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Evaluation of functional outcome of treatment for distal femur fractures

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Abstract
Background: This study evaluated functional outcome of treatment for distal femur fracture using distal femur condylar locking compression plate.
Material and Methods: This is a prospective study done at orthopaedics department of Krishna institute of medical science and hospital karad (Satara). In our study 25 cases of distal femur fracture studied. Fracture types were classified according to AO classification into AO type A and AO type C. Patients were treated with distal femur condylar locking compression plate. Functional outcome was done according to Neer's knee score.
Results: Functional outcome was analyzed according to the NEERS knee scoring system, average score was 70 with a range of 19-94. Out of 25 patients 10(40%) had excellent result, 5(20%) had good result, 7(28%) fair result and 3(12%) poor result.
Conclusion: AO Type A fractures had better functional outcome. Bone grafting is necessary in case of comminution. Distal femur locking compression plate is an optimal tool for supracondylar fractures of femur especially AO Type A fractures and AO type C.

Keywords: distal femur, condylar locking compression plate, AO classification, Neer"s knee

Introduction
In the past few decades man has taken traveling to high speeds with flexed knee joint with much of impacts taken first by patella then femoral condyles and tibial condyles in different positions and proportions, with vast increment in technology, travel modalities and industrialization there have been advantages and disadvantages too like easier and faster traveling but road traffic accidents too. Such accidents and falls resulting in loss of lives and disabilities.

The area between the condyles of femur and the metaphyseal – diaphyseal junction approximating 15cms of the distal end of femur measuring from the surface of articulation is termed as the distal end of femur. Fractures at lower end of femur are more often the complex fractures as they involve comminution and soft tissue injury. Distal femur region has wide medullary canal, thin cortices, compromised bone stalk, associated ligament injuries intra articular involvement, and difficult in achieving anatomical alignment, fractures at lower end of femur are difficult to treat [1, 2].

In early decades of 60's, operative method of management was not accepted as the modality because of high chances of infection, inadequate fixation, lack of complete union or malunion, lack of instruments and implants required. Then came traditional management of displaced type of supracondylar femur fracture according to the principles of Watson Jones [3] & John Charnley [4] which comprised of conservative managements in the form of immobilization by skeletal traction and external immobilization in the form of cast, slab, ring fixator and bracings. These methods met with certain complications like malunion, bone shortening, prolonged bed rest, stiffness of knee joint, wasting of quadriceps, instability, post-operative osteoarthritis and angulation.

Patients of elderly age presenting with the common complaints of osteoporosis with fractures around knee are difficult to manage as it requires restoration of geometrical relationship of

articular surfaces and its rotational axis, for free movement in joint without persistent pain. Condylar locking compression plates in such cases are of great use. Locking compression plates are of much advantage as they combine both conventional compression plating & locked plating techniques enhancing the plate osteosynthesis. Such a built results in marked reduction in soft tissue problems.

Material and Methods

This is prospective study conducted in Department Of Orthopedic Surgery at Krishna Institute of Medical Sciences Deemed to be University, Karad. For this study 25 patients with distal femur fractures were included who presented to KIMS casualty who fulfilled the criteria. Patients were classified into AO classification of distal femur fractures. Children (<18 years) skeletally immature, AO type B fractures, fractures in ipsilateral limb and pathological fractures were excluded from the study

Initial management

As the patient presented to the emergency department, proper assessment of the injuries was done. Initial management involved resuscitation and haemodynamic stabilization of the patient and splinting the limb in Thomas splint or plaster slab or skeletal traction given later on. Radiographs of the affected limb, pelvis and chest were taken and all routine blood investigations were carried out. Open fractures and wounds were documented properly. Cultures were sent. Adequate wound wash and irrigation was done with sterile normal saline. Appropriate antibiotics were started and prophylactic tetanus toxoid was given. Primary closure of the wound was done. The subject was included into the study once a diagnosis of distal femur fracture was made in the Emergency room. Distal femur fractures were classified according to AO Classification. Patients having AO type A and AO type C fractures were included in our study. Open fractures were classified according to Gustilo and Anderson classification. The plan of management for the given patient was made depending on the nature of fracture, type of fracture and associated soft tissue injuries. The limb to be operated was shaved and prepared a day before scheduled surgery. One gram of second/ third generation intravenous cephalosporin was injected previous night and early morning on the day of surgery. Test dose of xylocaine was done one day prior to surgery. Informed written consent was obtained from all patients and also consent for bone grafting from either ipsilateral or contralateral iliac crest was obtained. Primary care was given to all these patients and then they were treated with surgical management. The 25 patients were classified according to AO classification. Of these 11 were Type 33A and 14 were Type 33C.

