A PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME OF DISTAL FEMUR FRACTURES BY LOCKING PLATE

by

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Dissertation submitted to

In partial fulfillment for the degree of

MASTER OF SURGERY

IN

ORTHOPEDICS

Under the Guidance of

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2019

ABBREVIATIONS

ACL	Anterior cruciate ligament
AO	Arbeitsgemeinschaft fur osteosynthesis Fragen
ASIF	association of surgeons for internal fixation
CBP	Condylar blade plate
CPM	Continuous passive motion
CRIF	Closed reduction and internal fixation
DCS	Dynamic condylar screw
LCL	Lateral collateral ligament
LCP	Locking compression plate
LISS	Less invasive stabilization system
MCL	Medial collateral ligament
MIPO	A minimally invasive plate osteosynthesis
MIPPO	A minimally invasive percutaneous plate osteosynthesis
ORIF	open reduction and internal fixation
OTA	Orthopaedic trauma association
PCL	Posterior collateral ligament
ROM	Range of motion
RTA	Road traffic accident

ABSTRACT

Introduction: In last few decades, rapid industrialization and the fast pace of life have brought both comforts and catastrophe like road traffic accidents and crippling many young lives. High velocity road traffic accidents are responsible for distal femur fractures more commonly observed in the young and middle aged patients. This necessitates early stabilization of fractures. Internal fixation is the choice of treatment in fractures distal femur and Locking Condylar plate has shown to give one of the best results in terms of recovery, fracture union, return to work and the functional outcome.

Aims and objective: To study the outcome of open reduction and locking plate fixation of fractures of distal end of femur and to evaluate the effectiveness and complications of the Locking plate fixation method of treatment of fractures of distal end of femur.

Material and Method: It is a prospective observational study. Conducted in patients admitted to Department of Orthopedics' at BLDEU'S Shri B.M.Patil's Medical College, Hospital and Research Centre, Vijayapura with diagnosis of distal Femur fracture. The patients were informed about study in all respects and informed written consent was obtained. Period of study was between November 2017 to May 2019. Follow up period was for 6 months. Data was analysed by SPSS v21 and p-value <.05 was considered statistically significant.

Results: in our study 22 cases studied in our series were with 18 males and 4 females' patients. 15 of the fractures were caused by road traffic accidents (RTA), 6 were due to fall and 1 was due to assault. 15 patients were with fracture on right side and 7 on left side. 1 was Muller's type A1, 6 were Muller's type A2, 4 were Muller's type A3, 1 was Muller's type C1, 6 were Muller's type C2 and remaining 4 were with Muller's type C3 fracture. The duration of time required by patients to bear full weight was with mean of 15.8 weeks of time. The radiological union was seen at median of 17 weeks following surgery. Average flexion in the study of the limb was 110° angles with more than 50% patients having knee range of motion more than 120°. The outcome in form of regaining the knee function is assessed using NEER's scoring system. The median NEER's score in study was 94.5. Among 22 patients included, 12 patients showed excellent outcome, 6 with good and 4 with fair outcome at the follow-up. Poor outcome was found in patients with Muller's type C3 and type A3 fractures.

Conclusion: To conclude, **Locking Compression Plate** is an important armamentarium in treatment of fractures around knee especially when fracture is severely comminuted and in situations of osteoporosis. Fixation with locking condylar plate showed more effectiveness in severely osteoporotic bones, shorter post-operative stay, faster recovery, earlier union rates and excellent functional outcome compared to alternative procedures in other studies. Further study in large number of patients is required to comment regarding disadvantages and complications.

Keywords: Supracondylar Femur Fracture, Locking Condylar Plate, Open Reduction Internal Fixation, Intra Articular Fractures, NEER's Scoring System,

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INTRODUCTION:

In last few decades, rapid industrialization and the fast pace of life have brought both comforts and catastrophe like road traffic accidents and crippling many young lives. High velocity road traffic accidents are responsible for distal femur fractures more commonly observed in the young and middle aged patients. Low energy impact, such as fall at home, are usually responsible for producing fractures of distal femur in the older osteoporotic population especially women. Fractures of the distal end of the femur are tricky to treat and present constant challenges in management. Decreased range of movement, pain and compromised function of the knee joint are the common problems resulting from improper fixation of articular fragments in such fractures.[(1)]

The advent of fixed angle devices like the Condylar blade plate and the Dynamic Condylar Screw (DCS) needs a certain amount of bone stock which restricts their usage in comminuted fractures. This led to development of condylar buttress plate for fixation of comminuted femoral fractures. However, with the usage of condylar buttress plate, these fractures generally have a tendency to fall into a varus collapse because of toggle at the screw- plate interface. 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.[(1)]

Since, the plate does not depend on the friction created at the bone-plate interface to provide stability, it does not have to contact the bone directly. This helps in preserving the periosteal blood supply. Locked implants are typically indicated in patients with osteoporosis, fractures with metaphyseal comminution, where the medial cortex cannot be restored, or with a short articular segment. Comminuted articular fractures can also be approached more conveniently with the use of additional screws such as partially- threaded cancellous screws, herbert screws and other varieties of smaller screws.(1)

By making use of the technique of counter- sinking, the screw heads can be adjusted to seat the distal femur locking plate in a proper fashion. It also provides another useful choice for extra-articular fractures of distal femur. Thus, the flexibility of locking condylar plate with its fixed angle properties appears to offer an effective alternative to implants like DCS, condylar buttress plate and a supra- condylar or a distal femur retrograde nail. This study was done to study the functional and radiological outcome of distal femoral fractures in skeletally mature patients treated by open reduction and internal fixation with distal femur locking plate.

In addition, a locking compression plate has got distinct advantages of unicortical fixation and least chance of plate back out as the screw gets locked to the plate. Further, Minimal soft tissue injury occurs when closed reduction is done and MIPO technique is used.

The purpose of this study is to evaluate the results of fracture lower end of femur treated by open reduction and internal fixation using locking compression plate.

OBJECTIVE OF THE STUDY:

To study the outcome of open reduction and locking plate fixation of fractures of distal end of femur and to evaluate the effectiveness and complications of the Locking plate fixation method of treatment of fractures of distal end of femur.

REVIEW OF LITERATURE:

History:

The major advances in the treatment of all types of femoral fractures were first seen in 1870 when **Hugh Owen Thomas**[(2)] devised the "Thomas Splint".

First internal fixation of fracture with screw and plate was done in 1894 by **Sir Arbuthnot Lane**.

1909 saw the **"Steinman Pin"** devised by **Fritz Steinman**[(3)] which was used for skeletal traction replacing the age old skin traction.

In early 1930s **Venable Struck** described chromium molybdenum and nickel-vitallium inert alloys.

James E Anderson[(4)] described the anatomy of lower end of femur which guided the treatment of fractures around knee.

Muller [(5)] classified supracondylar fracture based on AO principles and tibial plateau fractures were classified by **Schatzker**[(6)] which have helped in understanding biomechanics of fracture treatment.

In 1945, **Modlin**[(7)] reported 23 fractures of distal femur treated by skeletal traction. He inserted one Kirschner wire in the distal femoral fragment and one in proximal tibia. He reported fairly acceptable alignment with minimal incidence of sagging, good results were obtained by this method. In 1948 and 1949, **Umansky *et al.***again reported the use of Blount blade plate with good result. In 1951, **Hampton** in his book "Wounds of Extremities in Military Surgery" reported good results with skeletal traction. He used suspended traction system mode of Thomas Splint with Pearson attachment. He used suspended traction system mode of Thomas splint with Pearson attachment. He emphasized the importance of early active exercises and high protein diet and frequent Roentgenographic examination during recumbent period. In 1956, **White and Russin** published an encouraging report on 46 fractures, which were treated by open reduction and internal fixation using Reverse-Blount plate supplemented with additional plate and screws. They condemned the then conventional method of traction and immobilization.

In 1961,**John Charnley**[8] in his monograph,"The Closed Treatment of Common Fractures"devoted a chapter on fracture of femoral condyles. He described in detail the technique of applying skin traction under anaesthesia to the leg and immobilization in Thomas Splint. He also advocated the principle of controlled collapse at the fracture site. He advocated operative treatment for fractures in athletic patient and where fracture fragments were held apart.

In 1965, **Bank**[9] demonstrated that accurate opposition and rigid immobilization was necessary for adequate healing in intra-articular fractures. He showed that devitalized free fragments in intra-articular fractures had no potential for callus formation.

In 1966, **Stewart *et al..,***[7] in their landmark study compared 442 patients who had received treatment for fracture of distal third femur during 20 years in the Campbell Clinic. They advocated 2 pin traction using 3/32 inch smooth Kirschner wires with spreaders as the treatment of choice. They condemned most of the then popular surgical techniques. They had 67% good results with closed methods as compared to 54% with open reduction and internal fixation techniques and they concluded that conservative method of management gives universally good results in supracondylar femur and distal third fractures.

In 1967, **Neer *et al.***[10] analyzed the results of internal fixation in cases of supracondylar fractures of femur as compared to those of closed methods of treatment.

They classified this fracture according to displacement of condyles in relation to shaft of femur. They studied 110 cases of supracondylar fractures of femur out of which 29 were treated by open reduction and internal fixation and rest were treated by closed methods. They reported only 52% satisfactory results with operative method while 90% satisfactory results with closed method. They also obtained satisfactory results in 84% of displaced supracondylar fractures. Neer *et al.*.formulated a rating system based on points given to functional and anatomical criteria. This rating system is followed by many and is recommended specifically for evaluating distal third fractures.

In the same year i.e., 1967, **Radolph and Anderson**(11) reported on the series of 56 cases of fracture shaft femur, 20 of which were in distal third and included supracondylar fractures of femur. He showed good results with conservativetreatment by Russel traction. He paid particular attention to find length and alignment and achieved nearly 120º of knee flexion in most of his distal femoral fractures.

In 1970, **Vert Mooney *et al.***(12) described advantages of cast bracing, early ambulation and weight bearing in conservative management of distal femoral fractures. They concluded that case bracing allows continued joint and muscle function after traction has been discontinued. At the same time, the fracture is protected from disruptive forces.

With the advent of AO methods, there was flurry of publications demonstrating surgical techniques of open reduction internal fixation of supracondylar fractures of femur. The technique however, remained complex and required experience. In the period of 1965-70, **Sven Olerud**(13) studied 15 cases of supracondylar fracture femur treated by AO technique. AO blade plate fixation was done. Good to excellent results were obtained in 14 cases. He advocated extensive exposure of the fracture by removing tibial tuberosity as a bone block by reflecting the entire extensor mechanism proximally. He was able to achieve stable anatomical reduction of intra-articular fracture by this method. However, 4 patients in this series developed infection, so he advocated caution in the use of this extensive approach.

In 1970, **Zickel *et al.***[14] developed a nail for use in distal femur. The nail had flexible stem and rigid curved condylar end allowing fixation by transfixation screws in femoral condyles. This nail could be inserted by open or closed method. As the nail alone could not prevent shortening in comminuted fractures its use was restricted to non-comminuted and minimally comminuted supracondylar fractures.

In 1979, **Schatzer and Lambert**[15] reported 17 supracondylar fractures treated by AO technique using blade plate with 71% good to excellent results.

In 1981, **Douglas Wardlaw *et al.***[12] conducted a biomechanical study of cast brace treatment of fractures of femur. Encouraged by the results obtained by Connolly and King in 1973, they submitted that closed reduction and early ambulation in cast bracing were best suited for distal femoral fractures.

In 1982, **Lars Kolmert & Krisier Wulff**[16] conducted an epidemiological study of distal femoral fractures in adults, out of 135 patients with 137 fractures, 47 fractures were treated non-surgically and rest 90 were treated surgically using AO blade plate, Rush Pins and Cancellous screws. Of the surgically treated patients, the authors reported unsatisfactory result in the elderly age group. Complications in elderly group were implant breakage or cutout of implant with resulting malposition or failure of osteosynthesis.

In the same year 1982, **RD Mize *et al.***[17] in their study of 30 supracondylar and intercondylar fractures reported good to excellent results in 24 patients. They treated the fracture using the extensile approach described by Sven Olerud and the use of AO blade plate for fixation. They advocated that the advanced age of the patients should not be contraindication to open reduction and internal fixation. They obtained good results in elderly patient treated operatively in their series.

In 1982, **JB Giles *et al.***[18] reported 26 cases of supracondylar and intercondylar fractures treated with the supracondylar plate and lag screw assembly. They reported that this device was very successful in restoring the normal alignment of femur and intraarticular anatomy of the knee joint. There were no nonunion or malunions and no implant failure in this study. Good range of knee motion (120º average) ROM was obtained.

In 1989, **JM Siliski**[19] reported the use of AO blade plate for the management of 52 supracondylar intercondylar fractures. They followed the AO classification of fractures and used the Neer rating system for evaluation of results and obtained 92% excellent and good results in C_1 type fractures, 72% good/excellent results in C_2 type fractures and 85% good/ excellent results in C_3 type fractures.

In 1990, **Yang *et al.***[20] evaluated 93 patients with supracondylar and intercondylar fractures. Open reduction internal fixation was done in all patients using 95º angled blade plate. Results were evaluated by Shelbourne and Brueckmann's criteria. 61.3% patients were rated as excellent and 23% as good results. Emphasis was laid on early postoperative knee mobilization.

