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A STUDY OF FUNCTIONAL OUTCOME OF DISTAL FEMUR FRACTURES INTERNALLY FIXED WITH DISTAL FEMUR LOCKING COMPRESSION PLATE

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The femur is the largest bone in the body connecting between the tibia and pelvic bone. Studies have proved this bimodal distribution of supracondylar fractures of the femur. The locking plate's standard is to have an anatomical reduction of the bone under the soft tissue envelope and could be applied without stripping the periosteum.

The aim: to study the union rates with locking compression plates and clinical outcome associated with this treatment modality, range of movements of the knee, pain relief and return to normal activities and work.

Methodology: this is a prospective study on patients with distal femur fractures. Conducted at Santhiram medical college and general hospital, Nandyal from October 2018 to September 2020. All patients aged more than 18 years diagnosed with distal femur fractures.

Results: in our study, around 46 % of them had Muller A1 type, followed by 23 % had Muller C1 and C2 respectively, and the remaining 13.3 % had Muller A2. Around 67 % had a Thomas splint with traction, 16.7 % had B.B. splint, 13.3 % had A/K POP slab, and the remaining 3 % had upper tibial traction with B.B. splint. The majority of the study participants, 53 %, had knee flexion more than 120 degrees. 30 %, took <16 weeks for the union, 33 %, took 16–20 weeks to complete weight-bearing, eight patients (26 %) had excellent outcomes; 21 patients (70 %) had a satisfactory outcome; one patient (3.3 %) had an unsatisfactory outcome.

Conclusion: in our study, out of 30 patients, eight patients had excellent outcomes, 21 patients had satisfactory outcomes, and one patient had unsatisfactory outcomes. We conclude, open reduction and internal fixation with a locking compression plate resulted in good clinical and radiologic outcomes

Keywords: open reduction, internal fixation, locking compression plate, tibial traction

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1. Introduction

The femur is the largest bone in the body connecting between the tibia and pelvic bone. It is surrounded by a large group of muscles, divided into three portions as the proximal, middle, and distal third. The distal femur (supracondylar and intercondylar) comprises the distal 10–15 cm of the femur. Distal femur fractures represent about 3–6 % of all femoral fractures. The overall incidence is about 8.7/1,00,000/year. Distal femur fractures present a considerable challenge in the treatment. They are due to high energy trauma with extensive soft tissue damage with articular and metaphyseal involvement and also ligamentous involvement of the knee joint [1]. Older patients, especially women, sustain fractures due to osteoporosis. Studies have proved this bimodal distribution of supracondylar fractures of the femur. Fractures of distal femur are complex injuries producing long term disability. They account for 6 % of all femur fractures, and 31 % [2, 3] if hip fractures are excluded. Nearly 50 % of distal femur intraarticular fractures are open fracture.

In the 19th century, numerous improvements and developments across all medical specialties took place; at the same time, advances in fracture fixation also occurred, thus improving the outcome for function and

quality of life of patients with fractures. While bone fractures' healing process is benefited by the plate and screw fixation construct, in 1995, a new application of plate fixation started – Minimally Invasive Percutaneous Plate Osteosynthesis (M.I.P.P.O.). Locking compression plates evolved from conventional plates and are widely used nowadays because of biomechanical advantages. The conventional strategy for O.R.I.F. (Open reduction Internal fixation) requires wide involvement of the fracture site with deprivation of the soft tissues, which may thus de-vascularise fracture fragments. This may add to delayed healing and infection brought about by injury and increases the dangers of infection, contamination, and delayed union or malunion. Open methods involve a bigger incision, increased blood loss, and the requirement for periosteal stripping. Postoperative recovery is extended. This procedure (M.I.P.P.O.) was created to avoid extensive opening of the fracture site and limit soft tissue damage and involve a smaller incision bringing about a small scar and allowing the recovery of the delicate soft tissue quickly [2].

The locking plate's standard is to have an anatomical reduction of the bone under the soft tissue envelope and can be applied without stripping the periosteum. The

locking plates and screws could embed as many numbers of screws as possible to the diaphysis for the most extreme fixation. Studies have indicated clashing reports of accomplishment, yet at the same time, L.C.P. is by and large widely utilized in a distal femur fracture. So the need for the study is to assess the effectiveness of the device in achieving the fracture union, functional recovery, and to know the rate of complications associated with the devices.