The method used for fracture fixation was open reduction and internal fixation with distal femur condylar locking compression plate.

Technique

Treatment of fractures was performed utilizing the lateral approach in all patients. Fractures were reduced under direct vision using manual traction. A knee roll assisted the procurement and maintenance of reduction. The plate length, axial and rotational alignment were checked under image intensification. Temporary fixation was achieved through the use of Kirschner wires. Inter-condylar type fractures were converted to a single condylar block before DF-LCP fixation. Where applicable, compression screws were used to approximate the plate to the femoral shaft.

Postoperative evaluation

Patients were immobilized according to fracture fixation stability and communition. Drain was removed within 24 hours post operatively. Physiotherapy was started from postoperative day 1 as quadriceps and hamstring strengthening exercises. Knee mobilisation was started depending upon the fracture pattern and modality of fixation. Non weight bearing was started and gradually increasing to partial and full weight bearing depending upon the modality of fixation. All patients were evaluated postoperatively at regular follow up of 6 weeks, 3 months, 4.5 months, 6 months. Serial x-rays in Antero-posterior and lateral views and functional assessment were carried out at each visit in outpatient clinic itself using the Neer's Knee Score. All the patients were assessed using a standard Proforma.

Case 1

Fig 1: Pre-operative X-ray

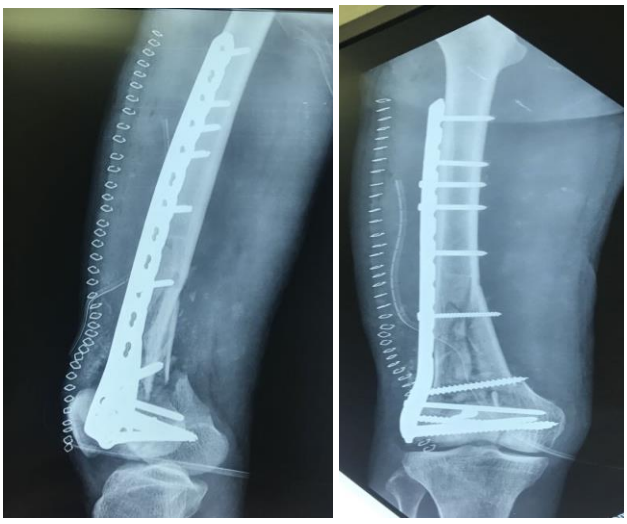

Fig 2: Post-operative X-ray

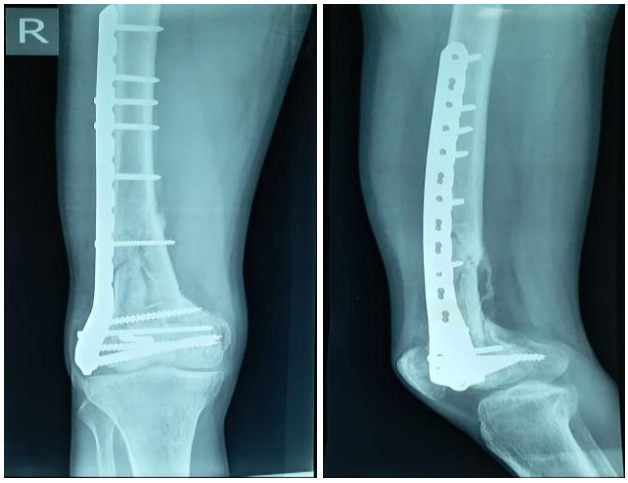

Fig 3: Follow up X-ray 6 months

Case 2

Fig 4: Pre-operative X-ray

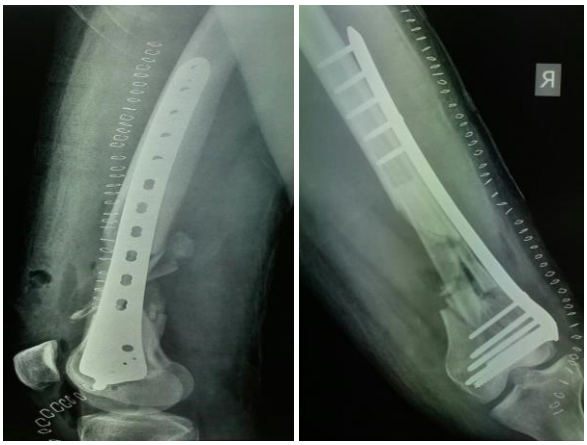

Fig 5: Post-operative X-ray

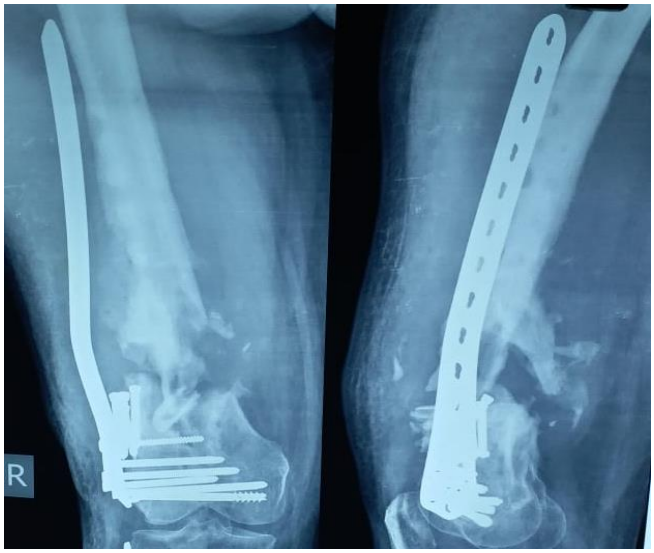

Fig 6: Follow up X-ray 6 months

Method of statistical analysis: The Excel and Graphpad Instat (Graphpad softwares inc, USA) software packages were used for data entry and analysis.

Observation and result