In 1993, **Lucas *et al.***[3] reported the results of 34 supracondylar fractures fixed with the supracondylar femur nail. It was a retrograde intramedullary nail designed specifically for supracondylar and intercondylar fractures of femur. The nail was inserted through the intercondylar notch. It has multiple holes along its length for 6.5mm locking screws. They had good results with the supracondylar nail with average arc of knee motion being 100º.

In 1994, **Iannacone WM *et al.***[21] reported 41 distal femoral fractures treated with retrograde supracondylar intramedullary nail. Thirty-five of 41 cases achieved at least 90º flexion. There was no infection and no wound healing problems. Modification of design of nail was made due to fatigue fractures. They concluded that, supracondylar nail would contribute to management of these fractures after further clinical trial and additional biomechanical testing.

In 1995, in the comparative study conducted by **Krickler and MS Butt *et al.***[22], 42 displaced fractures of supracondylar and intercondylar fractures of femur in elderly patients were studied. 20 patients received operative treatment with the AO DCS and side plate assembly and 22 received skeletal traction followed by cast bracing. Good to excellent results were obtained in 53% of the patients treated surgically while only 31% good results were obtained in conservative group. The author concluded that the use of DCS allowed good alignment, adequate joint congruity and early knee mobilization. In general, there were fewer incidences of complications in the operative group.

In 1995, **Danziger MB *et al.***[23] reported 94% excellent to good result with average knee range of motion of in 23 supracondylar femur fractures treated with GSH supracondylar nail and open reduction. They concluded that GSH supracondylar intramedullary nail is an excellent alternative for the treatment of supracondylar and inter-condylar femur fractures.

Zlowodzki *et al.*[24] have shown that the LISS fixator for treatment of distal femur fractures, which has similar material and design characteristics as the tibial LISS fixator, provides superior fixation in osteoporotic bone compared with the blade plate and retrograde IM nail. This series has demonstrated that its use prevents varus collapse in bicondylar tibial plateau fractures.

M Ahmad *et al.*[25] studied on biomechanics of locking compression plate. Consistent results were achieved in LCP constructs in which the plate was applied at or less than

2mm from the bone. When applied 5mm from the bone the LCP demonstrated significantly increased plastic deformation during cyclical compression and required lower loads to induce construct failure

Kenneth A. Egol *et al.*[26] conducted a study on Biomechanics of Locked Plates and Screws and showed that Locked plates and conventional plates rely on completely different mechanical principles to provide fracture fixation and they provide different biological environments for healing doing so. Locked plates may increasingly be indicated for indirect fracture reduction, diaphyseal/metaphyseal fractures in osteoporotic bone, bridging severely comminuted fractures, and the plating of fractures where anatomical constraints prevent plating on the tension side of the bone.

In a study by **Schutz M, Muller M *et al.***[27] Internal fixation using the LISS was performed at an average of 5 days (range: 0–29 days) after the injury. 48 fractures were operated on within the first 24 hours. Revision operations were required for 2 cases of implant breakage. 4 cases of implant loosening and 7 debridments to deal with infections. The study showed clearly that when working with LISS, primary cancellous bone grafting is not necessary. This is comparable to the results of recent, retroprospectively evaluated study using the retrograde IM nailing[j]. The total follow up rate was 93%. 5% non union was observed.

Yeap, E.J., and Deepak, A.S.,[28] conducted a retrospective review on eleven patients who were treated for Type A and C distal femoral fractures (based on AO classification) between January 2004 and December 2004. All fractures were fixed with titanium distal femoral locking compression plate. The patient’s ages ranged from 15 to 85 with a mean of 44. Clinical assessment was conducted at least 6 months post-operatively using the Schatzker scoring system. Results showed that four patients had excellent results, four good, two fair and one failure.

Zlowodzki *et al.*[24] combined these series of 327 patients with fracture distal end of femur and evaluated the outcomes as part of a systematic literature review. Average nonunion, fixation failure, deep infection, and secondary surgery rates were 5.5%, 4.9%, 2.1%, and 16.2% respectively. Some of the technical errors that have been reported for fixation failure have involved waiting too long to bone graft defects, allowing early weight bearing, and placing the plate too anterior on the femoral shaft.

Markmiller *et al.*[29] prospectively compared the outcomes of LISS and retrograde intramedullary nailing. At 12 months, no statistically significant differences were noted for nonunion, fixation failure, infection and secondary surgical procedures. However, this was a relatively small series and no power analysis was reported.

Vallier *et al.*[30] concluded that locking plates should only be used when conventional fixed-angle devices cannot be placed. They also noted the significant added cost of locking plates. To decrease the risk of implant failure with locking plates, they recommended accurate fracture reduction and fixation along with judicious bone grafting, protected weight bearing, and modifications of the implant design.

Several biomechanical studies have compared conventional fixed-angle implants and locking plates in supracondylar (AO/OTA A3) fracture models. **Marti *et al.***[31] compared the LISS plate with unicortical locking screws to the dynamic condylar screw and condylar buttress plate in axial loading and cyclic axial loading to failure in a cadaveric 1-cm fracture gap model. The LISS had more reversible and less irreversible deformation when compared to the other two constructs, which they attributed to the titanium composition and the unicortical screws.

Zlowodzki *et al.*[24] compared the LISS plate with unicortical locking screws to the 95° blade plate in axial, torsional, and cyclic axial loading in a cadaveric 1-cm fracture gap model. Under axial loading, significantly higher loads to failure, energy absorbed at failure, and displacement at load to failure were noted for the LISS plate.

The blade plate was significantly stiffer in torsion. But, the LISS plate had significantly less permanent deformation under cyclic axial loading. They concluded that the LISS provided improved distal fixation in osteoporotic bone. In a 4-cm fracture gap model in high bone density cadaveric specimens, no significant difference was found between the LISS plate with unicortical locking screws and the angled blade plate for axial load to failure, but the LISS plate had significantly less axial stiffness.

Higgins *et al.*[(32)] compared the Locking Condylar Plate, with distal locking screw fixation and bicortical locking and nonlocking diaphyseal fixation, to the angled blade plate in axial load to failure and cyclic axial loading in a cadaveric 1 cm fracture gap model. The locking construct had a significantly higher load to failure and less permanent deformation with cyclic loading. All of these studies reveal that locking plates with unicortical or bicortical diaphyseal fixation have adequate axial stiffness but more flexibility when compared to conventional fixed-angle implants. Although they have less torsional stiffness, the studies that evaluated torsional stiffness have shown that the distal fixation in locked implants is typically maintained while conventional fixed-angle implants have a higher rate of distal cutout from the femoral condyles.

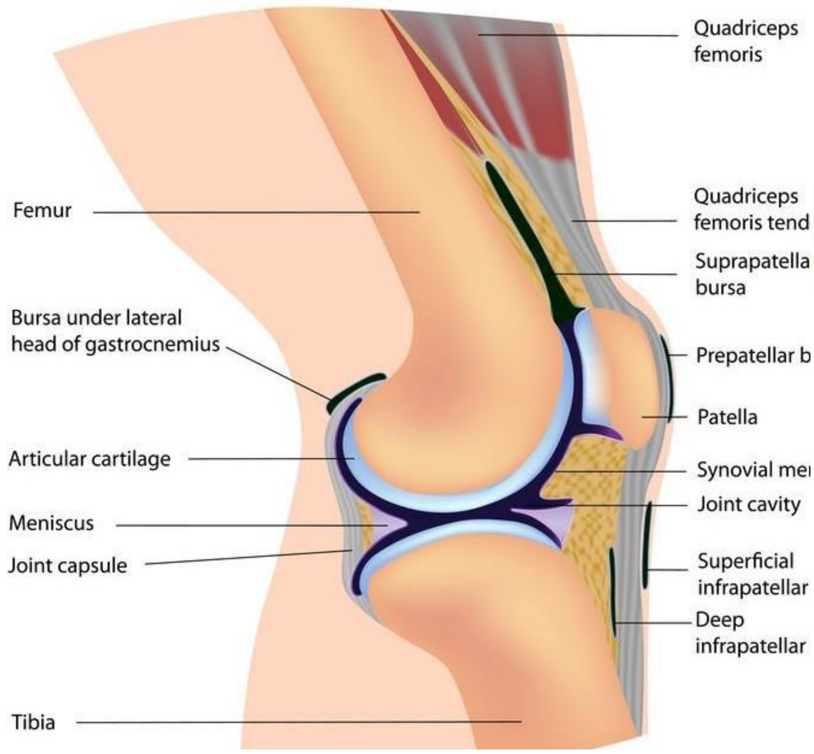
SURGICAL ANATOMY

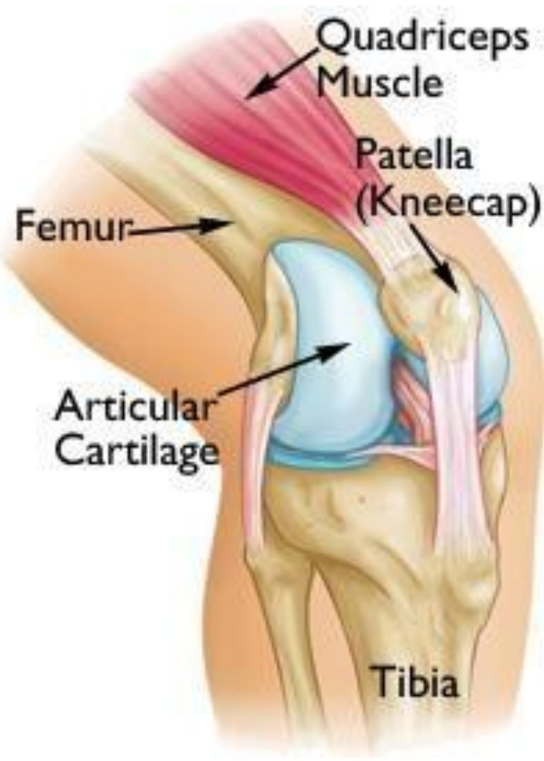
Distal femur is defined as the zone it comprises both femoral condyles and supracondylar region, junction of the metaphysis with shaft. Distal femur comprises about distal 15 cm of the femur measured from the joint line. Femur flares into two curved condyles at the junction of distal femoral diaphysis and metaphysis. The anterior surface between the two condyles has a shallow depression for articulation with the patella. The posterior surface between the two condyles is separated by a deep inter condylar fossa.

Medial condyle is longer and extends farther distally than the lateral femoral condyle. Outer surface of medial condyle is convex, and an epicondyle on the surface gives attachment to the medial collateral ligament. Adductor tubercle is present on the proximal medial surface of the medial condyle to which the adductor magnus is inserted. The medial head of gastrocnemius arises from the back of medial condyle. Lateral condyle is stouter and stronger than the medial condyle. In the coronal plane lateral condyle is more anterior compared to the medial condyle. This prevents the lateral displacement of the patella.

Most prominent part of its lateral surface is the lateral epicondyle to which fibular collateral ligament is attached.

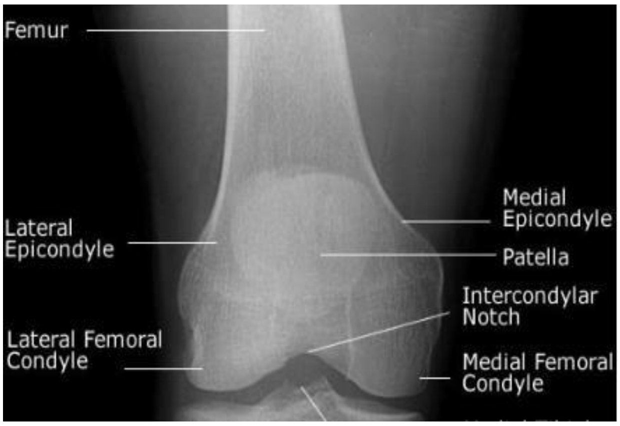
On Axial view distal femur is trapezoidal with greatest dimension located posteriorly and narrowest dimension anteriorly. Lateral wall inclines 10 degrees and medial wall inclines 25 degrees. On average, the anatomical axis (angle between the shaft of femur and the knee joint) has a valgus 12 angulation of 9 degrees.

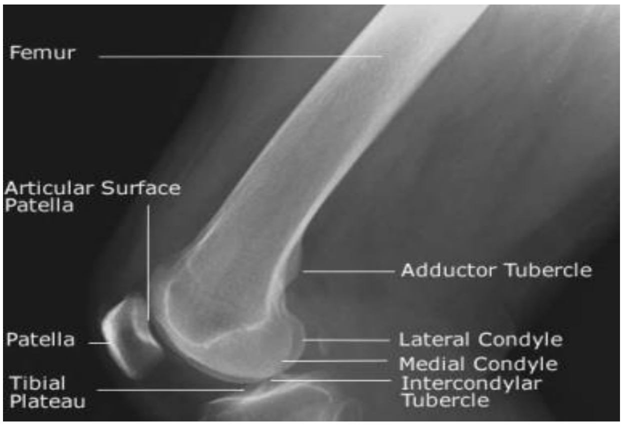


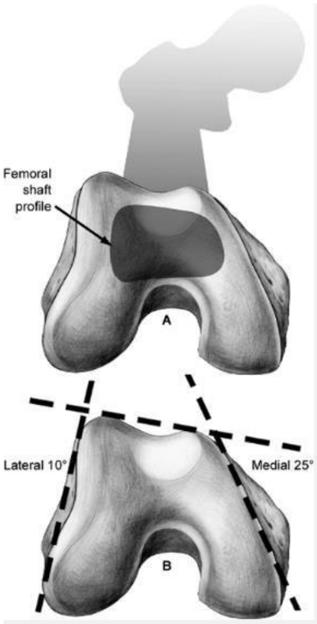


In the sagittal plane , the shaft of the femur lies with anterior two thirds of condyle. Tibial articular surface is convex antero posteriorly as well as from medio lateraly.

