



ISSN (P): 2521-3466
ISSN (E): 2521-3474
© Clinical Orthopaedics
www.orthoresearchjournal.com
2019; 3(1): 140-146
Received: 01-11-2018
Accepted: 04-12-2018

Dr. Dhoom Singh Jhatoth
Associate Professor, Department
of Orthopaedics, Deccan College
of Medical Sciences, Hyderabad,
Telangana, India

Clinical and radiological outcome of distal femur fractures treated surgically with locking compression plate

Dr. Dhoom Singh Jhatoth

DOI: <https://doi.org/10.33545/orthor.2019.v3.i1c.28>

Abstract

The incidence of distal femur fractures has increased significantly during recent decades, and the incidence is highest in older women and in adolescent boys and men. The present study was undertaken to assess the functional and radiological outcome of internal fixation of fractures of distal end femur surgically managed by distal femoral locking compression plate. Also to evaluate the effectiveness and complications of distal end femur fractures treated with locking compression plate based on rate of union, time till union, rate of infection, varus and valgus mal-alignment and fixation failures. A prospective study consisted of n = 32 subjects with distal femur fractures admitted to the Department of Orthopaedics, Mahatma Gandhi Memorial Hospital, Warangal, was conducted in the Department of Orthopaedics, Kakatiya Medical College, Warangal, Telangana, India for a period of one year. The subject's age ranged from 18 – 74 years. Of n = 32 subjects, 28 cases showed radiological union within 20 weeks and the average time for union was 16 weeks. Delayed union was found in 2 cases. 2 cases operated for supracondylar fracture non-union with implant failure had delayed union which took 13 months for union. Weight bearing without pain was achieved in n = 30 cases with mean time 12.2 weeks. 8 cases had limb length shortening: < 1 cm in 3 cases and 1 – 2 cm in 1 patient, more than 2 cm shortening was seen in 4 cases. Functional outcome was assessed at the end of 1 year in terms of regaining the lost knee function using NEER's Scoring System. Out of n = 32 subjects, n = 30 (93.75%) had excellent to fair results with no major complications. The functional outcome was Excellent in n = 19 (59.38%) subjects, Good in n = 6 (18.75%), Fair in n = 5 (15.63%) and Poor in only 2 (6.25%) cases.

Conclusion: The locking compression plate represents an evolutionary approach to the surgical management of distal femoral fractures, but it does not completely solve the age old problems of non-union and mal-union. It is an economical and safe fixation system for the treatment of fracture of any part of the long bones. The rate of union as well as increased range of motion, improved healing rate, restoration of articular surface, better biomechanical stability, decreased complication rates, decreased incidence of re-operation, early rehabilitation makes it a good treatment option.

Therefore, if preoperative planning and biomechanical principles are followed, LCP may provide excellent fixation in difficult situations offering good treatment option.

Keywords: Distal femur fracture, knee society score, locking compressive plate

Introduction

Distal femur fractures are one of the most common fractures encountered by orthopaedic surgeons in routine practice. Fractures of the distal femur are severe injuries accounting for < 1% of all fractures and comprising 4 - 6% of all femoral fractures [1, 2].

In young or middle aged persons the distal femur fracture can result from high energy trauma or low energy trauma in elderly persons. High energy trauma such as motor vehicle accidents, sports injuries and pedestrian accidents are common in persons aged between 15-55 years and low energy trauma such as fall from standing at home are most common in osteoporotic women age 50 years and above [2].

Fractures of the distal femur are complex injuries that present the surgeon with numerous potential complications [4]. These fractures pose therapeutic challenges of fracture treatment because they are usually compound, comminuted, readily deformed because of muscle forces acting on the distal fragment, prone to result in functional impairment of the knee joint and ankle joint because of the injury to quadriceps system and often occur in comminuted or

Correspondence

Dr. Dhoom Singh Jhatoth
Associate Professor, Department
of Orthopaedics, Deccan College
of Medical Sciences, Hyderabad,
Telangana, India

intercondylar in “T” or “Y” fashion and its management still evokes much controversy.

Various treatment options are available for the management of these injuries. With the development of improved techniques and internal fixation devices by the AO group, these fractures are best treated by surgical stabilization with anatomic reduction of articular surface, limb alignment restoration and early mobilization thereby, achieving early union and good knee function.