This was a prospective study conducted in Department Of Orthopedic Surgery at Krishna Institute of Medical Sciences Deemed to be University, Karad. For this study 25 patients with distal femur fractures were included. Age group ranged from 20 years to 70 years. Majority of the patients were from the age group 41-50 years 12(48%) patients, followed by less than 31-40 5(20%) patients, less than 30 years 4(16%) patients, 51-60 years 1(4%) and more than 60years (4%). Average age of patients was 41.32 years with a standard deviation of 11.12 years. Out of total patients majority of the patients were males 23 (92 %), and 2 females (8%). 19(76%) patients had right lower limb injury, and 6(24%) patients had left lower limb injury. Right sided dominance was seen. 24 patients (96%) had road traffic accident, while 1 patients (4 %) had fall from height. Out of 25 patients, majority of distal femur fracture were closed-11 cases (44 %) followed by open type 2 in 7 cases (28 %), open type 3A in 5 cases (20 %), open type 1 in 1 cases (4 %) and open grade 3B in 1 patient (4 %). 14(56%) patients had no associated injuries, 4(16%) patients had contralateral lower limb injury, 1(4%) patients had upper limb injuries, 1(4%) patient had chest trauma, 5(20%) patient had head injury, and 1(3.33%) patient had facial injury. In our study of 25 cases, 9(36%) cases were operated within less than 10 days, 12(48%) cases operated between 10-20 days, 3(12%) cases were operated between 20-30 days and 1(4%) patient was operated after 30 days. mean injury surgery interval 13.24 days. In our study 4(16%) surgeries required less than 100 minutes and 21(84%) surgeries required more than or equal to 100 minutes. Mean time for operative procedure in study was 112.4 minutes with standard deviation of 19.03 minutes. We compared surgery

injury interval and duration of surgery in all patients. By applying Chi-square test (0.64), P value (0.14) there is a no any significant association observed between Injury-surgery interval and duration of surgery.

Distal femur fractures was classified according to AO classification.

Out of total 25 patients, 11 cases (44%) are classified into Type A fracture, and majority were 14 cases (56 %) under Type C.