Lateral & medial meniscus creates greater conformity between the femur & Tibia. Between the condylar surface, the plateau is elevated into the intercondylar eminence. Capsule of knee joint is attached posterior to proximal margins of femoral condyles and the inter condylar region. Medially the capsule is attached proximal to the groove for popliteus tendon. Anteriorly the capsular attachment is deficient above the level of the patella. The tibial collateral ligament is a flat triangular band superiorly inserted above to the medial femoral condyle and below to the upper part of medial surface of the tibia.





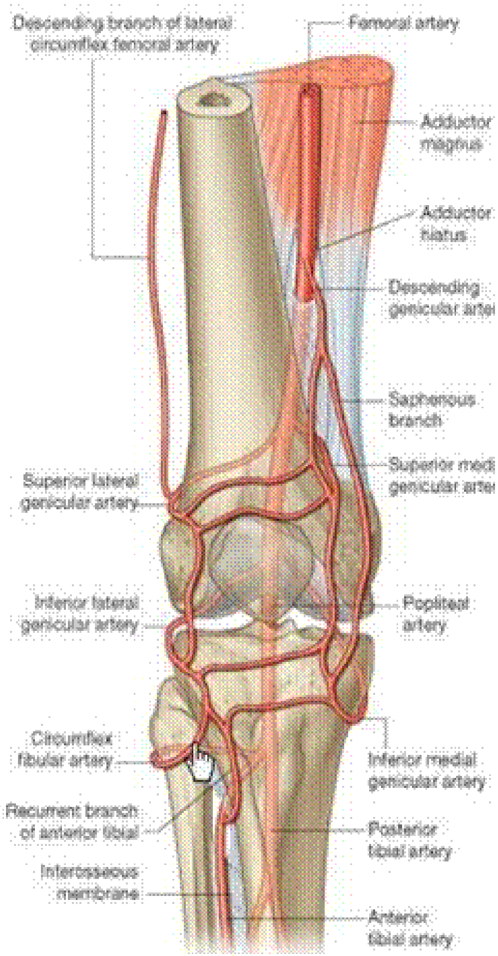


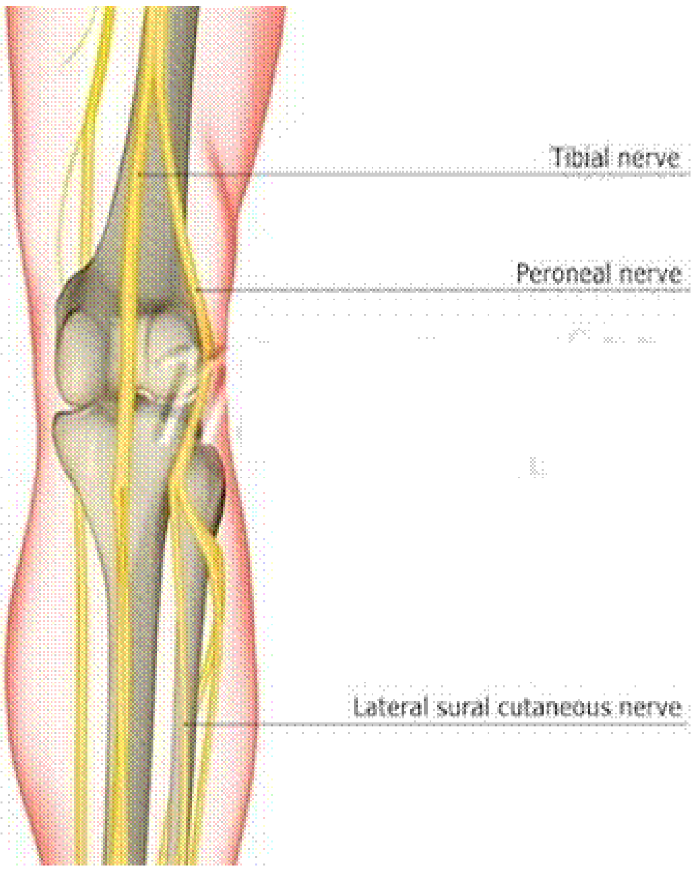
The fibular collateral ligament is cord like and is attached proximally to lateral epicondyle below the attachment of lateral head of gastrocnemius and above that of popliteus tendon. Its distal attachment is to head of the fibula. The cruciate ligaments are a pair of very strong ligaments connecting tibia to femur. They are intra capsular and extra synovial. Anterior cruciate ligament is attached to anterior part of tibial plateau between the attachments of anterior horns of medial and lateral menisci. It ascends postero laterally and is attached to posteromedial aspect of lateral femoral condyle. Posterior cruciate ligament is stronger, shorter and is attached to smooth impression on posterior part of tibial inter condylar area. It ascends antero medially and is attached to anterolateral aspect of medial femoral condyle.

Medial menisci is almost a semicircle and is broader posteriorly. Its anterior horn is attached to inter condylar area in front of the anterior cruciate ligament,while the posterior horn is similarly attached in front of the posterior cruciate ligament. The lateral meniscus is about four fifths of a circle. Anterior horn is attached to front of inter condylar eminence of the tibia, while the posterior horn is attached in front of the posterior horn of the medial meniscus. The intra articular entry point of the retrograde supra condylar nailing is situated about 5mm anterior to the attachment of posterior cruciate ligament in the inter condylar notch.

BLOOD SUPPLY

Distal Femur and knee joint has a rich blood supply supplied from the anastomoses around the knee. The chief contributors are the five genicular collaterals of the popliteal artery. In the anterior approach to the knee, subcutaneous dissection should not be done superficial to the facial layer because which results in devitalisation of the skin can occur.





NUTRIENT ARTERY TO FEMUR

This is originate from the second perforating tributary of the distal end of femur. Nutrient foramen is located on the medial aspect of linea aspera and is directed superiorly. The lower end has rich blood supply through genicular vessels. The lower end ossifies from a single secondary ossification center appearing at the 9th month of – intrauterine life and it gets fused with the shaft by the 20years. The lower end of femur is the growing end.

The lower end of femur is having a lot of applied anatomical importance.

1. Medico legally ossification of lower end of femur is very important. Presence of its center in a newly born child found dead indicates the child was viable and capable of independent existence of birth.

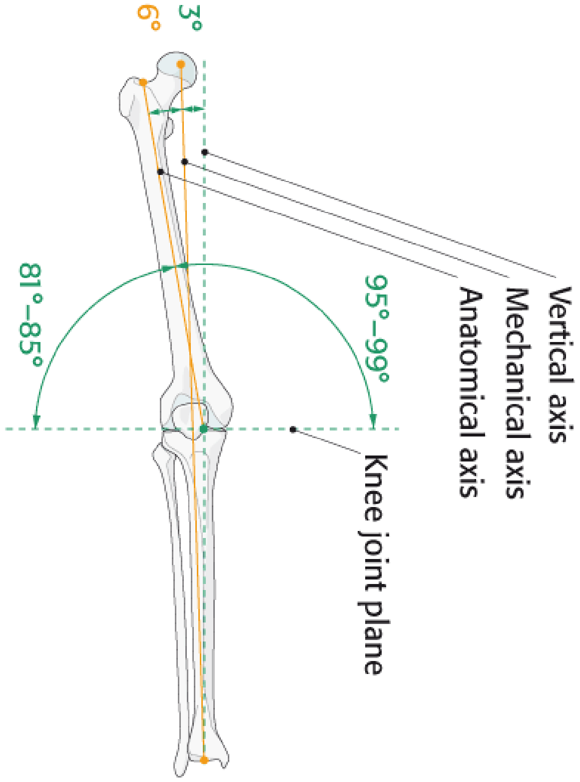
2. The epiphyseal line is at the level of adductor tubercle. Hence intervention here may damage the distal epiphyseal cartilage in children and may entail subsequent shortening of limb.

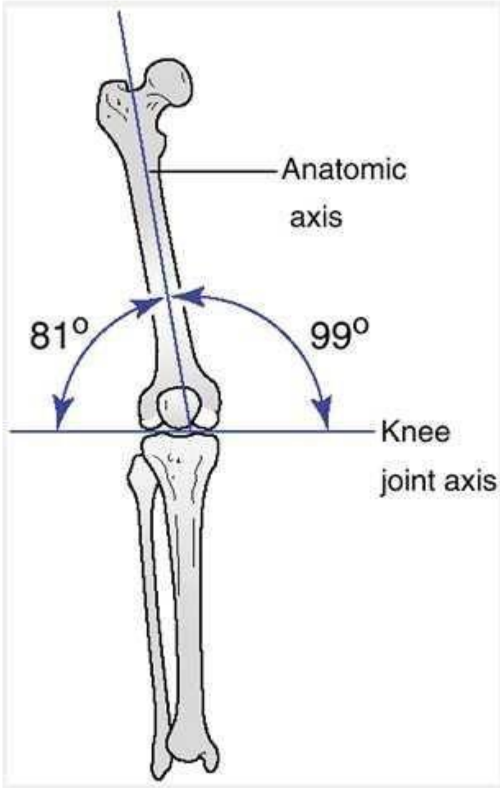
NERVE SUPPLY

The joint is supplied from the femoral nerve from lumbo sacral plexus though its branches to the three vasti, from the sciatic nerve by genicular branches of the deep tibial and common peroneal components and from the obturator nerve by the branch from its posterior division.

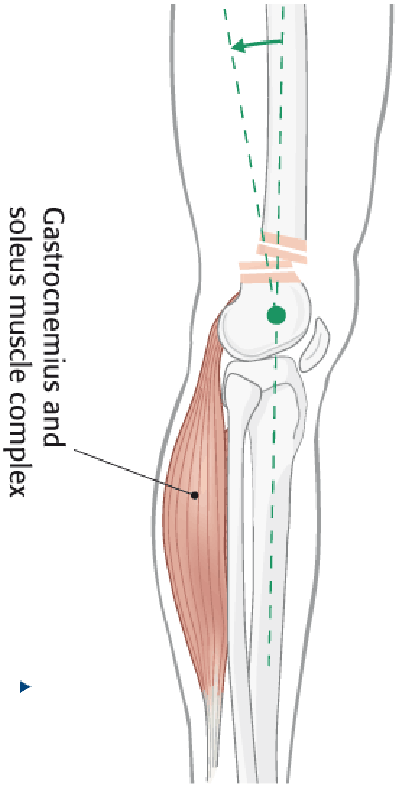
BIO MECHANICS OF INJURY[(33)]

Most distal femur fractures are the result of a both severe varus, valgus or rotational force with axial loading. In younger age group this amount of force is typically the result of high velocity trauma such as motor vehicle accidents and falls on a bend knee may be sufficient to produce these fractures. After fracture, the deformities observed are usually results of femoral shortening with posterior angulations, and posterior deviation of the distal fragment. These deforming forces are produced by the quadriceps femoris, posterior muscle group hamstrings, and gastrocnemius muscles.





Varus deformity may result from the pull of the adductor muscles. If an inter condylar fracture is present, there will often be rotational misalignment of the condyles (with resulting joint incongruity) because of the separate attachments of the gastrocnemius muscles to each condyle.



The axial bending loads applied to the femur in the production of a supracondylar fracture may produce additional injuries to the same extremity. Physical examination and radiographic assessment must assess the possible presence of a fracture to the acetabulum , femoral neck and shaft Varus or valgus force applied to the knee may result in associated ligament injury to the knee. Alternatively the same force may produce fractures of tibial plateau or shaft. Open fractures occur in 5- 10 % of all supracondylar fractures. Most common site for the open wound is over the anterior thigh , proximal to the patella and as a result patients have some damage to the distal quadriceps muscle or tendon.

Although femoral and popliteal arteries are at risk of injury because of their close proximity to the site of fracture, the incidence of associated injury to these vessels is low. The popliteal artery is more commonly at risk of injury when an associated posterior dislocation of knee occurs.

CLASSIFICATION

A Classification for distal femur fractures should distinguish possible injuries to this area, including extra articular, intra articular and isolated condylar lesions.

1. Allow different surgeons consistently & reliably to grade a fracture pattern into one of the classification patterns.
2. Assist in deciding the method of treatment.
3. Correlate with findings of outcome analysis.

Many classification systems have been used for fractures of distal femur like Neer *et al.*., Schwatzker and Tile, Seinsheimer and Muller *et al.*. The most widely accepted and used is that of Muller *et al.*.