The aim of the study was to study the union rates with locking compression plates and clinical outcome associated with this treatment modality, range of movements of the knee, pain relief and return to normal activities and work.

2. Materials and methods

This is a prospective study on patients with distal femur fractures in Santhiram medical college and general hospital, Nandyal from October 2018 to September 2020 in all patients both male and female patients more than 18 years diagnosed with distal femur fractures. Ethics committee Santhiram Medical College & General Hospital, number- IEC Ref No: SRMC/IEC/2018/048 and date as **03/10/2018** clearance was obtained before starting the study. The study's purpose was explained to the subjects in their dialect, and informed consent was obtained.

Inclusion criteria: all skeletally mature patients (>18 years) with osteoporosis.

Exclusion criteria: patients of age less than 18 years with supracondylar fracture femur associated with fracture neck of femur, associated tibial plateau fractures, associated with IDK (internal derangement of the knee), non-union and delayed union and patients with pathological fractures except for osteoporosis.

Thirty patients were diagnosed with a distal femur fracture. During the follow up patients were assessed clinically, radiological and functionally by NEERS criteria (Table 1).

Table 1

Neer's criteria for evaluation of patients [3]

FUNCTIONAL (70 POINTS)	SCORE
1	2
pain (20 points)	
no pain	20
intermittent	16
pain with fatigue	12
limits function	8
constant pain	4
walking capacity(20 points)	
same as before accident	20
mild restriction	16
restricted stair side ways	12
use crutches or other walking aids	4
joint movements (20 points)	
normal or 135 degrees	20
up to 100 degrees	16
up to 80 degrees	12
up to 60 degrees	8
up to 40 degrees	4
up to 20 degrees	0

Continuation of Table 1

1	2
work capacity(10 points)	
same as before accident	10
regular but with handicap	8
alter work	6
light work	4
no work	2
ANATOMICAL (30 POINTS)	
gross anatomy(15 points)	
thickening only	15
5 degree angulation or 0.5 cm shortening	12
10 degree angulation or 2 cm shortening	9
15 degree angulation or 3 cm shortening	6
healed with considerable deformity	3
non-union or chronic infection	0
roentgenogram (15 points)	
near normal	15
5 degree angulation or 0.5 cm shortening	12
10 degree angulation or 1 cm shortening	9
15 degree angulation or 2 cm displacement	6
union but with greater deformity,	
spreading of condyles and osteoarthritis	3
non-union or chronic infection	0

Neer clinical outcome scores

EXCELLENTmore than 85 points
 GOOD.....70 to 85 points
 FAIR.....55 to 69 points
 POOR.....less than 55 points

Data was entered in Microsoft Excel and analysis was done using SPSS version 20. Descriptive statistical analysis was done. Results on continuous measurements are presented as Mean & Standard Deviation. Results on categorical measurements are presented as percentages. Significance is assessed at 5 % level of significance. Student t test (independent, two tailed) has been used to find out the significance of study parameters on a continuous scale between two groups. Chi square test is used to find out the significance of study parameters on a categorical scale.

3. Results

The overall mean age of the participants was 49±11 years. The majority of them were in the age group of 51–60 years (33.3 %), followed by 30–40 years (26.7 %). Male preponderance (70 %) was seen in our study. The majority of the study participants were farmers (23 %), followed by 23 % of the homemakers. Around 13.3 % were teachers and laborers, respectively. Around 57 % of the study participants had R.T.A., followed by 23 % falling from a height, and the remaining 20 % had fallen in the bathroom. Our study participants had the same proportion of sides concerning the side of the injury. In our study, around 7 % only had open type (Table 2).

In our study, around 46 % of them had Muller A1 type, followed by 23 % had Muller C1 and C2 respectively, and the remaining 13.3 % had Muller A2 (Fig. 1).