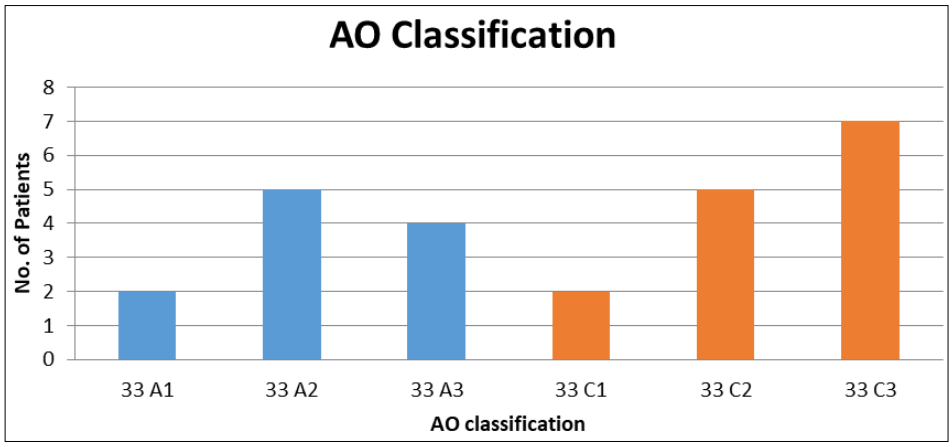

Fig 7: Distribution according to AO classification

In our study of 25 patients, no bone graft required in 15(60%) patients, iliac crest bone graft required in 9(36%) patients and combined iliac crest and fibula strut graft in 1(4%) patient majority 7(28%) patients in AO type C fractures required bone graft 3(12%) patients in AO type A fractures required bone graft. In our study of 25 patients, majority patients were started with knee mobilisation within 4 weeks 10(40%) patients, 9(36%) patients in 9-12 weeks, 3(12%) patients in 5-8 weeks, 3(12%) patients in 13-16 weeks. Knee flexion was studied in all patients, out of total 25 patients mostly observed knee flexion was between 60-100^0 -15(60%) patients, preceding to that knee flexion was <60^0 – 9(36%) patients, and >100^0 -1 patient, (4%). average knee flexion was 70.8^0.

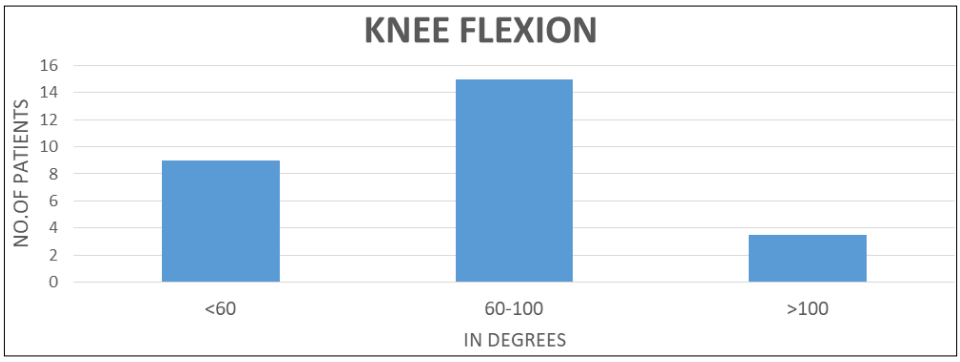

Fig 8: Knee flexion at final follow up

Out of total 25 patients 21 (84%) patients had 0^0 extensor lag, preceding to that 3(12%) had less than 10^0 extensor lag and only 1(4%) patient had 20^0 extensor lag. Average extensor lag was 11.2^0. Out of total 25 patients, most of the patients 18(72%) had radiological union between 15-18, preceding to that 5 (20%) patients had radiological union between 11-14 weeks, 2(8%) patients had no signs of radiological union at 24 weeks. 11 cases with AO type A fractures took a mean of 15.45 weeks for union with standard deviation of 2.54 weeks, and AO type C took a mean of 17.33 weeks with a standard deviation of 1.77 weeks.

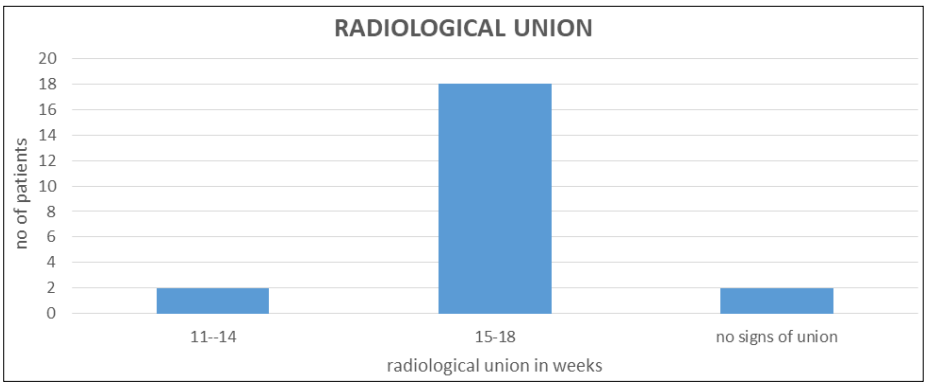

Fig 9: Time required for radiological union

1 (4%) started full weight bearing walking between 10-12 weeks, 1 (4%) started full weight bearing walking between 13-15 weeks, 9 (36%) started full weight bearing walking between 16-18 weeks, 8(32%) started full weight bearing walking between 19-21 weeks and 5(20%) started full weight bearing walking between 22-24 weeks.1(4%) patient was non weight bearing walking at 24 weeks.