NEER CLASSSIFICATION (10)

Neer classified these injuries into:

1. Minimal displacement
2. Displacement of condyles Medial Lateral
3. Concomitant supracondylar and shaft fractures.

It is an anatomical classification and does not correlate with the severity of the Injury

SEINSHIEMER CLASSIFICATION(5)

He classified these injuries into:

1. **Non displaced fracture**

Any fracture with less than 2 mm of displacement of fractured fragments.

2. **Fractures involving only the distal metaphysis without extension into the lnter condylar region.**

a. Two Part fracture.

b. Comminuted fractures.

I. Fractures involving the inter condylar notch in which one or both condyles are separate fragments.

A. Medial condyle is a separate fragment, lateral condyle remains attached to the femoral shaft.

B. The lateral condyle is a separate fragment, medial condyle is intact.

C. Both condyles are separated from the femoral shaft and from each other.

II. Fractures extending through the articular surface of the femoral condyles

A. A fracture through the medial condyle (two parts are comminuted)

B. A fracture through the lateral condyle (two parts are comminuted) This classification is exhaustive and is no longer used.

C. AO /ASIF CLASSIFICATION-[(5)]

MULLER CLASSIFICATION,

The classification described by Müller *et al.*. and expanded in the AO/OTA classification is useful in determining treatment and prognosis. It is based on the location and pattern of the fracture and considers all fractures within the trans epicondylar width of the knee.

AO Classification based on Muller *et al.*. is as follows:

A Extra articular fracture

A1 Extra articular fracture, simple

A2 Extra articular fracture metaphyseal wedge A3 Extra articular fracture metaphyseal complex

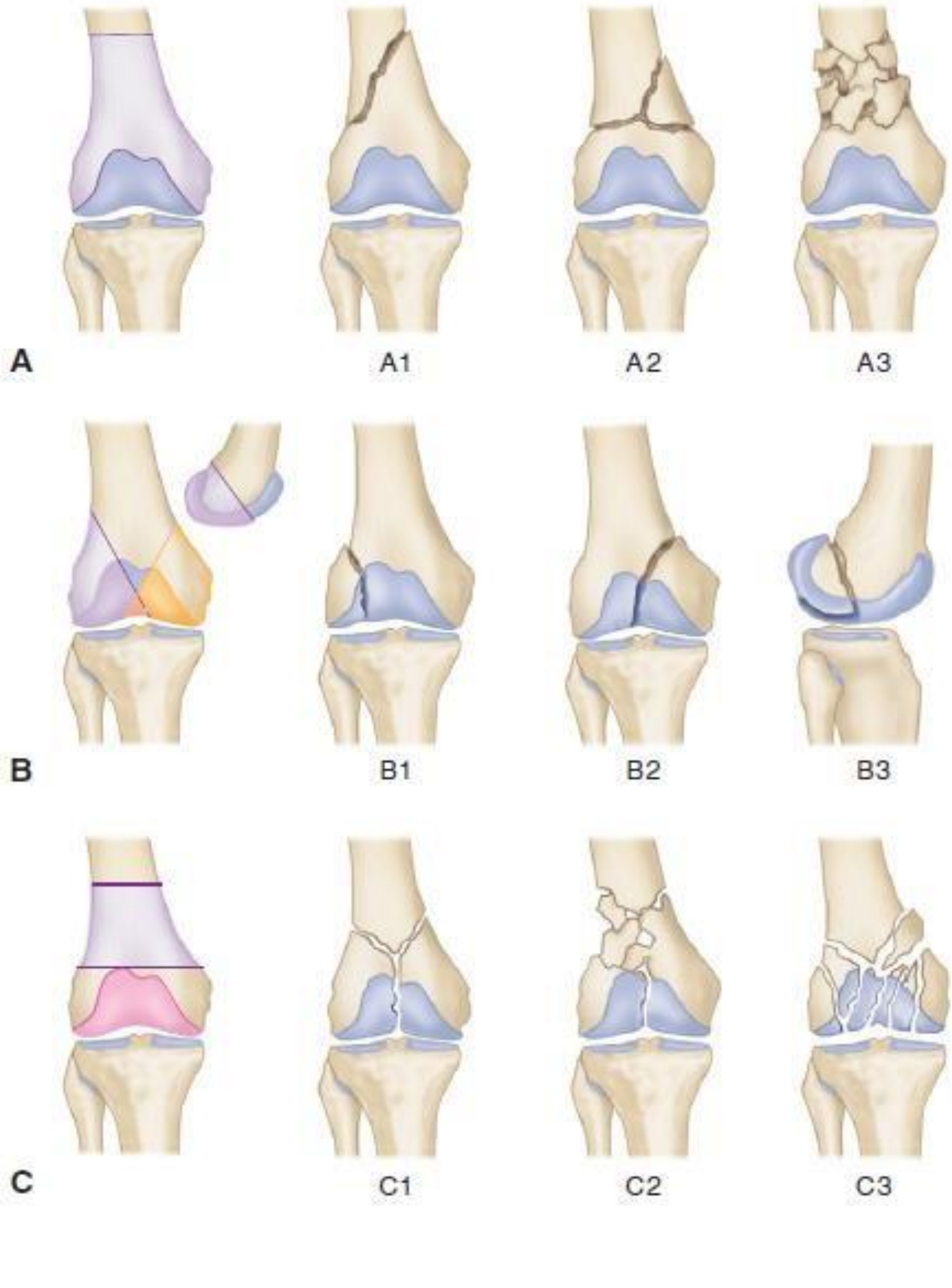
B Partial articular fracture

B1 Partial articular fracture, lateral condyle, sagittal B2 Partial articular fracture, medial condyle sagittal B3 Partial articular fracture, frontal

C Complete articular fracture

C1 Complete articular fracture, articular simple, metaphyseal simple C2 Complete articular fracture, articular simple, metaphyseal multi fragmentary C3 Complete articular fracture multi fragmentary.

This classification is widely accepted and although the classification is complex, severity of the fracture progressively increases from one type to the next. **Hence we have followed this classification in our study.**



A
A1
A2
A3
B
B1
B2
B3
C
C1
C2
C3

DESCRIPTIVE CLASSIFICATION:

- Open injury or Closed injury
- Location of fracture whether supra condylar, inter condylar involvement
- Pattern of the injury spiral, oblique, or transverse
- Intra articular involvement or not
- Angulation of fracture - Varus, valgus or rotational deformity
- Displacement of the fracture- Shortening or translation
- Comminution, Segmental and butterfly fragment

INVESTIGATIONS

Clinically the patients may present with symptoms and signs either of supracondylar fractures (or) other major problems like hypovolemic shock. All patients with fracture lower end of femur should be looked for peripheral pluses.

A good quality X ray in two perpendicular views is a must to look for the subtype of Muller's classification. Computer tomography portrays the distal femur in cross section, which helps to identify fracture lines in the frontal plane. Two and three dimensional reconstructions may also improve understanding of the fracture pattern in preparation for surgery.

PRINCIPLES OF MANAGEMENT

There are a lot of factors which play a important role in management. They include.

1. Pattern of fracture displacement
2. Degree of comminution and bone loss
3. Extent of soft tissue involvement
4. Associated Neurovascular complications

5. Severity of joint involvement
6. Degree of Osteopenia
7. Associated injuries
8. Complex ipsilateral injuries (patella/ tibial plateau fracture)

So the objective of treatment of fracture of lower end of femur are

1. To obtain and maintain accurate reduction and stable fixation of the fracture.
2. To restore a functional range of motion of knee joint
3. To restore normal strength of quadriceps and hamstring muscles group.
4. To treat the associated injuries.

Distal femur fractures with multi system involvement like pelvic organ injuries blunt injury abdomen, head injury must be managed as multi-disciplinary approach.

METHODS OF TREATMENT

In the decade of 1960s, conservative methods such as traction of involved limb and cast bracing produced better results than operative management, because of the lack of adequate internal fixation of the fractures. With the development of improved internal fixation devices, treatment options begin to change in 1980s. The blade plate designed by the AO group was one of the first used device and gain wide acceptance for management of fractures of the distal femur. As it was technically complicated, a less technically demanding device Dynamic Condylar screw was introduced. Those fracture for which both Dynamic Condylar screw & Condylar Blade Plate could not be used remained a problem which was sorted out by the introduction of Condylar Buttress plate. The intramedullary nailing was used in the treatment of distal femoral fractures, because they obtained more biological fixation. Nails have been designed specifically for retrograde insertion through inter condylar notch for the treatment of supracondylar and inter condylar femoral fractures. Flexible intramedullary implants like Zickel's supracondylar device, Ender rods, Rush rods have been used with success to treat distal femoral fractures. External fixation was used as either temporary (or) definitive fixation in severe open distal femur fractures especially those associated with vascular injury.

A recent advance in technology for the treatment of distal femoral fractures includes the less invasive skeletal stabilization system (LISS) and the locking compression Condylar plates (LCP). They offer multiple points of fixed angle contact between the plate and screws in distal femur (Angle stable construct), reducing the tendency for varus collapse and at the same time afford better stability. Hence management of distal femur fracture can be divided into two broad categories.

1. Conservative treatment
2. Operative treatment

CONSERVATIVE MANAGEMENT

Considerable controversy existed as to whether conservative (or) surgical treatment leads to better results for management of distal femur fracture. Early attempts at internal fixation of these complex injuries were associated with high incidence of malunion, nonunion and infection.

Because of the increased risk of complications, numerous authors concluded that closed methods were preferable to operative treatment. With the improvement in surgical techniques, availability of better implants, prevalence of better antibiotics, the conservative management has become almost not applicable for fracture of lower end of femur. In this modern era of fracture management, there is no single absolute indication for conservative treatment.

The relative indications for conservative therapy include.

1. Non displaced (or) Incomplete fractures.
2. Impacted stable fracture in elderly osteoporotic patients.
3. Lack of modern internal fixation devices.
4. Unfamiliarity or inexperience with surgical techniques.
5. Significant underlying medical disease.
6. Advanced osteoporosis
7. Spinal cord injury with fractures.

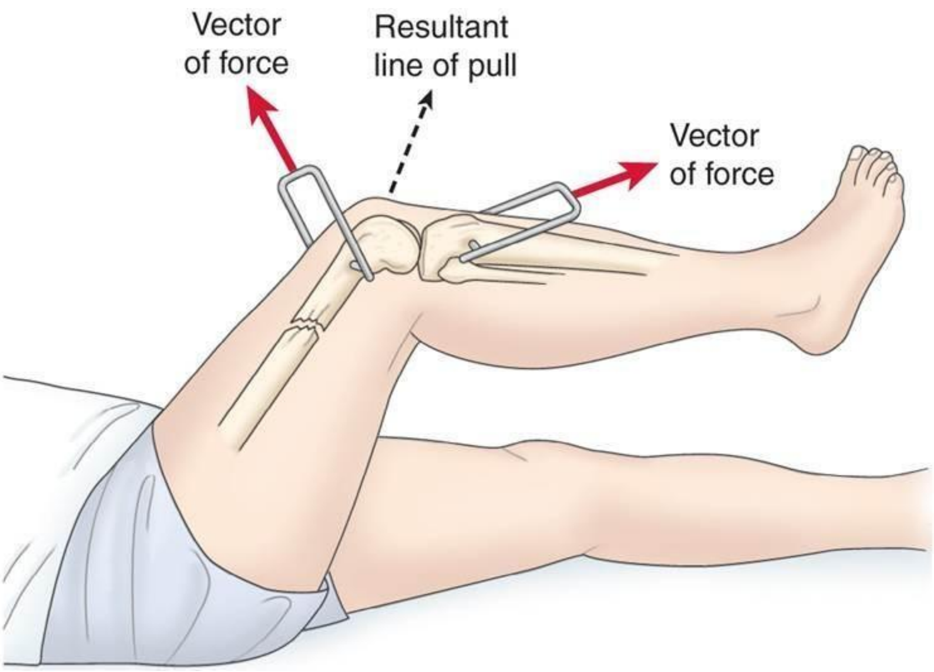
The goals of conservative treatment are not anatomical reduction of fracture fragment but restoration of overall length and axial alignment.

The criteria's for acceptable fracture management include

1. $< 7^{o}$ mal alignment in frontal plane.
2. $< 10^{0}$ mal alignment in sagittal plane
3. Limb shortening < 1.5 cm.
4. Articular incongruity < 2 mm

Various methods of conservative management include

1. Two pin method of skeletal traction – One through upper tibial and other through lower femoral pin.
2. Skeletal traction with single pin followed by cast immobilization.
3. Ambulatory cast brace method.
4. Fracture Brace technique.



TRACTION:

Traction can be used for management of Muller type A and B supracondylar femoral fractures as long as it is possible to restore limb longitudinal alignment, axial rotation, and limb length. Commonly, it involves skeletal traction with one pin placed 10 cm below the tibial tuberosity and the leg maintained in a Thomas splint with Pearson attachment at the level of the fracture and flexed about 20° or on Bohler Braun Splint. And applies 10 to 15 kg of traction, in line with the thigh segment. The patient must remain bed bound with maintenance of traction for 2 to 12 weeks, depending on the fracture.