A newer concept of internal fixation, Locking Compression Plate (LCP) was introduced to overcome the drawbacks of conventional and simple locked plating system. This distal femoral “Locking Compression Plate” is a unique design developed by Robert Frigg^[5] with the combination of conventional compression plate and locked internal fixator which enhances the plate osteosynthesis^[6, 7]. It allows internal fixation with a combination of conventional and locking head screws. In this method of plate screw fixation, the plate does not touch the bone at all, which is an advantage in minimal invasive percutaneous osteosynthesis (MIPO).

Distal femoral locking compression plate has a smaller application device and allows both locking and compression screw fixation of the femur shaft^[8, 9]. The locked internal fixator method has been based on scientific insights into Bone biology especially with reference to its blood supply. The basic locked internal fixation technique aims at flexible elastic fixation to initiate spontaneous healing, including its induction of callus formation.

The benefits of LCP include angular stable fixation of fragments regardless of bone quality, reduced impairment of periosteal blood supply, due to limited plate-bone contact, good purchase, early and active mobilization in osteoporotic bone and in comminuted fracture.

Considering various advantages of this locked plate over traditional plating in the treatment of supracondylar fracture of femur, the present study was undertaken as it would help in defining a definite role of locking condylar plate in distal femur fractures.

The aim of the present study was to assess the functional and radiological outcome of internal fixation of fractures of distal end femur surgically managed by distal femoral locking compression plate (DF-LCP). To evaluate the effectiveness and complications of distal end femur fractures treated with locking compression plate based on rate of union, time till union, rate of infection, varus and valgus mal-alignment and fixation failures.

Material and Methods

A prospective study was conducted constituting n = 32 subjects in the Department of Orthopaedics, Kakatiya Medical College, Warangal, Telangana, India for a period of one year.

The patients with distal femur fractures (with supracondylar and intra-articular extension) who were admitted to the Department of Orthopaedics, Mahatma Gandhi Memorial (MGM) Hospital, Warangal, Telangana, India were included in the present study. All the patients were informed about study in all aspects and written informed consent was taken about their inclusion in the study. All patients were operated by the same surgical team. Ethical Committee approval was taken from the College Ethical Committee Board.

The mean follow up period was 12 months and the duration ranged from 12 - 36 months. The patients were assessed for functional capacity and radiological fracture healing every month. All the fractures in this series were post-traumatic. No pathological fracture was included in the study. Also

supracondylar fractures in children were not considered.

The follow up protocol was observed for patients with fracture lower end femur on arrival was general and systemic examination as well as local examination of the patient according to ATLS guidelines. Thorough assessment of patient to rule out head / chest / abdominal / spinal or pelvic injury, evaluation of the patients in terms of age, gender, mode of trauma, period between injury and arrival. Musculo-skeletal examination of patients to rule out associated fractures. Stabilization of patient with intravenous fluids, oxygen and blood transfusion as and when required. Careful assessment of injured limb as regards to neurovascular status. Primary immobilization of involved limb on Thomas splint was done with a cotton pad below the distal fragment and transport of patient to the Dept. of Radiodiagnosis. Radiological assessment included antero-posterior and true lateral views of injured limb including complete knee joint and distal femur / proximal leg. Thorough irrigation and lavage of associated compound injuries with hydrogen peroxide and normal saline followed by povidone iodine padded dressings. Injection ATS 1500 IU, Injection AGGS 20,000 IV, broad spectrum injectable antibiotics and analgesics were administered for compound injuries of other parts as and when required.

Selection criteria

Inclusion criteria included patients with above 18 years of age having supracondylar and intercondylar fractures of femur with willingness for surgical treatment, patients presenting with distal femoral fractures with or without osteoporotic changes, all patients with fresh fractures (gustilo type I and II; i.e. less than 2 weeks), patients without any proposed contraindications for surgical management.

Exclusion criteria included patients unfit for surgery or anesthesia or having pre-existing hip / femoral deformity, children with distal femoral fractures, patients with polytrauma, patients with open / pathological / bilateral fractures, cases with compound fractures, distal femoral fractures with neurovascular compromise, patients with less than 12 months follow-up, patients who were bed ridden or non-ambulatory.