Table 2
Distribution of study participants according to age (N=30)

Age	Frequency	Percentage
<30	1	3.3
30–40	8	26.7
41–50	6	20.0
51–60	10	33.3
61–70	5	16.7
Gender		
Male	21	70
Female	9	30
Occupation		
Bank employer	1	3.3
Business	2	6.7
Clerk	2	6.7
Driver	1	3.3
Farmer	7	23.3
Housewife	6	20
Laborer	4	13.3
Mason	1	3.3
Sales executive	1	3.3
Software	1	3.3
Teacher	4	13.3
Mechanism of Injury		
Fall from height	7	23.3
Fall in bathroom	6	20.0
RTA	17	56.7
Side of injury		
Right	15	50
Left	15	50
Open or closed		
Open	2	6.67
Closed	28	93.33

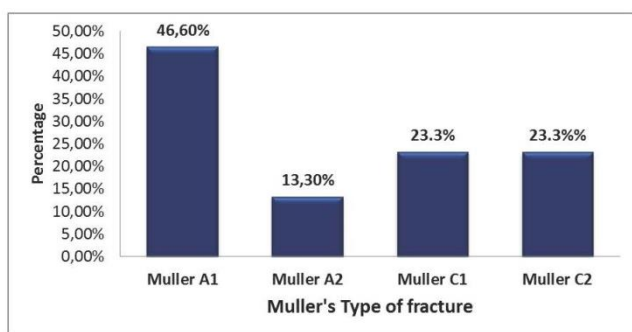


Fig. 1. Distribution of study participants according to Muller's type of fracture

Around 67 % had a Thomas splint with traction, 16.7 % had B.B. splint, 13.3 % had A/K POP slab, and the remaining 3 % had upper tibial traction with B.B. splint. The majority of the study participants, 93 %, had O.R.I.F. with L.C.P. (Table 3).

The majority of the study participants, 30 %, took <16 weeks for the union.

The majority of the study participants, 33 %, took 16–20 weeks to complete weight-bearing (Table 4).

The majority of the study participants, 53 %, had knee flexion more than 120 degrees (Fig. 2).

Table 3
Distribution of study participants according to initial treatment done (N=30)

Initial treatment	Frequency	Percentage
Above knee POP slab	4	13.3
BB splint	5	16.7
Thomas splint with traction	20	66.7
Upper tibial traction with B.B. splint	1	3.3
Procedure		
Debridement and O.R.I.F. with L.C.P.	2	6.7
O.R.I.F. with L.C.P.	28	93.3

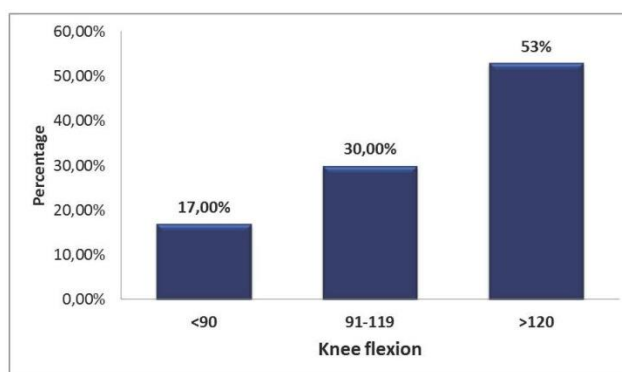


Fig. 2. Distribution of study participants according to knee flexion (N=30)

Table 4
Distribution of study participants according to the time taken for fracture union in weeks (N=30)

Time union in weeks	Frequency	Percentage
<16	9	30
16–18	6	20
18–20	4	13
20–22	6	20
22–24	5	17
Achieved time in weeks (complete weight-bearing)		
<16	8	27
16–20	10	33
20–24	9	30
24–28	3	10

In our study, around 10 % had a 10mm shortening followed by 3.3 % had delayed wound healing, another 3 % had pin tract infection, and the remaining 3 % had plate breakage with Reimplantation (Table 5).

Table 5
Distribution of study participants according to complications (N=30)

Complication	Frequency	Percentage
10 mm shortening	3	10
Delayed wound healing	1	3.3
Pin tract infection	1	3.3
Plate breakage and reimplantation	1	3.3
None	24	80

The majority had satisfactory results, followed by 26.67 %, had an excellent outcome, and the remaining 3 % unsatisfactory (Fig. 3).