SURGICAL MANAGEMENT [17,19,34,35]

In the past 25 years, internal fixation of displaced fractures of lower end of femur has gained widespread acceptance as operative technique and implants have improved. The combination of properly designed implant, a better understanding of fracture pattern, meticulous soft tissue handling, judicious use of antibiotics, and improved anaesthetic methods have made internal fixation safe and practical. Since 1970, all studies comparing the results of conservative and operative methods have favored operative stabilization of distal femur fractures.

The goals of operative treatment of distal femur fractures are

a) Anatomical Realignment of fractures

b) Stable fixation of the fractures

c) Early Mobilization of the knee joint

d) Early functional rehabilitation of joint by physiotherapy

Indications for operative management include

1) Displaced intra articular fragments
2) Poly trauma patients with multi system injuries
3) Open fractures
4) Associated vascular injuries requiring repair.
5) Severe same limb injuries (patellar fracture, tibial plateau fractures)
6) Major associated knee ligamentous injuries.
7) Irreducible fracture.
8) Pathological fracture
9) Fractures around TKR (Peri prosthetic)

Contraindications to internal fixation include

1) Active infection elsewhere
2) Severely contaminated open fracture (type III B)
3) Massive comminution (or) bone loss
4) Severe osteopenia
5) Inadequate facilities
6) Inexperienced surgeons

Principles of internal fixation.

Sequences in the surgical management of supracondylar fracture includes

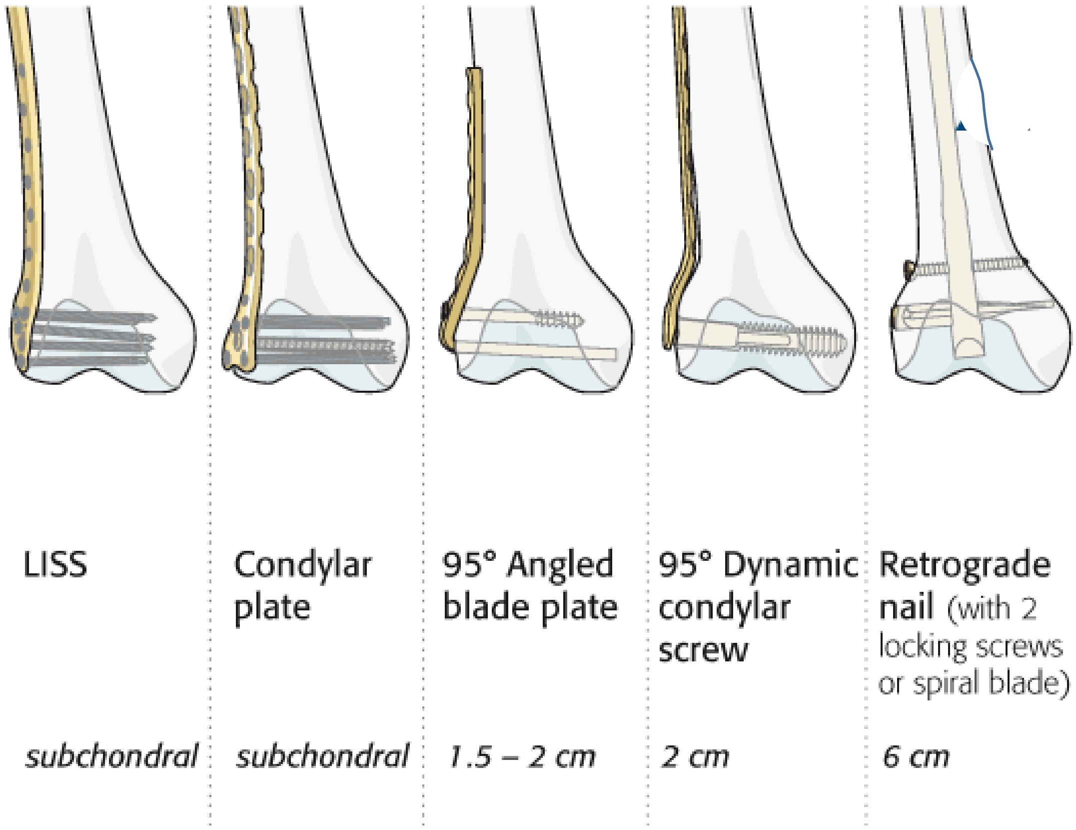
1) Restoration of articular surface
2) Metaphyseal alignment.
3) Impaction of fracture in osteoporotic patients.
4) Early mobilization of knee.

In Operative Treatment, Various Modalities Include

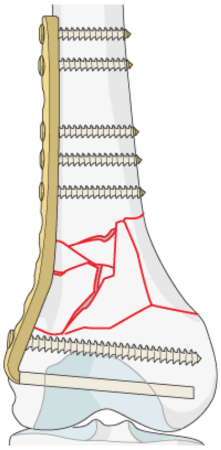
1. Open Reduction Internal Fixation with Dynamic Condylar screw
2. Open Reduction Internal Fixation with Condylar blade plate
3. Open Reduction Internal Fixation with Condylar Buttress plate
4. Open Reduction Internal Fixation with Cancellous screws
5. Closed reduction & internal fixation with ante grade locking nails.
6. Closed Reduction & Internal Fixation with supracondylar nail.
7. Closed Reduction & Internal Fixation with flexible intramedullary nail.
8. Ilizarov ring fixation

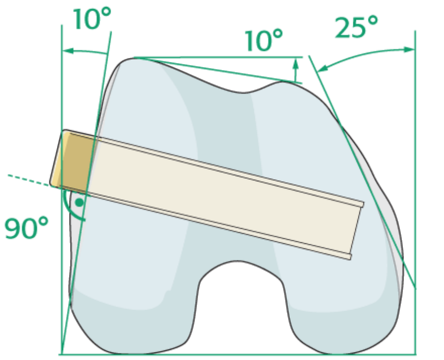
9. External fixation.

10. Open Reduction internal fixation with locking compression plate. (LCP)



95^{0} CONDYLAR BLADE PLATE (CBP) [28,36,37]





It is the first implant used for supracondylar fractures. When used by experienced surgeon, this restores alignment and provides stable internal fixation. Because it is a one piece device, it affords the best control of the fracture. However placing of 95^{0}CBP is technically demanding procedure, leaving little room for error. It can be used for inter condylar fracture, provided the lateral cortex is not comminuted.

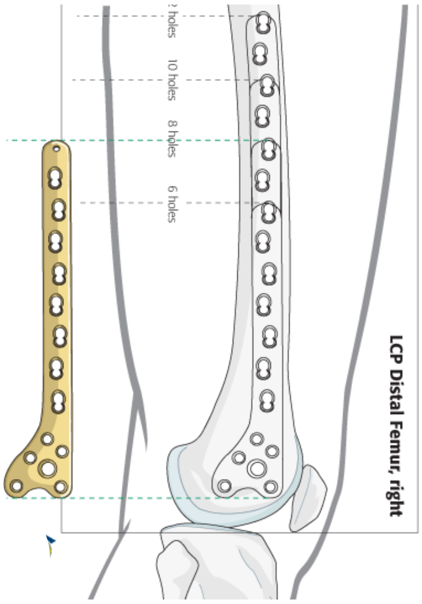
The main advantages of CBP is increased strength and increased corrosion resistance of implant. The disadvantage is the increased difficulty of insertion. In the distal femur, the blade has to be inserted so that it will line up with the axis of the shaft and with joint axis and with the inclination of patella femoral joint and be inserted exactly in the middle of anterior half of the femoral condyle at a predetermined distance from the joint and has to line up with the axis of femoral shaft. Initially the 130° plate was used for the distal femur also. With time it became evident that the 95° plate was the physiological one.

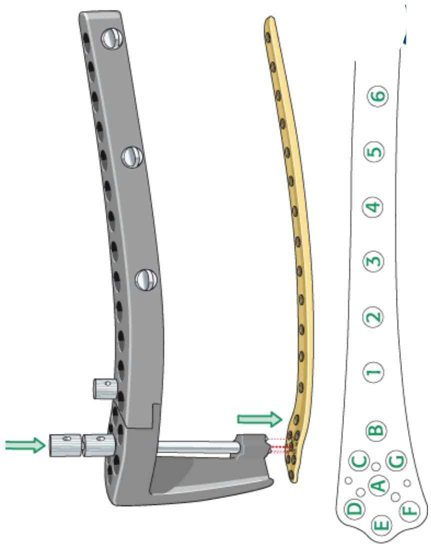
Therefore, CBP has a fixed angle of 95° between its blade and plate. Plate comes in varying diameter. The length to be used varies with fracture pattern. The shortest available blade is 50 mm.

CONDYLAR BUTTRESS PLATE: [36]

Blade plates and condylar screws are unsuitable for use in fractures with <3- 4cm of intact femoral condylar bone and in fracture with a large amount of articular comminution. For these fractures, the Condylar Buttress plate is the most commonly used implant. It is a one piece device specifically designed for the lateral surface of distal femur. It is essentially a broad DCP with a cloverleaf shaped distal portion designed to accommodate up to 6 cancellous screws. Because the posterior portion of cloverleaf is larger than anterior portion. It is manufactured separately for right and left sides. Mechanically it is not as strong as a blade plate or condylar screw with side plate and therefore should not be used or substituted for these preferred implant,. The problem with condylar buttress plate is that the screws passing through the distal holes do not have a fixed relationship to the plate., With indirect reduction techniques (such as the use of distraction device) the screws may shift relative to the plate producing varus deformity or valgus deformity., So its use should be restricted to cases in which the lateral femoral condyle is comminuted or there are multiple intra articular fractures in coronal plane or sagittal plane. In cases with extensive medial comminution a second medial plate need to be used to prevent varus deformity.

LOCKING COMPRESSION PLATE: [33,38–41]



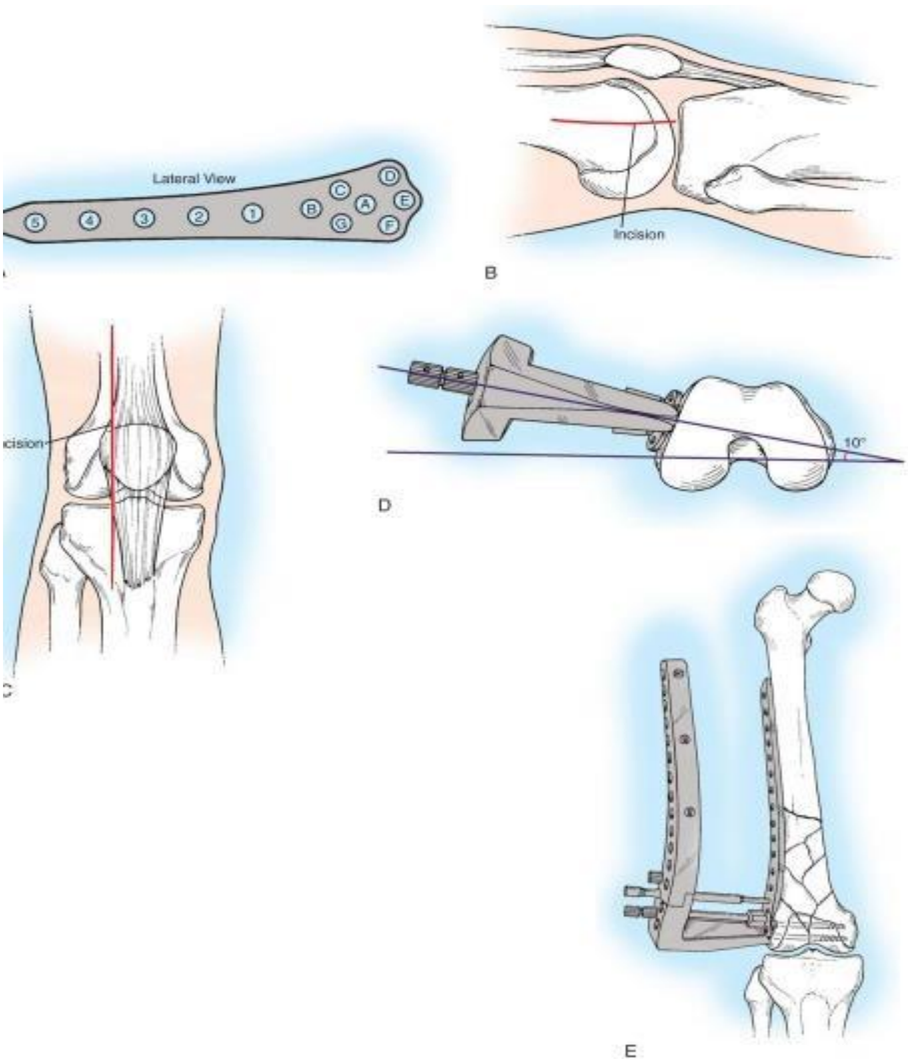


The plate system has many similarities to traditional plate fixation methods with few improvements such as Locking screws provides fixed angle construct and improved fixation in osteoporotic bones (38,42)

1. The screws do not rely on plate bone compression
2. Multiple screw fixation in distal femoral condyle allows improved fixation in Type C3 fractures
3. Anatomically shaped distal end is contoured to match the distal femur and hence intra-operative contouring is not required.
4. Combi - holes have additional dynamic compression holes providing options for axial compression in addition to locking mechanism.