Implants used were plate and screws manufactured from 316L stainless alloy with gun drilling technique; locking compression plates from 5-10 holed with 4.5 mm thickness plate for lower end of femur; anatomically pre-contoured plate head with soft edges; locking screws in the head of the plate for a secure support; head of the locking screw threaded which gets locked to the plate as it is tightened; LCP combi-holes in the plate shaft-intraoperative choice between angular stability and compression; 4.5mm LCP have 50° of longitudinal screw angulation and 14° of transverse screw angulation with uniform hole spacing. 4.0 mm and 5.00 mm self-tapping locking screws with 3.2 mm and 4.3 mm drill bits respectively along with threaded drill sleeves.

All the patients were initially managed in the emergency department according to advanced trauma life support guidelines. All cases were evaluated clinically and history of the incident was recorded / elicited.

Patients with open wounds were subjected to debridement and lavage under anesthesia and were put on intravenous antibiotics, which continued post operatively according to the requirement.

Radiological evaluation was done to assess the type of fracture, which included antero-posterior and lateral X-Ray of the femur along with a pelvic X-ray to rule out proximal fractures. CT scan was done as per the requirement. Pre-operative investigations such as complete blood count (CBC), serum electrolyte, renal function test, coagulogram, fasting or random blood sugar, blood

urea and serum creatinine levels, Blood group and Rh typing, Bleeding time, clotting time and viral markers consisting of Hepatitis B, C and HIV were done. Chest X-ray and ECG were taken in those patients required during anaesthetic evaluation.

Pre-operative planning and preparation

After pre-operative evaluation and fitness for surgery, patients were operated with distal femoral locking compression plate (DF-LCP).

Fractures were categorized based on the radiographs according to AO-ASIF classification. Based on the radiographs, pre-operative calculation was done 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. 1 gm of Cephalosporin was injected 10 min before the surgery.

All the patients were operated under general / spinal and/or epidural anaesthesia. The patients were placed in supine position on operating table slightly elevating the affected side with a sandbag under ipsilateral hip joint. Skin was cleaned at the operating site by povidone iodine (10% w/v) solution and spirit. The operating field from the hip to the knee was draped.

Fracture site was opened through a lateral approach. After skin incision deep fascia, iliotibial band and vastus lateralis was split in layers till the fracture site was exposed and reduction of the articular surface was done under IITV guidance.

The fracture was reduced by direct method and appropriate size and shape of the plate was fixed, some extent of reduction or compression was also achieved by applying conventional screws through dynamic compression unit of LCP. Then locking screws were fixed through locking unit of LCP. On each side of the fracture, minimum of 3 screws were fixed. Finally, under image intensifier reduction, placement of plate and size of screws were assessed. Suction drains were used in all the patients and was removed after 24 - 48 hrs. The wound was closed done in layers and tourniquet deflated. Sutures were removed 2 weeks after surgery.

Post-operatively after 48 hours suction drain was removed and wound was checked on 3rd post-operative day. Intra-venous antibiotic cephalosporin was given routinely for 3 days post-operatively. The patients were advised exercises of the related joints from the 2nd to 3rd post-operative day. Range of motion exercises to the hand and wrist was started 2nd day post-operatively. Progressive shoulder and elbow exercises were also advised.

Check X-rays were taken in immediate post-operative period and on follow up visits, and also checked for complications if any.

The patients were followed up for clinical and radiological evaluation at 3 weeks interval for a period of 12 weeks and at 6 weeks interval till signs of fracture union and subsequently at quarterly intervals.

The parameters evaluated at 1 year follow-up were range of motion, radiological union, mal-union, or non-union, complications if any, surgical revisions.

Initially the patients were allowed non-weight bearing crutch walking for about 6 weeks. Gradual weight bearing was started on the evidence of bridging callus based on the follow up radiographs.

On clinical examination, if fracture site was stable and full weight bearing without pain, then union was considered satisfactory. A fracture was considered completely healed when the patient could bear weight without pain at the fracture site. The failure of fracture union at 9 months follow up was

considered non-union, shortening of > 2cm or valgus / varus >5° was considered as mal-union. Also return to work was evaluated. All the patients had their final assessment at 1 year. No patients were lost to follow up. Clinical and functional outcomes were evaluated using Neer's Score System [10].