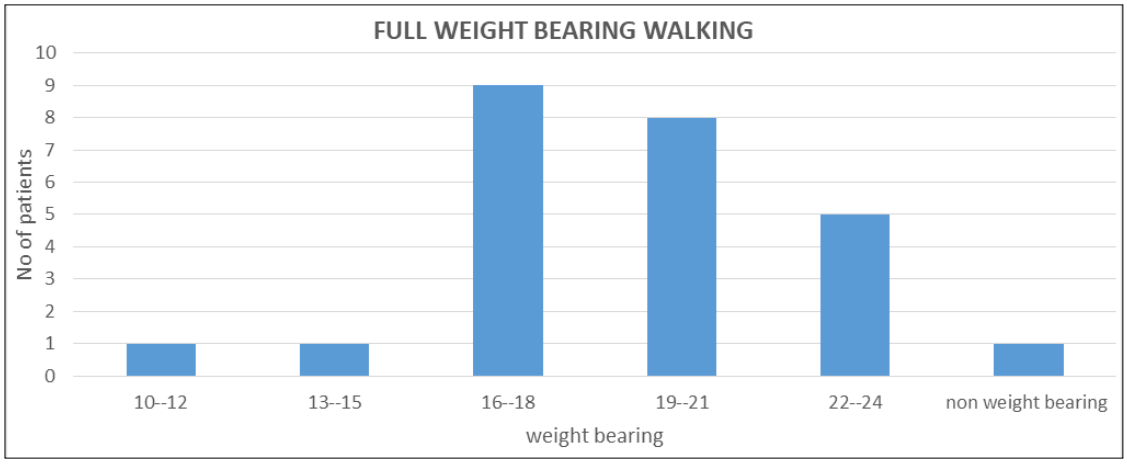

Fig 10: Full weight bearing starting period

In our study, out of 25 patients 6(24%) patients had varus Mal-alignment and 3 (12%) patients had valgus Mal-alignment 16(64%) patients had no Mal-alignment. Out of total 25 patients, limb length discrepancy less than 2cm was observed in 5(20%) patients and in 2(8%) patients had more than 2 cm limb length discrepancy.

In our study of 25 patients, 10(40%) observed excellent result, 5(20%) observed good result, 7(28%) observed fair result and 3(12%) observed poor result.

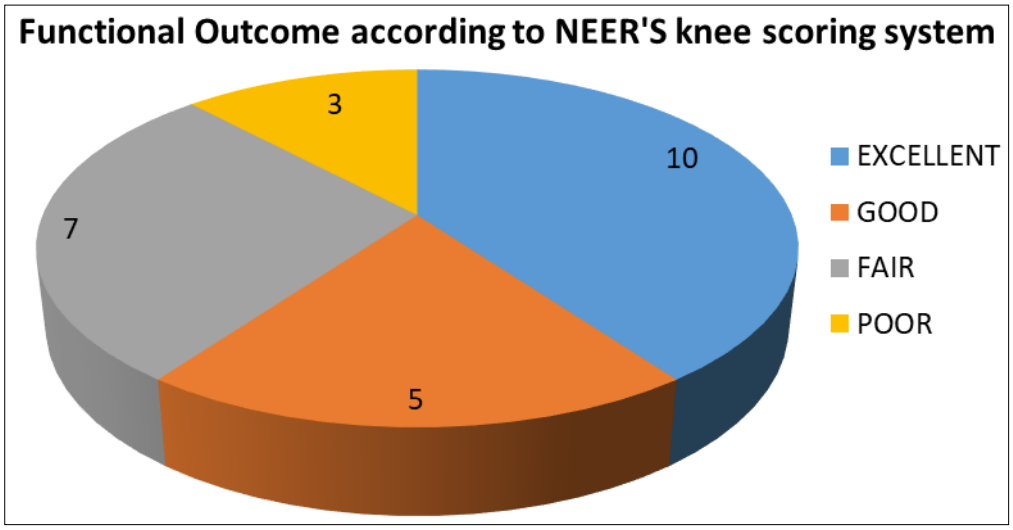

Fig 11: Functional outcome according to NEER's score

Table 1: Functional outcome according to AO type

	Excellent and good result	Fair and poor result
AO type A	9	2
AO type C	6	8

In our study of 25 patients, most common complication knee stiffness 15(60%), post traumatic arthritis 9(36%), mal alignment 9(36%), infection 4(16%), delayed union 2(8%) and implant failure 2(8%) and limb length discrepancy>2cm in 2 (8%).