5. Lateralisation of proximal femur is prevented by maintaining a gap between the proximal fragment and the plate until locking screw is applied after which the alignment is maintained

It combines the advantages of the dynamic compression plate principle with the locking screw head principle, giving the surgeons great flexibility of choice within a single implant. The screw holes in plate have been specially designed to accept either a standard cortical screw with a hemi spherical head or a locking screw with a threaded head.

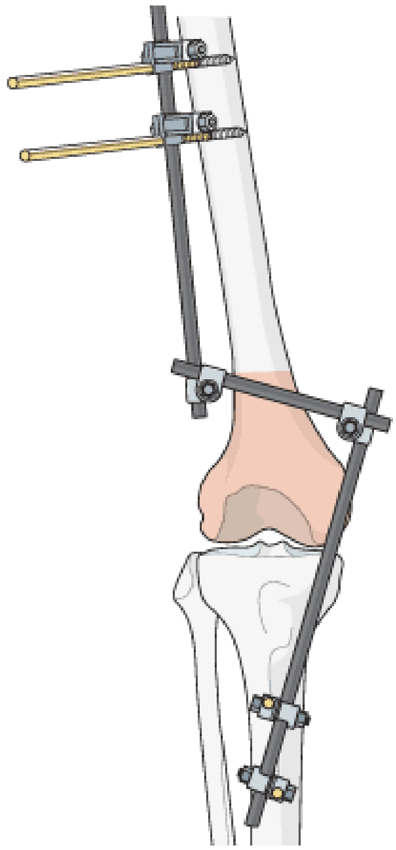


A locked screw plate construct can be compared to an implanted external fixation device.[26] When under load, the screws in the LCP plates distribute loading on cortical and cancellous bone. They form an angle stable construct. The plate is manufactured with a beveled edge, right and left separately because of larger posterior portion. The plate is pre contoured to the lateral surface of distal femur. It allows up to 3 screws in the condylar potion. It comes in various lengths 5, 7 & 9holed.Anatomically pre contoured: Reduces soft tissue problems and eliminates the need for plate contouring.

LCP combi-holes: Intraoperative choice between angular stability and compression. Guiding Jig: Enable easy and correct mounting of the plate and enable screw fixation through guide and centering sleeves. There is no consensus on the best treatment of complex intra articular fractures and high energy diaphyseal fractures of the long bones. The new screw-plate systems seem to offer an excellent alternative for the operative fixation in these cases.

EXTERNAL FIXATION[40]

External fixation can be used as either temporary or definitive fixation in severe open distal femoral fractures, especially fractures associated with vascular injury. External fixator can be used as temporary stabilization of fracture or definitive treatment for few kind of fractures.



It plays major role in treating distal femur or tibial plateau fractures associated with neuro vascular injury, it assist as skeletal stabilization for both vascular surgeon as aid in exploring the vascular structures and enhance wound healing for plastic surgeons. In type III fractures spanning of the knee joint is mandatory to avoid further cartilage injury .Knee joint stiffness and infection of pin site limits this mode of treatment only to Gr III compound fractures. For mobilization of poly traumatized external fixator play pivot role. External fixator removal and definite procedure should be carried out within 14 days to avoid pin tract infections. Major complications include pulmonary embolism, infected nonunion, and aseptic nonunion. The early conversion from a spanning external fixator to an intramedullary nail was safe in patients with multiple injuries. External fixators have incidence of infection of about 1 % to 10 % and also knee stiffness unavoidable due to span the knee joint. Early reversal to definite procedure will improve clinical out come

POSTOPERATIVE MANAGEMENT:

Postoperative management depends upon the individual patient needs. If patient has type C and other system involvement like chest injury, head injury or pelvic injury, it is better to have management in multi centric intensive setup. Antibiotics given according to the severity and nature of injury .In stable internal fixation the patients were started on knee mobilization & CPM exercise from 24-48 hours after surgery once the patient tolerates pain, Isometric muscle strengthening exercises & limited active assisted knee range of motion is encouraged. Patients initially encouraged to tip toe down walking it will increase callus formation over 6 weeks, complete weight bearing advised only after 12 weeks.

COMPLICATIONS: [43–45]

The surgical treatment for supracondylar femoral fractures now has a better outcome than in the past because of improved implants. However the new methods are not without problems.

Complication of fractures:

1. Infection
2. Vascular injuries
3. Nerve injuries
4. Nonunion
5. Mal union
6. Pulmonary complications
7. Missed ligamentous injuries
8. Knee stiffness

Complication of operative treatment:

1. Incomplete reduction
2. Incongruous reduction
3. Loss of knee motion
4. Infection
5. Implant Breakage [30]

INFECTION:

The major drawback of fixation of supracondylar femoral fracture is the high risk of infection. However it should not exceed 5%. If wound drainage develops postoperatively, aggressive irrigation and wound debridement indicated. Appropriate antibiotics should be given intravenously for 3 to 6 weeks. In florid infections it is better to keep implant in situ rather than removing it is because stable infected injuries better manage than unstable fractures. However if the implant is loose, it should be removed and the fracture should be protected with external fixation.

NONUNION: [37,46]

It is much more common in conservatively treated cases than in surgically treated cases, owing in part to the rich blood supply to the distal femur and the predominance of cancellous bone. Nonunion generally is due to presence of infection, unstable fixation, mechanical failure of the implant or any combination of these factors. Treatment may be difficult owing to preexisting osteopenia, proximity to knee joint and prior surgical procedures. Aseptic nonunion should be treated by repeat osteo synthesis. Septic nonunion should be treated with external stabilization

POST TRAUMATIC ARTHRITIS:

The incidence of post traumatic arthritis is unknown. However incongruity of the joint surface is the leading cause of the early arthritis. Unfortunately lot of patients developing post traumatic arthritis is young patient becoming unsuitable for TKR. Arthritis affecting only part of the condyle then plan for corrective osteotomy, if involve both compartment and patello femoral compartment it is better proceed with arthrodesis or total knee replacement. Patients age and available range of movement and presence of Fixed flexion contractures and sepsis will play major role in surgical management of this kind of fractures.

KNEE STIFFNESS:

The most common complication that occurs after Distal femur fracture is loss of knee movement. This is unavoidable complication either due to damage to quadriceps mechanism and intra articular injuries by trauma or surgical fixation, Quadriceps scarring following injury or arthro fibrosis of knee joint is the reasons for knee joint stiffness. Moreover it is aggravated by immobilization of the fracture either by external and internal fixation. Immobilization more than 21days usually leads to few degrees of knee joint stiffness. Early mobilization of patient, active and passive quadriceps physiotherapy exercises and meticulous soft tissue management will increase the chance of good outcome in distal femur injuries. Patients with significant loss of motion after an injury may be candidates for quadriceps plasty as a late reconstructive procedure.

VASCULAR INJURIES :

The exact incidence of vascular injury accompanying supracondylar fracture is unknown but is estimated to be only 2-3 %.Vascular injuries can be caused by direct laceration (or) contusion of the artery or vein by fracture fragments or indirectly by stretching leading to initial damage, clinical examination for signs of ischemia with evaluation of pulses and motor and sensory function is essential.

MALUNION:[46]

Mal union of both medial and lateral condyles very common due to improper fixation against mechanical forces against the joint and soft tissue imbalance around the joint. Mal united fractures leads to not only mechanical limitation and limping ,often sets in early secondary arthritis of joints if it involves intra articular injuries.

PULMONARY COMPLICATIONS

When stabilization of the fractures was delayed in patients who had multiple injuries, the incidence of pulmonary complications was higher, patients who were treated conservatively or with late stabilization of fractures in poly trauma had high incidence of fat embolism (22%).

ASSOCIATED LIGAMENTOUS INJURIES

Concomitant ligamentous injuries to the knee are uncommon and are rarely diagnosed preoperatively. The most commonly injured Ligament is Anterior Cruciate ligament. Initially non operative treatment is advocated as repair (or) reconstruction may produce further comminution, prolonged operation time and increases the risk of loss of knee motion and infection. Protected motion in conjunction with a knee orthosis and vigorous rehabilitation may obviate the need for late reconstructive surgery. If necessary late reconstruction should be done after the fracture has healed.

Hernanz *et al.*. concluded that the locking compression plate system for distal femoral fractures to be a safe and reliable procedure. The new system offers numerous fixation possibilities and has proven its worth in complex fracture situations.[47]

Christoph Sommer in his study in 2006 on the biomechanics of locking plates summarized the following:

The existing benefits of the new internal fixator principles are enhanced by the combination hole concept in the following aspects:

- Improvement in angular stability due to locking head screws (even if uni-cortical).
- Accurate plate contouring not required.
- Less damage to the periosteum and its blood supply.
- More options and greater versatility in fracture management, especially if complex epi-metaphyseal fractures or fractures with limited bone quality are present.[33]

He concluded, thus, by making the decision in using the LCP in specific cases, one can significantly contribute to the improvement of the clinical outcome of the operative treatment of bone fractures. Promising early clinical results have already been published. However, he also noted that these new techniques demand very careful pre-operative planning, especially in the sequence of applying the different types of screws, since this process requires a clear understanding of the principles governing each technique.[33]

Vallier HA *et al.*. while reporting failure of six cases of LCP in 2006, retrospectively reviewed the cases of all forty-six patients who had been treated primarily with the LCP condylar plate for a distal femoral fracture during a thirty-six month period at their hospital. They identified six implant failures. They concluded that the LCP condylar plate represents an evolutionary approach to the surgical management of distal femoral fractures, but it does not completely solve the age-old problems of nonunion and mal-union. Accurate reduction and fixation, judicious use of bone-grafting and protected weight-bearing, perhaps combined with modifications in implant design, may decrease the prevalence of these problems in the future. They further said that locking plates represent a valuable advancement in fracture treatment. However, the limitations of this new technology and the indications for its use have not been completely elucidated.[30]

The results of 57 A-O type A or C supracondylar femur fractures treated by open reduction and internal fixation using indirect reduction techniques was done by Bolhofer *et al.*. No bone grafting or dual plating was used. All patients were placed in a continuous passive motion (CPM) machine postoperatively. Patients were followed at 4-week intervals until fracture healing had occurred.

All patients were followed for at least 1 year after injury. The average time for fracture healing was 10.7 weeks (range 8-16). Hardware failure did not occur in this series. Outcomes were assessed using a modified Schatzker scoring method. Using the scale, there were 84% good to excellent results, 11% fair results, and 5% poor outcomes. Fair and poor results tended to occur in more severe fractures and were primarily due to limited knee motion. Complications included two broken screws, one deep infection, and one malunion. No fractures failed to unite. In conclusion, it appeared that biologic reduction techniques, although they provided excellent bone healing capability, did not guarantee universally satisfactory outcomes.[34]

Sommer in 2004 while reporting on Locking Compression Plate Loosening and Plate Breakage in their studies, concluded that the experience to date with the LCP system has shown that this system provides effective fixation in a wide range of fractures, with a low incidence of implant-related complications. As in the cases reported in their studies, the pit falls had been consistently attributable to technical errors such as the use of an inappropriate plate or technique at the beginning of using this new system. Even though 4 cases of failure were reported, they concluded that the successful application of the LCP system needs careful preoperative planning and attention to the biomechanical principles that have been incorporated in its design.[45]

O'brien *et al.*. in Chapter 51 of Rockwood and Green's Fractures in Adults quote that the advantage of combining conventional screw capacity with fixed angle technology is that the fixed angle screws provide stable fixation in small articular blocks (protecting against collapse and loss of alignment), while the conventional screw can provide inter-fragmentary compression and make it possible to use the device as an aid in reduction of the non articular portion of the fracture.[1]

Christopher *et al.*. concluded based on their restrospective studies found a high rate of non union in distal femur fractures treated with locking plates. Non-union presented late without hardware failure and with limited callus formation suggesting callus inhibition rather than hardware failure is the primary problem. Pre-operative planning is crucial for using this implant. The optimal mechanical environment for a distal femur fracture treated with locking implants remains uncertain.[48]

Surgical treatment of supracondylar or inter-condylar distal femoral fractures (AO/OTA types 33-A and 33-C) remains a significant surgical challenge with significant complication rates. Adverse events include infection, decreased range of motion, need for bone grafting, mal-union, and nonunion. Recent advances in sub-muscular plate applications using existing plate constructs seem to offer the advantages of a lower infection rate and need for bone grafting. A problem unique to these fractures is loss of fixation of the distal femoral fragment, however, especially in osteoporotic bone when using the condylar buttress plate. Loss of distal fixation and toggling of distal screws can lead to varus angulation and fracture fixation failure.[37]

METHODOLOGY

Source of data:

- It is a prospective observational study
- Conducted in patients admitted in Department of Orthopaedics in BLDEU'S Shri B.M.Patil's Medical College, Hospital and Research Centre, Vijayapura with diagnosis of fracture of distal Femur.
- The patients were informed about study in all respects and informed written consent was obtained.
- Period of study was between November 2017 to May 2019.
- Follow up period was for 6 months.

Method of collection of data:

- Patients admitted in Department of Orthopaedics in BLDEU'S Shri B.M.Patil's Medical College, Hospital and Research Centre, Vijayapura with diagnosis of fractures of distal end Femur.
- By clinical examination.
- By interview.
- By follow up at 6 weeks, 3 months and 6 months.