Neer's criteria was used for over all functional rating and Knee Society Scoring System [11] was followed to quantitate the functional status of the knee.

Results and Discussion

In the present study of both retrospective and prospective constituted n = 32 subjects of supracondylar femur fractures treated surgically and evaluated for functional and radiological outcome results after fixation with locking compression plate (LCP). All the patients included in this study were presented at regular intervals for clinical and radiological evaluation and the follow up ranged from 12 - 36 months.

The subject's age in the present study ranged from 18 - 74 years (Table 1) with mean age 44 yrs. Lee *et al.* [12] in a similar study found the average age 42 years ranging from 18 to 82 years. These results indicate that distal femoral fractures around knee joint are common in young adult group as they are involved in outdoor activities. High-speed vehicular accidents are responsible for distal femur fractures commonly observed in the young and middle aged.

Table 1: Age distribution

Age in years	Lower end femur	Percentage (%)
18-30	12	37.5
31-40	5	15.62
41-50	6	18.75
51-60	3	9.38
Above 60	6	18.75
Total	32	100

Of the total n = 32 subjects, n = 24 (75%) were male cases and n = 8 (25%) were females (Table 2), with male: female ratio 3: 1. In the present study series, male predominance was observed constituting 75% similar to the earlier study reports [13, 14]. The high male to female ratio in our study may probably be due to males involved more in outdoor activities hence, exposed to high energy trauma.

Table 2: Gender distribution

Gender	Lower end femur	Percentage (%)
Male	24	75
Female	8	25

Right side fractures were found in n = 22 (68.75%) subjects and left side was involved in n = 10 (31.25%) (Table 3) cases in the ratio of 2.2: 1. Right side involvement dominated over left, probably because right side is the dominant side in most people and during road traffic accidents the brunt of injury falls on the most active limb.

Table 3: Side effected

Side affected	Right (%)	Left (%)
Lower end femur	22 (68.75%)	10 (31.25%)

The cause of fractures were motor vehicle accident in n = 24 (75%) cases and domestic fall in the remaining n = 8 (25%) cases (Table 4). Similar pattern observations were reported in earlier studies [13-15], which suggests that with modernization there has been a steep increase in high velocity trauma. High

velocity trauma not only increases the number of distal femoral fracture but also their complexity.

Table 4: Mechanism of injury

Mechanism	Distal end femur	Percentage (%)
Road Traffic Accident (RTA)	24	75
Domestic fall	8	25
Total	32	100

Majority of the subjects $n = 30$ (93.75%) had acute fresh fractures and $n = 2$ (6.25%) subjects were supracondylar fractures. Lee *et al.* [12] in a similar study, observed an incidence of RTA in 80% cases, 11.4% due to fall from height, 5.8% due to blow and 2.8% due to shotgun injury.

According to the AO/ Muller's classification of distal femur, $n = 4$ (12.5%) fractures were Muller's Type A1, $n = 11$ (34.37%) Type C1, $n = 11$ (34.37%) Type C2 and $n = 6$ (18.75%) Type C3 (Table 5). 26 (81.25%) subjects had closed fracture and $n = 6$ (18.75%) had open type fractures. In the present series, majority of the fractures are of Type C in $n = 28$ (87.5%) and $n = 4$ (12.5%) of Type A similar to the observations in the study made by Rajaiah and his associates [13]. This indicates that type C fractures occur more commonly than type A, which signifies that most of the distal femoral fractures are caused by high energy trauma. They are associated with severe comminution and are unstable.