Discussion

Distal end of femur is defined as the area between femoral condyles and metaphyseal- diaphyseal junction comprising of distal 15 cm of femur measuring from articular surface.

Age- The age distribution was from 20 years to 70 years (Mean 41.32 years). Ram Avatar Saini *et al.* [3] observed age ranged from 18 to 82 years where mean age of patients was 44.94 years. Ramji Lal Sahu [4] observed average age of 41.4 years with range from 17-62 years.

Gender- In our study of 25 patients, males predominated in our study (92% male, 8% female).Ramji Lal Sahu[4] observed 80% (136/170) male and 20% (34/170) female in their study. Vishwanath C *et al.* [5] observed 64% male and 36% female in their study.

Side- In our study, out of total 25 patients, 19 patients had right lower limb injury (76%) and 6 patients had left lower limb injury (24 %). Right sided dominance was seen. Vishwanath C *et al.* [5] observed right lower limb injury (66 %) and left lower limb injury (34 %) in their study. Right sided dominance was seen. Patil *et al.* [6] observed right lower

limb injury (60 %) and left lower limb injury (40 %) in their study. Right sided dominance was seen.

Mechanism of Injury- It occurs usually due to high velocity trauma. There is an increase in the occurrence of distal femur injuries due to the increase in number of road traffic accidents. These are always associated with high morbidity. In our study the most common mechanism of injury was road traffic accidents 24(96 %), such number of road traffic accident cases were due to the fact that our hospital is situated on a major highway and that our hospital is a tertiary referral centre. Ramu *et al.* [7] when the machine in which the subject is travelling stops suddenly, much of the impact is taken first upon the patella, then the condyles of the femur and then the tibia in varying proportions and positions. Kumar SK *et al.* [8] described 60% in their study had road traffic accidents. Dr. Ram Avatar Saini *et al.* [3] observed 76.5% road traffic accidents cases in their study.

Nature of injury- Out of 25 patients, majority femur fracture were closed- 11 cases (44 %) followed by open type 2 in 7 cases (28 %), open type 3A in 5 cases (20 %), open type1 in 1 cases (4 %) and open grade 3B in 1 patient (4 %). 9 (36%) AO type A fractures were closed and 2(8%) AO type C fractures were closed.12 (48%) AO type C fractures were compound and 2(8%) AO type A fractures were compound. Vishwanath C *et al.* [5] Observed majority of cases were close 56% fractures and remaining were open 44% fractures.

Table 2: Type of fracture according to gustilo anderson classification

Study				
	Closed (%)	**Open Type 1 (%)**	**Open Type 2 (%)**	**Open Type 3 (%)**
Gajendra R *et al.* [9]	66.67	14.10	10.35	8.97
Yeap E [10]	63.2	9.09	9.09	18.10
In our study	44	4	28	24

Table 3: AO Classification

Study	AO Type A (%)	AO Type C (%)
Vishwanath C *et al.* [5]	50	50
Gyanendra Kumar Jha *et al.* [11]	56.66	43.34
Yeap E [10]	54.54	45.45
In our study	44	56

Table 4: Injury-surgery interval

Study	Injury Surgery Interval		
	<10 Days (%)	**>10 Days (%)**	**Mean Days**
Rajanish R Menon *et al.* [12]	80	20	4
Patil *et al.* [6]	83	17	6
S K Kumar *et al.* [9]	40	60	11.86s
In our study	36	64	13.24

Table 5: Duration of surgery

Study	Range (Minutes)	Mean Duration (Minutes)
Yeap E [10]	80-180	119.2
Rajesh *et al.* [13]	60-100	70
Rajanish R Menon *et al.* [12]	58-123	83
Gyanendra Kumar Jha *et al.* [11]	60-150	93.83
In our study	80-160	112.4

Bone grafting: In our study of 25 patients, no bone graft required in 15(60%) patients, iliac crest bone graft required in 9(36%) patients and combined iliac crest and fibula strut graft in 1(4%) patient.