Inclusion criteria

1. Patient aged 18 years and above.
2. Intraarticular fratures of distal femur.
3. Communited fractures of distal femur.
4. Closed and Compound fractures of distal end of femur including Gustillo and Anderson types I and II

Exclusion criteria

1. Pathological fractures.
2. Associated neurovascular injury.
3. Patients medically unfit for surgery.
4. Immunocompromised status.
5. Gustillo and Anderson Type III
6. Floating knee

Sampling:

With 95% confidence level and margin of error of ±20%, a sample size of 22 (or more) of Distal Femur Fracture subjects will allow the study to determine the functional outcome by locking plate with finite population correction (N=200).

By using the formula:

$$n = \frac{z^2 p(1-p)}{d^2}$$

where

Z= z statistic at 5% level of significance

d is margin of error

p is anticipated prevalence rate by using the reference article 'The Results of Open Reduction and Internal Fixation of Distal Femur Fractures Using a Biologic (Indirect) Reduction Technique' by Bolhofner *et al.*.(34)

Statistical analysis:

All characteristics are summarized descriptively. For continuous variables, the summary statistics of N, mean, standard deviation (SD) was used. For categorical data, frequency and percentage was used in the data. Non parametric variables was analyzed by Chi square test for association and for parametric variable student t-test used to assess mean difference. Statistical analysis is performed using SPSS v21 for Microsoft windows format. p-value <.05 is considered statistically significant.

RESULTS:

Following were the observations made in the present study. The total number of patients was 22 with 18 males and 4 female. Male to female ratio in present study was 4.5:1.

Table 1. Distal Femur Fracture Treated with Locking Plate *Gender

	Gender		Total
	Female	Male	
Count	4	18	22
%	15.0%	85.0%	100.0%

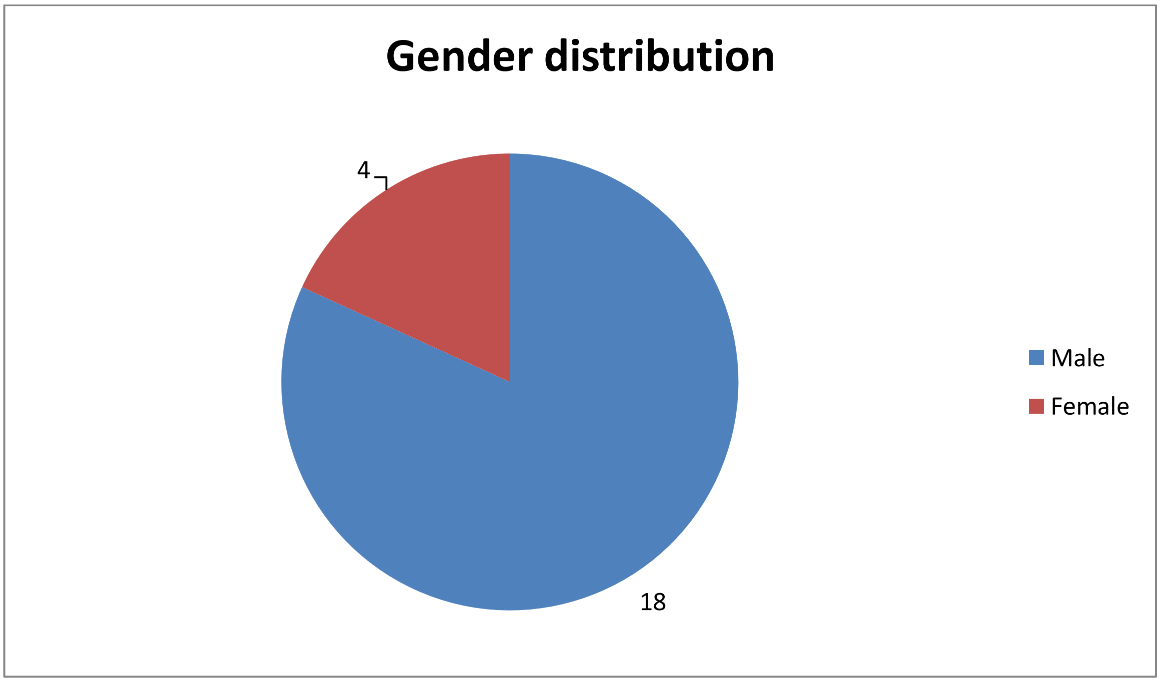


Figure 1. Distribution of Gender.

Table 2. Figure 2. Distal Femur Fracture Treated with Locking Plate * Occupation								
	Occupation							Total
	Laboures	Farmer	Household	Cleaner	Teacher	Businessman	Engineer	
Count	8	6	3	2	1	1	1	22
%	32.0%	30.0%	15.0%	10.0%	5.0%	5.0%	5.0%	100.0%

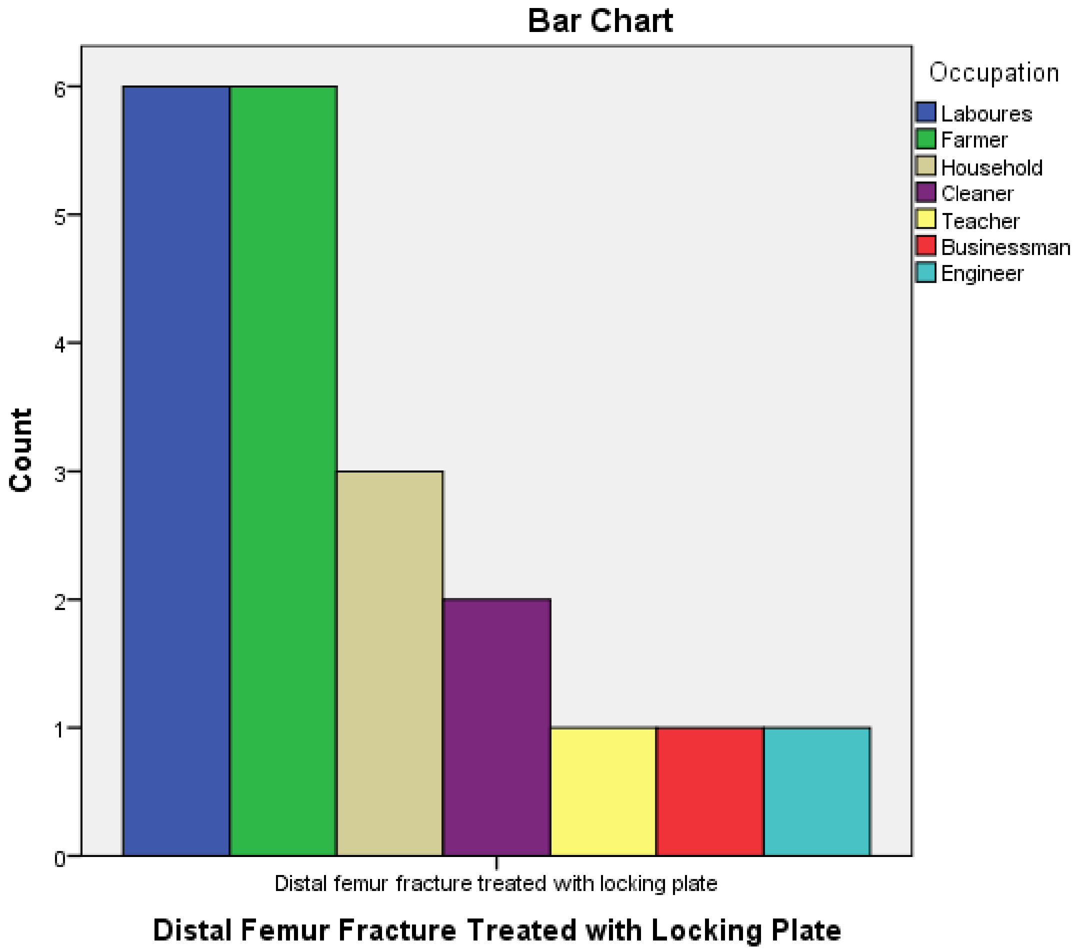


Figure 2. occupation of patients

Table 3. Distal Femur Fracture Treated with Locking Plate * Mechanism of injury				
	Mechanism of injury			Total
	Fall	RTA	Assault	
Count	6	15	1	22
%	25.0%	70.0%	5.0%	100.0%

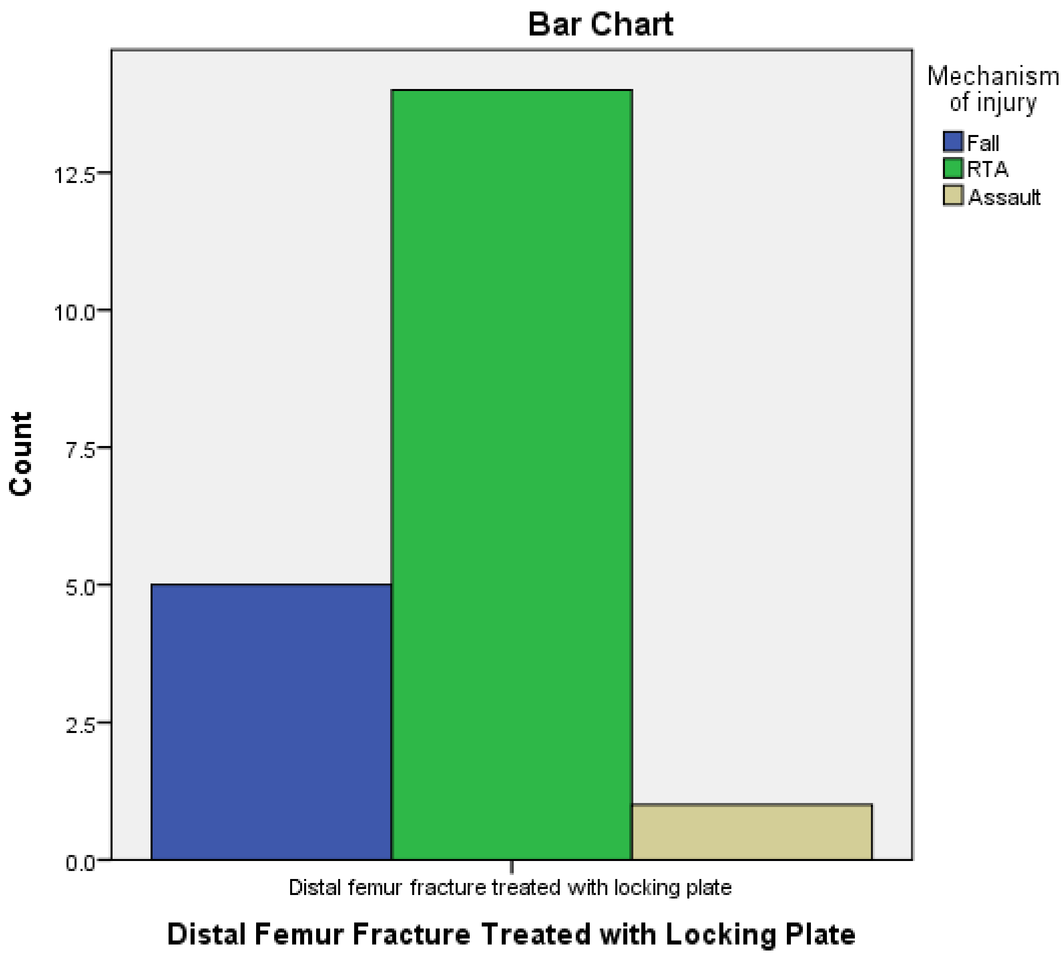


Figure 3. Cause of fracture.