Table 5: Type of fracture lower end femur according to the AO/ Muller's classification

Supracondylar fracture	No. of patients	Percentage (%)
Mullers' A1	4	12.5
A2	NIL	NIL
A3	NIL	NIL
B1	NIL	NIL
B2	NIL	NIL
B3	NIL	NIL
C1	11	34.38
C2	11	34.38
C3	6	18.75

In the present study, the mean interval between injury and surgery was 3.22 days (ranging from 1 – 7 days). Majority of the patients $n = 16$ (21.25%) were operated within the first 3 days of injury and $n = 2$ (6.25%) patients within 7 days. Surgery was delayed for more than 7 days in $n = 4$ (12.5%) cases (Table 6), of which $n = 1$ (3.13%) had head injury, second (3.12%) had open wound which was managed initially with AO External Fixator, then ORIF with LCP done. 2 (6.25%) more cases were of supracondylar fracture, non-union with implant failure. The advantages of early fixation of fractures are short hospital stay, better muscle strength, early mobilization, improved union and good knee joint range of motion.

Gosling and his colleagues [16] in the similar study, the average time to surgery was 7.5 days (range 0 - 28 days). However, Lee *et al.* [12] studies reported that all patients underwent operation within a mean time of 12 days with range between 1 - 30 days. The lesser delay in the surgery in our study could be because at the time of presentation patients had less swelling and minor abrasions around knee.

Table 6: Injury – Surgery Interval

Injury- surgery interval (days)	Number	Percentage (%)
1 – 3	26	81.25
4 – 7	2	6.25
More than 7	4	12.5
Total	32	100

The operative time ranged from 90 – 240 min with average 140 min. 15 (46.88%) patients (Table 7) had surgical time more than 120 min, of which $n = 7$ (21.88%) patients underwent ORIF for other fractures, $n = 2$ (6.25%) patients underwent implant removal, freshening and bone grafting for supracondylar non-union.

Table 7: Duration of surgery

Operation time (minutes)	Number	Percentage (%)
<90	2	6.25
91 – 120	15	46.88
>120	15	46.88
Total	32	100

The size of the plate was selected based on the type of fracture. However, 7 and 9 holed plates were commonly used and the details are presented in Table 8. Average blood loss was 200 ml.

Table 8: Size of plates used in the present study subjects ($n = 32$)

Plate size (holed)	Number	Percentage (%)
4 – 6	2	6.25
7 – 9	28	87.5
10 – 12	2	6.25
>12	0	0
Total	32	100

Union

Radiological union was defined as presence of bridging callus across three cortices. In the present study, delayed union was found in $n = 2$ (6.25%) cases. Of $n = 32$ subjects, $n = 28$ (87.5%) showed radiological union within 20 weeks and the average time for union was 16 weeks (Table 9). 2 (6.25%) cases operated for supracondylar fracture non-union with implant failure had delayed union which took 13 months for union. On analyzing retrospectively we believe the reason for delayed union was due to pre-existing non-union.

Lee *et al.* [12] in their study consisting of 25 fractures found average time of union was 4.2 months (range 3 - 7 months). Ryan *et al.* [17] in their comparative study reported average time for union with locking plating was 6 months (range 3 - 14 months) versus 7 months (range 3 - 15 months) in external fixation group. These results indicate that peri-articular fractures (around knee joint) with meta-physeal extension take longer time with other methods of fixations over locking plate fixation. Rajaiah *et al.* [13] reported 14 - 25 weeks, Kim and his associates [18] reported 13-20 weeks' time for the union similar to the present study results.

4 (12.5%) patients had primary bone grafting at the time of surgery, of which $n = 1$ (3.13%) patient had allogeneic bone graft. 1 (3.13%) patient who had non-union underwent secondary bone grafting.

Table 9: Radiological union

Union (weeks)	Number	Percentage (%)
<16	6	18.75
16 – 18	17	53.13
19 – 20	5	15.63
21 – 22	0	0
Delayed union	2	6.25
Non-union	2	6.25

In the present study series, the average range of flexion was 115° with n = 19 (59.38%) subjects having knee range of motion >110° (Table 10). Taking into consideration Indian life style and working pattern much importance was given to knee range of motion which was necessary for patient to enable sitting cross legged.

Stannard *et al.*^[19] Lee *et al.*^[12] and Cole *et al.*^[20] in their studies reported average range of motion 127° (range 90 - 145°), 105° (range 0 - 135°) and 122° respectively. Ryan *et al.*^[17] in their comparative study found that the average knee flexion in patients managed with locked plating was 109° (range 75 - 150°) versus 104° in external fixation patients. Good range of motion (average 124°) at knee can be attributed to early knee motion. Open reduction increases fibrosis and thus decreases subsequent range of motion, but this difficulty is minimally seen with less invasive methods like LCP fixation.