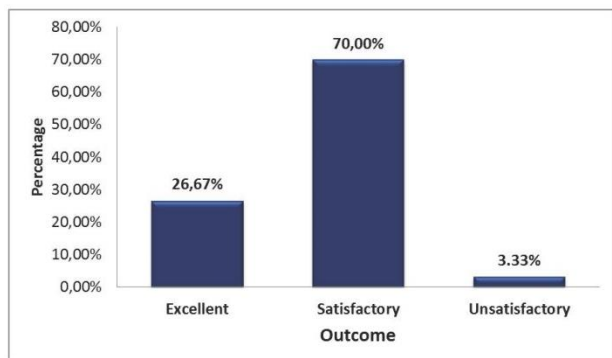


Fig. 3. Neer's Score- Overall rating (N=30)

4. Discussion

Our study comprised 30 patients with distal femur fractures who were treated by a locking compression plate. The overall outcome was measured in terms of loss of knee function using Neer's score. The overall mean age of the participants was 49±11 years. The majority of them were in the age group of 51–60 years (33.3 %), followed by 30–40 years (26.7 %) (Table 2).

The mean age was comparable with other study results. Adult distal femur fractures present in a bimodal distribution. Most of the time, young patients present secondary to high-energy mechanisms, for example, motor vehicle accidents. Old patients present commonly after a low-energy mechanism, for example, ground level-falls [4]. In present study male preponderance (70 %) was seen in our study. Gender preponderance was almost similar to other studies. Injury caused by high-energy mechanisms is very common among men, while women have injuries from low-energy mechanisms. In our study, around 57 % of the study participants had R.T.A., followed by 23 % falling from a height, and the remaining 20 % had fallen in the bathroom (Table 6).

All studies fetched similar results as our study, with the common mode of injury being road traffic accidents. Our study participants had the same proportion of sides concerning the side of the injury. It has been very well established before that there is a strong association between bone mineral density and the limb's dominant side. In all the studies, the dominant side of the patient was affected more than the non-dominant limb. Bone is deposited uniformly to the compressive load, and this is why athletes are having greater bone mass than people who do not practice exercise.

In our study, around 46 % of them had Muller A1 type, followed by 23 % had Muller C1 and C2 respectively, and the remaining 13.3 % had Muller A2.

The most common type of fracture seen in our study was type Muller A1. In Shenoy et al. and Chandra et al., it was Muller C2, and in Reddy et al., it was Muller A2 type from the above table findings [4–6].

In our study, around 7 % only had open type. Distal femur fractures could be closed – in a sense, the skin needs to be intact or open. An open fracture bone could fracture in a way that bone fragments could be exposed out through the skin or a wound that penetrates down to

the fractured bone. An open fracture often involves much more damage to the muscles, tendons, and ligaments surrounding it. They have a very high risk for complications and usually take a longer time to heal.

Table 6

Comparison with other studies in demographic details

Mean age	Year of study	Percentages	
Reddy et al ⁴	2019	47.4	
Shenoy et al. ⁵	2018	35.7	
Chandra et al. ⁶	2017	30.7	
Present study	2020	49	
Preponderance of gender			
Reddy et al. ⁴	2019	Males 66.7 %	
Shenoy et al. ⁵	2018	Males 81 %	
Chandra et al. ⁶	2017	Males 83.3 %	
Present study	2020	Male (70 %)	
Mode of injury		R.T.A.	Fall
Reddy et al ⁴	2019	66.7 %	33.3 %
Shenoy et al ⁵	2018	68.1 %	31.9 %
Chandra et al ⁶	2017	86.66 %	13.33 %
Present study	2020	57 %	43 %
Right limb injury			
Reddy et al ⁴	2019	56.7 %	
Shenoy et al. ⁵	2018	68.1 %	
Chandra et al. ⁶	2017	60 %	
Present study	2020	50 %	
Open/closed		Open	Closed
Shenoy et al ⁵	2018	20 %	80 %
Reddy et al ⁴	2019	13.3 %	86.7 %
Vishwanath et al ⁷	2016	44 %	56 %
Present study	2020	7 %	93 %

The majority of the study participants, 93 %, had O.R.I.F. with L.C.P. which is comparable to Shenoy et al. [5] with DFLCP in 100 %, Reddy et al. [7] with DFLCP in 100 %, Vishwanath et al. [4] with O .R.I.F in 70 % (Table 3).