Reddy JAV and Chary NB [14] in their study of total 60 cases operated primary bone grafting was performed in 20 cases (33.34%) same as our study and stated "When comminution is present, supracondylar femoral fractures are especially prone to varus collapse that is why we have done primary bone grafting in many cases of our series". Dr. Ram Avatar Saini *et al.* [3] performed primary bone grafting in 6(17.64%).

Knee mobilisation starting period

Our study knee mobilisation was started before 4 weeks in 10(40%) patients till 13-16 weeks in 3(12%) patients. Range was 2 weeks to 14 weeks. Average duration was 7.68 weeks. Average duration in AO type A was 4.90 weeks and in AO type C was 9.85 weeks. Average duration of knee mobilisation starting period in closed fractures was 5.45 weeks and in compound fractures was 9.42 weeks.

Knee flexion at final follow up- Minimum knee range of motion was $0\text{-}20^0$ and maximum was $0\text{-}130^0$.

Average range in extra-articular fracture was 85.45^0 and average range in intra-articular fractures was 59.28^0. Average knee flexion at final follow up in closed fractures was 82.72 degrees and average knee flexion at final follow up in compound fractures was 61.42 weeks.

Table 6: Comparison of knee flexion with other studies

Study	Average Knee Flexion (In Degrees)
Yeap E [10]	107.7
Shriharsha RV [16]	99.0
Schuetz *et al.* [15]	103
Our study	70.8

Extensor lag

In our study 4(16%) patients had extensor lag 4% has less than 5^0 lag and 12% had more than 5^0 of extensor lag.in a study conducted by Gyanendra Kumar Jha *et al.* [11] 10%

patients had extensor lag, 3.75%had less than 5^0 and 6.25% had more than 5^0.in a similar study conducted by Schuetz *et al.* [15] 60% of total extensor lag patients had $<5^0$ of lag while 40% of total extensor lag patients had $>5^0$ of extensor lag.

Radiological union

Average time of union in closed fractures was 15.09 weeks and average union time in open fractures was 17.83 weeks.

Table 7: Average time for union (In weeks)

Study	Average Time For Union (In Weeks)
Rajesh *et al*. [13]	16.8
Vishwanath C [5]	18
Gyanendra Kumar Jha *et al*. [11]	17.83
In our study	16.43

Full weight bearing walking

Full weight bearing was permitted depending on the modality of fixation and bony union seen radiologically. In majority, it was started within 16-21 weeks in 17 cases (68 %). Average time period was 18.75 weeks.76% fractures united at the end of 21 weeks. Average time taken by patients with AO type A fractures was 18.36 weeks and average time by AO type C was 19.07 weeks. 1 patients were advised not to do full weight bearing walking because of poor bone union. Average time to start full weight bearing walking in patients having closed injuries was 18.18 weeks and average time to start full weight bearing walking in patients with compound fractures was 19.23 weeks.

Table 8: Starting Time for Full Weight Bearing (In Weeks)

Study	Starting time for full weight bearing (In Weeks)
Rajanish R Menon and Subramanian V [12]	17.42
Gyanendra Kumar Jha *et al*. [11]	16.3
In our study	18.75

Post-operative complications

Infection

Infection occurred in total 3 patients (12%) out of which all 3 (12%) patients had compound fractures in which 2(8%) had gustilo and Anderson type 2 injury and 1(4%) had gustilo and Anderson type 3 B injury. 2(8%) patients recovered with regular dressings but 1 patient required wound debridement and vaccum assisted closure followed by skin thickness split grafting. Poor functional outcome was observed in 2(8%) patients amongst these. Gyanendra Kumar Jha *et al.* [11] in their study of 30 cases had 2 cases of infection which resolved with regular dressing.

Table 9: Comparison of occurrence of infection

Study	Infected cases	Sample size	percentage
Ram Avatar Saini *et al*. [3]	2	34	5.8
Kumar SK *et al*. [8]	3	20	15
Rajesh *et al*. [13]	4	22	18.18
Our study	3	25	12

Delayed union

Delayed union occurred in2patients (8%) in our study. 1 (4%) patient had gustilo and Anderson type 2 compound fracture and 1 (%) patient had gustilo and Anderson type 3A compound fracture. In similar study by Reddy JAV *et al*. [14] they had 3(5%) cases of delayed union. Kumar SK [8] had 1(5%) case of delayed union. Vishwanath C [5] in their study had similar cases 4(8%) of delayed union.