Table 10: Knee flexion in the present study subjects (n = 32)

Knee flexion (degrees)	Number	Percentage (%)
<90	11	34.38
91 – 109	2	6.25
110 and more	19	59.38

In this study, the mean time of full weight bearing was 18.1 weeks (range from 9 - 34 weeks). Weight bearing without pain was achieved in n = 30 cases with mean time 12.2 weeks (range 8 – 19 weeks). Cole *et al.*^[20] found the mean time to allowance for full weight bearing was 12.6 weeks (ranging from 6 to 21 weeks). In the present study, delay in weight bearing was observed in n = 2 (6.25%) cases, which may be attributed to associated injuries like patella fracture, both bones leg fracture.

Table 11: Time at which weight bearing achieved

Achieved time (months)	Number	Percentage (%)
2 – 3	4	12.5
4 – 5	26	81.25
>6	2	6.25
Total	32	100

Out of n = 32 subjects, n = 8 (25%) cases had limb length shortening; < 1 cm in n = 3 (9.38%) cases and 1 – 2 cm in n = 1 (3.13%) patient (Table 12). More than 2 cm shortening was seen in n = 4 (12.5%) cases.

Table 12: Limb length discrepancy in the study subjects (n = 32)

Shortening (cm)	Number	Percentage (%)
No limb length discrepancy	24	75
0.5 – 1	3	9.38
1 – 2	1	3.13
>2	4	12.5
Total	32	100

Functional outcome was assessed at the end of 1 year in terms of regaining the lost knee function using NEER's Scoring System. Out of n = 32 subjects, n = 30 (93.75%) had excellent to fair

results with no major complications. The functional outcome was Excellent in n = 19 (59.38%) subjects, Good in n = 6 (18.75%), Fair in n = 5 (15.63%) and Poor in only 2 (6.25%) cases (Table 13).

Table 13: Functional outcome results in the present study subjects (n = 32)

Grade	Number	Percentage (%)
Excellent	19	59.38
Good	6	18.75
Fair	5	15.63
Poor	2	6.25

Complications

Out of n = 32 subjects, n = 2 (6.25%) had non-union, who were managed with implant removal, freshening of edges, Hizarov external fixator application and bone grafting. No patient had superficial infection. 1 (3.13%) patient developed deep infection for which thorough wound debridement, wash, implant removal, freshening of edges, Hizarov external fixator application and bone grafting was done. 1 (3.13%) subject each had varus and valgus mal-alignment. 2 (6.25%) cases had implant failure of screw breakage (Table 14). Same patients had plate back-out also.

Table 14: Complications recorded in the present study subjects (n=32)

Complications	Number	Percentage (%)
Superficial infection	0	0
Delayed union	2	6.25
Plate back-out	2	6.25
Deep infection	1	3.13
Non-union	2	6.25
Implant failure- screw plate breakage	2	6.25
Varus mal-alignment	1	3.13
Valgus mal-alignment	1	3.13

The results of locking compressive plating in various types of fractures of distal femur were analysed. These plates are designed to apply in minimal invasive fashion to preserve local biology and avoid problems of fracture healing and infection^[21, 22] thus, achieving high union rates with good functional outcome.

The present study was conducted to evaluate the functional and clinical outcome of fracture distal femur in patients treated by open reduction and internal fixation with distal femur "Locking compression plate" (LCP) and also for any complication if occurred during study.

Locking Compression Plate is an optimal tool for supracondylar fractures of femur. It provides rigid fixation in the region of femur, where a widening canal, thin cortices and frequently poor bone stock makes fixation difficult. Surgical exposure for plate placement requires significantly less periosteal stripping and soft tissue exposure than that of normal plates. However, careful understanding of its base principles, identification of appropriate fracture patterns for use of LCP is essential to avoid complications like generation of non-union.

At a mean follow-up of 12 months, the mean knee range of motion in this cohort was 0 – 115°. In the present study, the functional outcome results were excellent in n = 19 (59.38%) cases, good in n = 6 (18.75%), fair in n = 5 (15.63%) and poor in n = 2 (6.25%) and are similar to the functional results achieved in other studies so are the rate of complications. The present study results are in agreement with earlier study observations reported.

