males are involved more in outdoor activities, Pascarella R *et al.* [23] reported female predominance with 35 male and 54 female patients, Acharya K N *et al.* [26] reported 20 male and 7 female patients among study population. The reason might be road traffic accident being the predominant cause of trauma.

Mode of injury: In the present study, road traffic accident accounted for 85% of cases. Jillala S R *et al.* [22] and Daroch M S [21] *et al* observed 56 % and 96.66 % of patients sustained injury due to roadside accidents respectively. Virk J S *et al.* [24] observed 80 % of their cases having road traffic accidents as their cause.

Time taken for union for plating: In present study, time taken for union for plating was around 24 weeks, which was comparable to Virk J S *et al.* [24] and Pascarella R *et al.* [23] who observed it to be 19 and 16.3 weeks respectively. Union was defined as bridging of three of the four cortices. Daroch M S *et al.* [21] achieved union at an average of 14 weeks and Jillala S R *et al.* [22] at 15.6 weeks, Time taken for union for Nailing: In present study, average healing time in weeks was 20 which was comparable to Rathi N B *et al.* [27] study with 24 weeks and Acharya K N *et al.* [26] with 19 weeks. Neubauer T H *et al.* [28] shows osseous healing occured in shaft fractures in 18.1 weeks on an average compared to 16.5 weeks in distal femur fractures. Jillala S R *et al.* [22] showed healing at 13.4 weeks.

Comparison of average union in weeks for nailing and plating: Average healing time for nailing was 20 weeks and was earlier than plating for which it was 24 weeks which was statistically significant (p value = 0.0084). The more complex fractures (Muller type C) were managed by plating and hence, the healing time is more for plating technique.

Table 2: Average fracture union time.

	LCP	DFN
AVG. Union Time	24 Weeks	20 Weeks

Comparison of knee flexion in plating and nailing: In this study, range of motion is more in nailing series (115 degrees) than in plating (114 degrees) in comparision with Jillala S R *et al.* [22] study in which range of motion is more in nailing series (112 degrees) than in plating (107 degrees) mostly because knee mobilization is started early in nailing than plating Complex comminuted fractures which need immobilization are treated by plating and hence, the delayed mobilization. Daroch M S *et al.* [21], Virk J S *et al.* [24], reported 116, 109 degrees of knee movement. Whereas in retrograde nailing patients, Rathi N B *et al.* [27] showed average knee range of motion as 115 degrees and Neubauer T

H *et al*. [28] observed better results in shaft fractures with average range of 120° than in distal femoral fractures with range of motion of 105 degree.

Table 3: Average range of motion of patients.

Follow Up	Average Rom In LCP (Degrees)	Average Rom In DFN (Degrees)
1 Month	99.6	96.9
3 Months	100	111
6 Months	114	115

Average time of surgery: In the present study for nailing it was 107.4 minutes and for plating it was 123.8 minutes.

Comparison of complications of non-union in nailing and plating: In the present study, the rate of delayed-union was 10 % for both plating and nailing, in comparision with Jillala S R *et al*. [22] study where delayed union rate was 7 % in both plating and nailing group. When comparing non-union rates, there is no much difference between nailing and plating series. A study done by Pascarella R *et al*. [23] shows non union of 9.1 % with plating. A study by Acharya K N *et al*. [26] and and Rathi N B *et al*. [27] showed 3.6 % and 15 % patients with non union respectively in retrograde nailing group. All the delayed union patients were treated with cancellous bone grafting. 1 patient had implant failure in LCP and 2 patients had implant failure in DFN group.

Functional outcome: In our study, in LCP group, excellent outcomes were seen in 17 (56.6%) patients and in DFN group, 15 (51.7%) had excellent results. In LCP, Daroch M S *et al*. [21] had 33.34% of patients had excellent results and Virk J S *et al*. [24] had 80 % excellent results. In nailing, Acharya K N *et al*. [26] had 77 % excellent result and Rathi N B *et al*. [27] showed 50% excellent results. Poor results were seen in comminuted and compound fractures with gross infection.

Table 4: Functional outcome of the patients.

	NO. OF Patients		Percentage	
	LCP	DFN	LCP	DFN
Excellent	17	15	56.67	51.7
Good	9	6	30	20.6
Fair And Poor	4	8	13.3	27.5

*1 (3.3%) Patient expired in DFN group

Table 5: Complications.

Complications	LCP	DFN
Surgical Site Infection	3(10%)	0
Limb Shortening	3(10%)	3(10%)
Knee Stiffness	4(13.33%)	3(10%)
Extensor Lag	3(10%)	3(10%)
Delayed Union	3(10%)	3(10%)
Pulmonary Embolism	0	3(10%)
Implant Failure	1(3.33%)	2(6.67%)
Death	0	1(3.33%)

Nailing group had early knee mobilisation and ambulation, less average surgical time, increase range of movement, early wound healing, but more complications compared to plating group. This might be attributed to the reason that simple fractures were treated by nailing and open and comminuted fractures by plating. Fracture union was early in retrograde nailing patients as compared to locking compression plate group which was statistically significant (p value = 0.0084). There were no statistically significant differences (p value = 0.3492) found in functional outcome of the patients between the two surgical methods.

6. Conclusion

Both locking compression plating and retrograde intramedullary nailing are appropriate treatment options for distal femur fractures. LCP is better implant in comminuted intra-articular fractures of distal end of femur, particularly in elderly patients with osteoporotic bone. The screw head gets locked to the plate and thus increasing the holding power of the implant by acting as one construct, making it an implant of choice in comminuted fractures and in osteoporotic bone. All fractures of the distal femur including extra-articular, partial articular and intra-articular, comminuted and non-comminuted, if fixed with the basic principles of fracture fixation, optimum results can be obtained by using a distal femur locking plate as the single implant of choice. Retrograde intramedullary nailing is a good operative technique for extra-articular distal third femoral fractures. The operative time is reduced with minimal blood loss. Fracture hematoma is preserved and soft tissue dissection is comparatively less in nailing procedure. Good knee range of motion and good union are influenced by factors like closed reduction and early postoperative knee mobilization. Retrograde intramedullary nailing requires significantly less periosteal stripping and soft tissue exposure than that required in plating. Our study observes that there is no significant difference in functional outcome of patients treated with locking compression plate and intra-medullary retrograde nailing. However, both techniques require sufficient surgical experience and appropriate preoperative planning.

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