Malalignment

Malalignment was observed in 7(28%) patients, 5(20%) patients had varus malalignment and 2(8%) patients had valgus malalignment. All 7 patients had AO type C fractures. Shahhoseini *et al*. [17] in their study had 31.6% cases of malunion. Moradi *et al*. [18] malunion rate was (21.3%). Gyanendra Kumar Jha *et al*. [11] in there study had 36.7% cases of malalignment.

Implant failure

In our study, Implant failure occurred in 2(6.66%) patients in form of plate bending and screw back out. Both were AO type 3 fractures, Out of which 1 patient had bone loss and was augmented with primary contralateral fibula strut graft. Yeap E[10] observed 1(9.09%) case of implant failure in form of screw backout, similar study by Vishwanath C [5] observed 6(12%) cases with implant failure, 2(4%) were plate bending cases and 4(8%) had screw backout. Patil *et al*. [6] Observed 1 case with implant breakage and was removed and reoperated augmenting bone graft.

Knee stiffness

Most common complication in our study was knee stiffness 15(60%)patients. 11(44%) patients were AO type C and 4(16%) had AO type A fractures. by Vishwanath C [5] observed 15(30%) cases of knee stiffness at final follow up. Reddy JAV [14] in their study had 8(13.3%) cases of knee stiffness.

Functional outcome

Functional outcome was analyzed according to the NEERS knee scoring system. In our study of 30 patients, 6(20%) observed excellent result, 9(30%) observed good result, 6(20%) observed fair result and 9(30%) observed poor result.

Table 10: Comparison with other studies

Study	Excellent (%)	Good (%)	Fair (%)	Poor (%)
Ramu AC [7]	30	46.7	23.3	0
Ramji Lal Sahu [4]	66.4	22.30	7.05	5.83
M. Agunda *et al*. [19]	48	41	6.5	4.3
Umansky [20]	70	16.6	8.33	5.55
In Our Study	40	20	28	12

Conclusion

Distal femoral fractures are common in young males in the age group of 30 – 50 years with high velocity high impact injuries. Closed type fracture and -Extra – articular fractures AO Type A fractures had better functional outcome.-Bone grafting is necessary in case of comminution. Distal femur locking compression plate is an optimal tool for supracondylar fractures of femur especially AO Type A fractures and AO type C where we found higher Neer scores. Accurate positioning and fixation is required to produce satisfactory results. It provides rigid fixation in the region of femur, where a widening canal, thin cortices and frequently poor bone stock with severe comminution make fixation difficult. But careful selection of patients and strict adherence to the basic principles of fracture fixation will help in reducing the complications of fracture fixation using locking compression plates. Regular Follow up and physiotherapy have great role. Rate of knee stiffness in our study was slightly higher as compared to standards, because of late knee mobilisation starting period. Most common complications in this study are knee stiffness, post traumatic arthritis and infection. Neuro – vascular compromise is rare. Minimally invasive percutaneous osteosynthesis (MIPO) is a new modality of treatment, biological healing via this technique, may reduce infection and promote healing and need to be assessed. Our study is a small sample study, with no strict criteria of treatment modality and many surgeon's involvement.

Table 11: Neer's scoring system

Functional (70 points)		**Anatomical (30 points)**	
A) Pain (20 points)		**A) Gross anatomy (15 points)**	
No pain	20	Thickening only	15
Intermittent	16	5 degree angulation or 0.5 cm shortening	12
With fatigue	12	10 degree angulation or rotation, 2 cm shortening	09
Limits function	8	15 degree angulation or rotation, 3 cm shortening	06
Constant or at exertion	4	Healed with considerable deformity	03
B)Walking capacity (20 points)		Non-union or chronic infection	00
Same as before accident	20	**B) Roentgenogram (15 points)**	
Mild restriction	16	Near normal	15
Restricted stair side ways	12	5 degree angulation or 0.5 cm displacement	12
Use crutches or other walking aids	4	10 degree angulation or 1 cm displacement	09
c)Joint movement (20 points)		15 degree angulation or 2 cm displacement	06
Normal or 135 degrees	20	Union but with greater deformity, spreading of condyles and osteoarthritis	03
Up to 100 degrees	16	Non-union or chronic infection	00
Up to 80 degrees	12	Excellent:- More than 85 points Good:- 70 to 85 points Fair:- 55 to 69 points Poor:- Less than 55 points Total:-	
up to 60 degrees	8		
Up to 40 degrees	4		
Up to 20 degrees	0		
D)Work capacity (10 points)			
Same as before accident	10		
Regular but with handicap	8		
Alter work	6		
Light work	4		
No work	2		

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