No implant failure occurred in this study similar to the results reported by Rajaiah *et al.* [13] Yeap and Deepak [14] reported 1 case of implant failure.

The introduction of locking compression plates with option of locked screws has provided the means to increase the rigidity of fixation in osteoporotic bone or in presence of peri-articular fractures.

In this study with plating through open reduction technique the soft tissue damage was considerably less, since periosteal stripping and soft tissue exposure can be kept to a minimum compared to other techniques used. Use of Locking Compression Plate through Less Invasive Stabilization System and Minimally Invasive Percutaneous Plate Osteosyntheses would probably further decrease the amount of soft tissue trauma.

Careful intraoperative attention should be given to restoring alignment in all planes. Restoration of both medial and lateral column is necessary to prevent complication. Potential reasons for implant failure might be due to technical errors in plate placement and early weight bearing in the presence of delayed fracture union.

Judicious use of bone graft or bone-graft substitutes would enhance the healing response and decrease the potential mechanical failure and varus collapse.

Since the late 1970s, open reduction and internal fixation with plate and screws osteosynthesis had emerged as the gold standard of operative therapy. They act on the internal fixator principle in order to bridge meta-physeal comminution [23, 24]. The primary goal of surgery with locking plates is to achieve union with bridging callus through relative stability which allows movement at the fracture gap. The biomechanical principle of relative stability allows a relative dynamic deformation [25], which induces secondary callus formation compared to primary callus formation with absolute stability [26]. Locking plates present multiple points of fixation even in case of low bone quality; the screws, once locked to the plate, do not pull the fragments towards the implant [27, 28].

Conclusion

In conclusion, locking compression plate represents an evolutionary approach to the surgical management of distal femoral fractures, but it does not completely solve the age old problems of non-union and mal-union. It is an economical and safe fixation system for the treatment of fracture of any part of the long bones. The rate of union as well as increased range of motion, improved healing rate, restoration of articular surface, better biomechanical stability, decreased complication rates, decreased incidence of re-operation, early rehabilitation makes it a good treatment option. LCP is an important armamentarium in treatment of fractures of distal end femur, especially when fracture is severely comminuted and in situations of osteoporosis. However, a more comprehensive study with longer follow up periods is essential to throw more light into the advantages, complications and possible disadvantages of the use of LCP with special focus on the long term outcomes. Therefore, if preoperative planning and biomechanical principles are followed, LCP may provide excellent fixation in difficult situations offering good treatment option.

References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006; 37:691-697.
2. Martinet O, Cordey J, Harder Y, Maier A, Buhler M, Barraud GE. The epidemiology of fractures of the distal