The majority of the study participants, 53 %, had knee flexion more than 120 degrees, which is comparable to Shenoy et al. [5] 50 %, had knee flexion more than 120 degrees Reddy et al. [7] 80 %, had knee flexion more than 120 degrees, Vishwanath et al. [4] 70 %, had knee flexion more than 120 degrees (Fig. 2).

The majority of the study participants, 30 %, took <16 weeks for the union (Table 4).

Early weight-bearing benefits are increasing functional recovery, early independence, the diminished effect on the family, increased psychological benefits, decreased utilization of medicinal services, and the diminished requirement for family involvement (Table 7).

The distal femoral locked nailing includes the opening of the knee joint and is related to the protrusion of the nail into the joint and joint pain. The intraarticular section could prompt knee stiffness, knee sepsis, and patellofemoral pain related to a high rate of removal of the implant.

The results of our present study were consistent with the existing literature with minimal complications (Tables 5, 8). Our study in Neer's Score is in comparison with studies (Fig. 3, Table 9).

Table 7

Fracture union and Full weight-bearing in weeks in comparison with studies

Study	Year of study	<16	16–18	18–20	20–22	22–24
Chandra et al ⁶	2018	20 %	24 %	20 %	29 %	7 %
Reddy et al ⁴	2019	26 %	22 %	20 %	22 %	10 %
Vishwanath et al ⁷	2016	22 %	26 %	22 %	20 %	10 %
Present study	2020	30 %	20 %	13 %	20 %	17 %
Study	Year of study	<16	16–20	20–24	24–28	
Chandra et al ⁴⁶	2018	40 %	30 %	10 %	20 %	
Reddy et al ⁴⁴	2019	20 %	30 %	30 %	20 %	
Vishwanath et al ⁷	2016	30 %	40 %	20 %	10 %	
Present study	2020	27 %	33 %	30 %	10 %	

Table 8

Complications in in comparison with studies

Complication	Chandra et al. [6]	Reddy et al. [4]	Vishwanath et al. [7]	Present study
10 mm shortening	–	20 %	6 %	10 %
Delayed wound healing	16.67 %	–	10 %	3.3 %
Pin tract infection	–	–	–	3.3 %
Plate breakage and Reimplantation	–	–	–	3.3 %
Delayed union	6.67 %	–	8 %	–
Stiffness	–	–	30 %	–
Knee pain	–	–	14 %	–
Malalignment	–	20 %	–	–
None	76.66 %	60 %	32 %	80 %

Table 9

NEER'S SCORE in comparison with studies

Author	Scoring System	Excellent and Good Results (%)
Yeap et al [8]	Schatzker	72.7
Hosam et al [9]	Neer	78.26
Kanabar et al [10]	Neer	88.23
R. Sahaya Jose [11]	Sanders	70
Our study	Neer	96.6 %

Limitation of the study: rotational error was not included; study period was less; sample size was small.

Prospects for further research: former studies involving less invasive stabilization system do not recommend primary bone grafting. In our opinion, sensible use of bone graft or bone-graft substitutes would enhance the healing response and decrease the potential mechanical failure and varus collapse, especially in elderly patients. But the major challenge is difficulty in correcting rotation, varus and valgus malalignment. With the introduction of locking compression plates, this difficulty has been overcome.

5. Conclusion

Locking compression plate is the best option for the management of comminuted distal femur fractures. Locking compression plate prevents damage to periosteal

blood vessels, metaphyseal collapse, and maintains limb length in comminuted fractures. There is less chance of implant failure. In type-A fractures, we have seen a high Neer's score; however, in some type-C fractures the outcome is unsatisfactory, but it is the implant of choice for type-C fractures. Complications like knee stiffness, limb shortening, plate breakage, wound infections are seen. In our study, out of 30 patients, eight patients had excellent outcomes, 21 patients had satisfactory outcomes, and one patient had unsatisfactory outcomes. To conclude, open reduction and internal fixation with a locking compression plate resulted in good clinical and radiologic outcomes.

Conflict of interest

The authors declare there is no conflict of interests.

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