- femur. *Injury*. 2000; 31(3):C62-C63.
3. Wahnert D, Hoffmeier K, Frober R, Hofmann GO, Muckley T. Distal femur fractures of the elderly-different treatment options in a biomechanical comparison. *Injury*. 2011; 42:655-659.
4. Chapman MW, Szabo RM, Marder RA, Vince KG, Mann RA, Lane JM *et al.* Chapman's Orthopaedic Surgery. Michael. W. Chapman 3rd Edn. Chapter 21. Lippincott Williams & Wilkins Pbl, 2001.
5. Frigg R. Locking Compression Plate (LCP). An osteosynthesis plate based on the Dynamic Compression Plate and the Point Contact Fixator (PC-Fix). *Injury*. 2001; 32(2):63-66.
6. Frigg R. Development of the Locking Compression Plate. *Injury*. 2003; 34(2):B6-10.
7. Wagner M, Frenk A, Frigg R. New concepts for bone fracture treatment and the locking compression plate. *Surg Technol Int*. 2004; 12:271-277.
8. Campbell WC, Canale ST, Beaty JH. Campbell's Operative Orthopaedics, Chapter 51- fractures of lower extremity, A. Paige Whittle, 11th ed. 2008; c51:3170-3190.
9. Peter O'Brien J, Robert NM, Piotr AB, Broekhuysen HM. Distal Femur Fractures, Chapter 48 in Rockwood and Green Fractures in Adults. USA: Lippincott Williams and Wilkins, 6th Ed, 2010, 1915-1967.
10. Neer CS, Grantham SA, Shelton ML. Supracondylar fracture of the adult femur. A study of one hundred and ten cases. *J Bone Joint Surg Am*. 1967; 49(4):591-613.
11. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the knee society clinical rating system. *Clin Ortho Rel Res*. 1989; (248):13-14.
12. Lee JA, Papadakis SA, Moon C, Zalavras CG. Tibial plateau fractures treated with the less invasive stabilisation system. *International Orthopaedic*. 2007; 31:415-418.
13. Rajaiah D, Ramana Y, Srinivas K *et al.* A study of surgical management of distal femoral fractures by distal femoral locking compression plate osteosynthesis. *J Evid. Based Med. Healthc*. 2016; 3(66):3584-3587.
14. Yeap EJ, Deepak AS. Distal femoral locking compression plate fixation in distal femoral fractures: early results. *Malaysian Orthopaedic Journal*. 2007; 1(1):12-17.
15. Virk JS, Garg SK, Gupta P, Jangira V, Singh J, Rana S. Distal Femur Locking Plate: The Answer to All Distal Femoral Fractures. *Journal of clinical and diagnostic research: JCDR*. 2016; 10(10):RC01.
16. Gosling T, Müller M, Richter M, Hüfner T, Krettek C. The less invasive stabilization system for bicondylar fractures of the proximal tibia. Paper presented at: 18th Annual Meeting of the Orthopaedic Trauma Association, Toronto, Canada, 2002, 11-13.
17. Ryan JK, Arthur LM, Craig SR, David S. Treatment of bicondylar tibia plateau fractures using locked plating versus external fixation. *Orthopedics*. 2009; 32:559-570.
18. Kim KJ, Lee SK, Choy WS *et al.* Surgical treatment of AO type C distal femoral fractures using locking compression plate (LCP-DF Synthes). *J Korean Fract Soc*. 2010; 23(1):20-25.
19. Stannard JP, Wilson TC, Volgas DA, Alonso JE. The less invasive stabilization system in the treatment of complex fractures of the tibial plateau: short-term results. *J Orthop Trauma*. 2004; 18(8):552-558.
20. Cole PA, Zlowodzki M, Kregor PJ. Less Invasive Stabilization System (LISS) for fractures of the proximal tibia: Indications, surgical technique and preliminary results

- of the UMC Clinical Trial. *Injury*. 2003; 34:16-29.
21. Krettek C, Schandelmaier P, Nliclau T, Tscherne H. Minimally invasive percutaneous plate osteosynthesis (MIPPO) using the DCS in proximal and distal femoral fractures. *Injury*. 1997; 1(28):A20-30.
 22. Krettek C, Schandelmaier P, Miclau T, Bertram R, Holmes W, Tscherne H. Transarticular joint reconstruction and indirect plate osteosynthesis for complex distal supracondylar femoral fractures. *Injury*. 1997; 1(28):A31-41.
 23. Greiwe RM, Archdeacon MT. Locking plate technology: current concepts. *J Knee Surg*. 2007; 20(1):50-55.
 24. Giuseppe T, Giampiero C, Antonio T, Alessandro DS, Giovanni I. Locking plate fixation of distal femoral fractures is a challenging technique: a retrospective review. *Clin Cases Miner Bone Metab*. 2015; 12(1):55-58.
 25. Perren SM. Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br*. 2002; 84(8):1093-1110.
 26. Hitendra KD, Png Wenxian, Maitra VB, Diarmuid PM. Clinical Outcomes of Distal Femoral Fractures in the Geriatric Population Using Locking Plates with a Minimally Invasive Approach. *Tr and Orth*, 1987.
 27. Gautier E, Sommer C. Guidelines for the clinical application of the LCP. *Injury*. 2003; 34(2):B63-76.
 28. Jagandeep SV, Sudhir Kumar G, Parmanand G, Vivek J, Jagdeep Singh, Sudhir Rana. Distal Femur Locking Plate: The Answer to All Distal Femoral Fractures. *J Clin Diagn Res*. 2016; 10(10):RC01-RC05.