Table 4. Distal Femur Fracture Treated with Locking Plate * Side of Injury			
	Side of Injury		Total
	Left	Right	
Count	7	15	22
%	30.0%	70.0%	100.0%

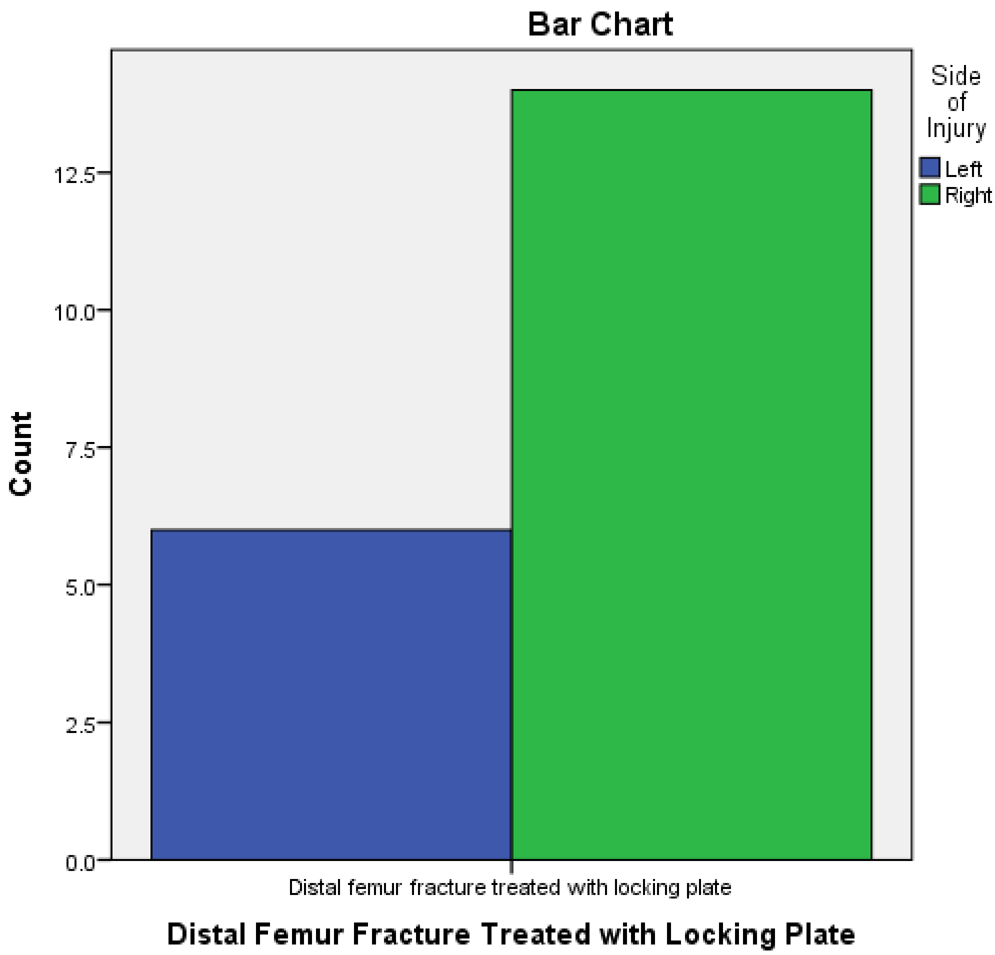


Figure 4. Side of injury.

Table 5. Distal Femur Fracture Treated with Locking Plate * Type of fracture							
	Type of fracture						Total
	Muller's A1	Muller's A2	Muller's A3	Muller's C1	Muller's C2	Muller's C3	
Count	1	6	4	1	6	4	22
%	5.0%	25.0%	20.0%	5.0%	25.0%	20.0%	100.0%

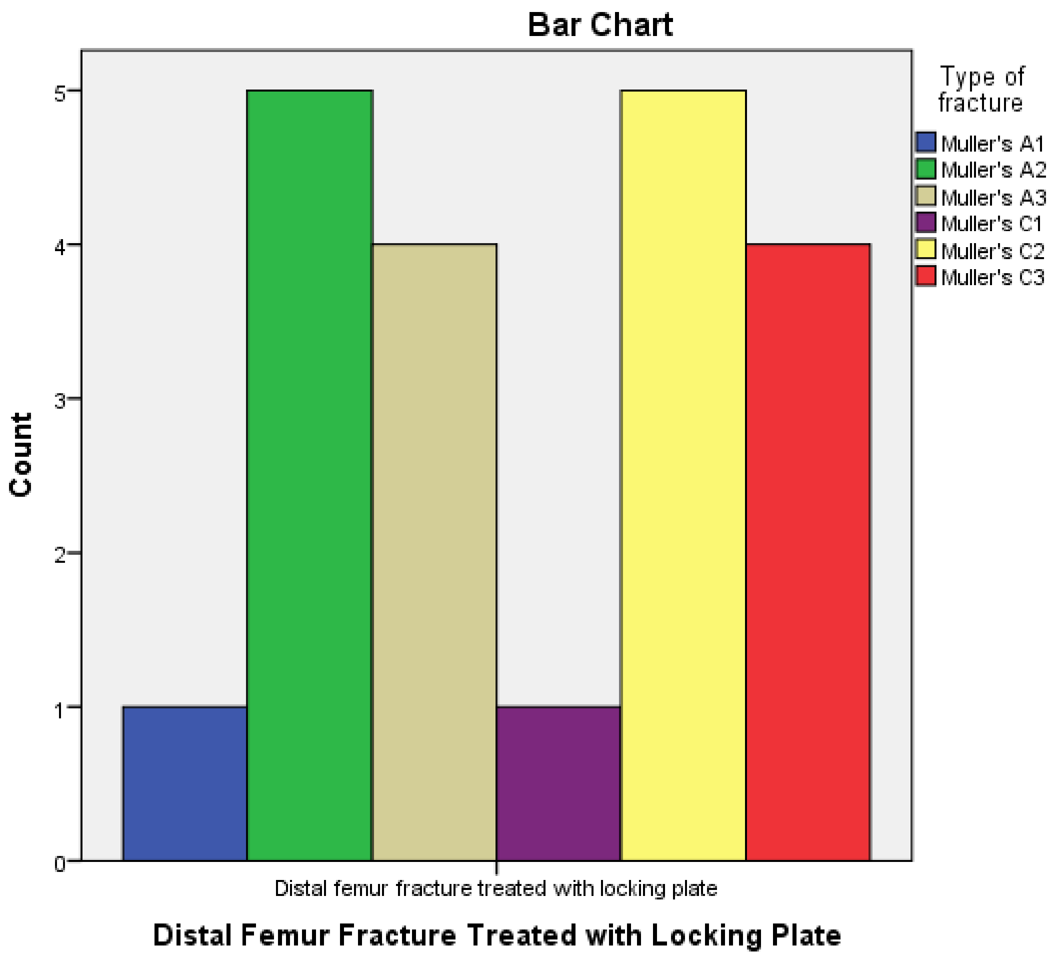


Figure 5. Type of distal femur fracture.

Table 6. Distal Femur Fracture Treated with Locking Plate * Associated fractures

	Associated fractures					Total
	NA	Proximal tibial and patella fractures	Fracture left ulna	Fracture patella and proximal tibia	Fracture proximal tibia	
Count	18	1	1	1	1	22
%	80.0%	5.0%	5.0%	5.0%	5.0%	100.0%

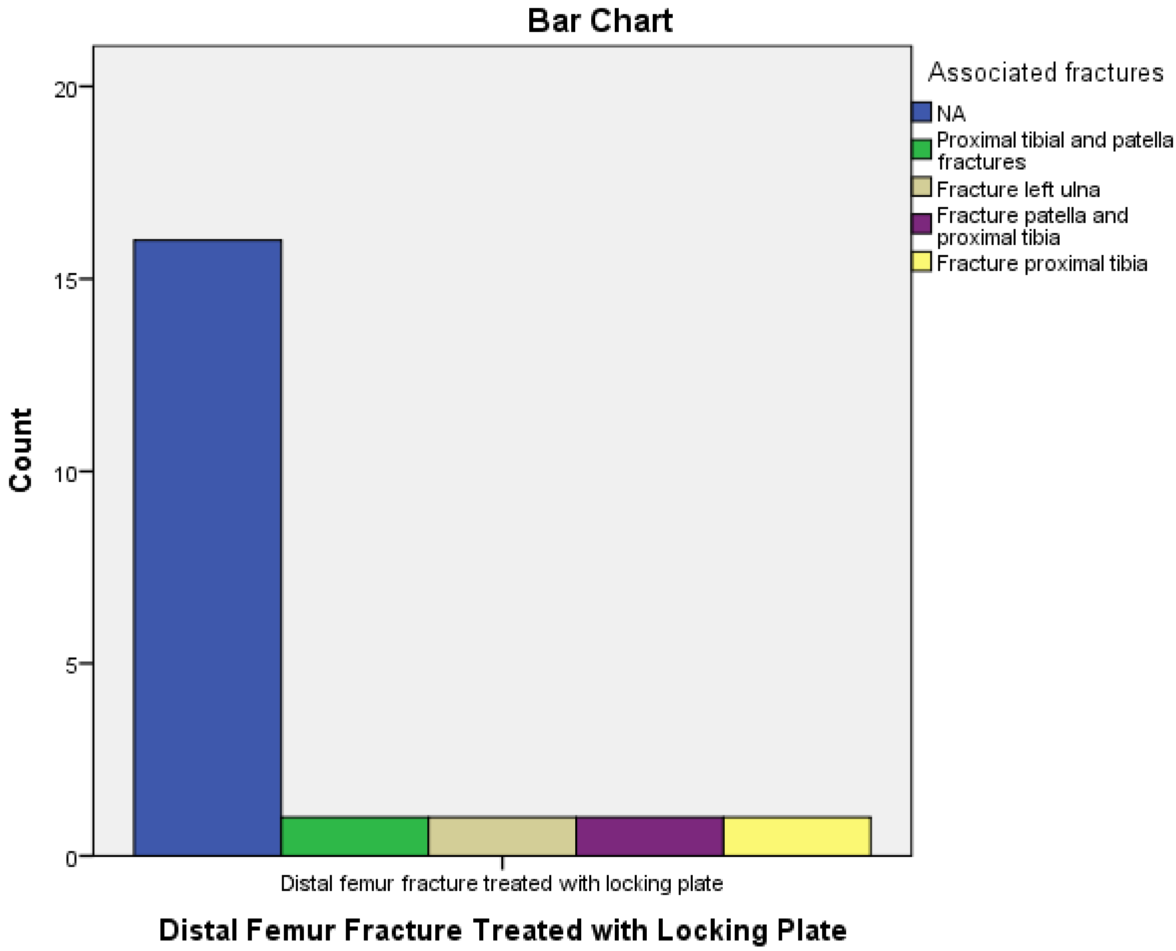


Figure 6. Type of associated fracture in patients

Table 7. Distal Femur Fracture Treated with Locking Plate * Varus/Valgus malalignment					
	Varus/Valgus malalignment				Total
	NA	10º Valgus	8º Valgus	10º Valgus	
Count	18	1	1	2	20#2
%	80.0%	5.0%	5.0%	10.0%	100.0%

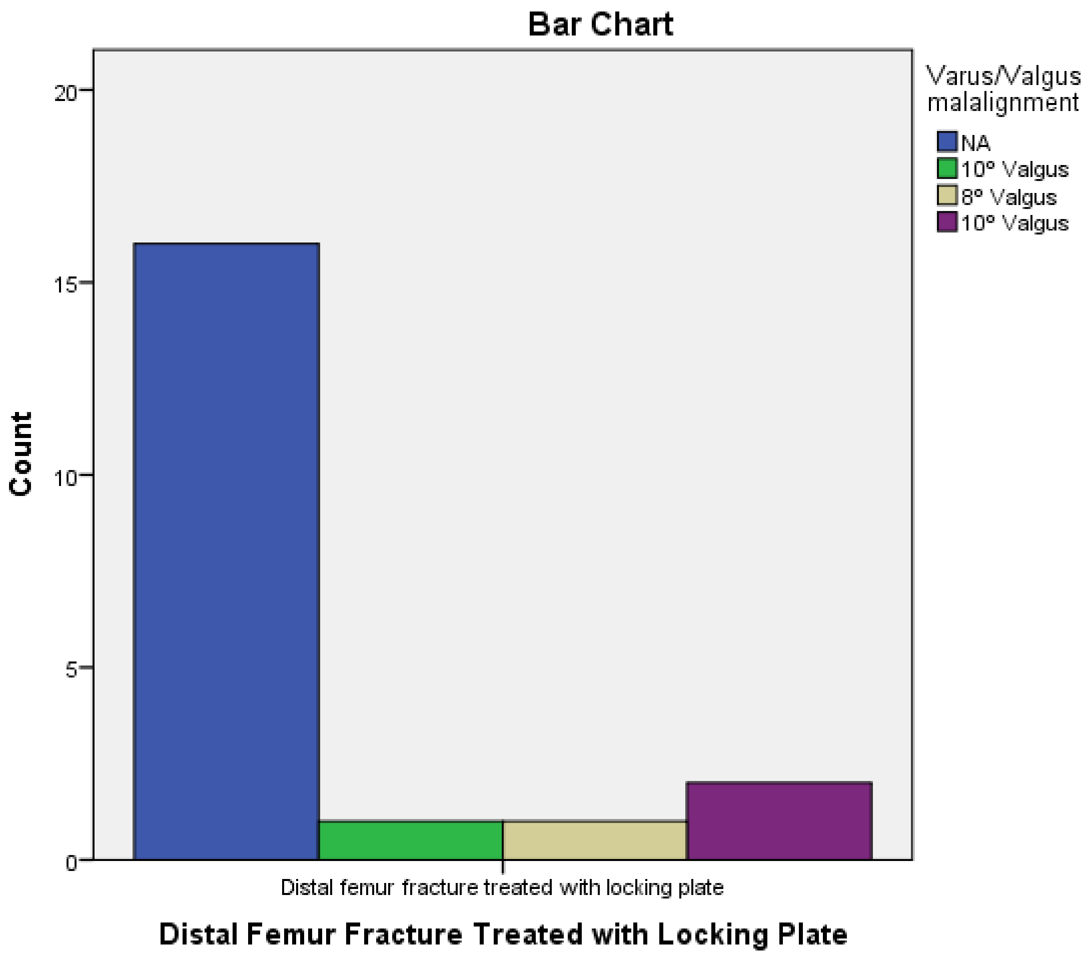


Figure 7. Malalignment in patients

Table 8. Distal Femur Fracture Treated with Locking Plate * Results				
	Results			Total
	Fair	Good	Excellent	
Count	4	6	12	22
%	20.0%	30.0%	50.0%	100.0%

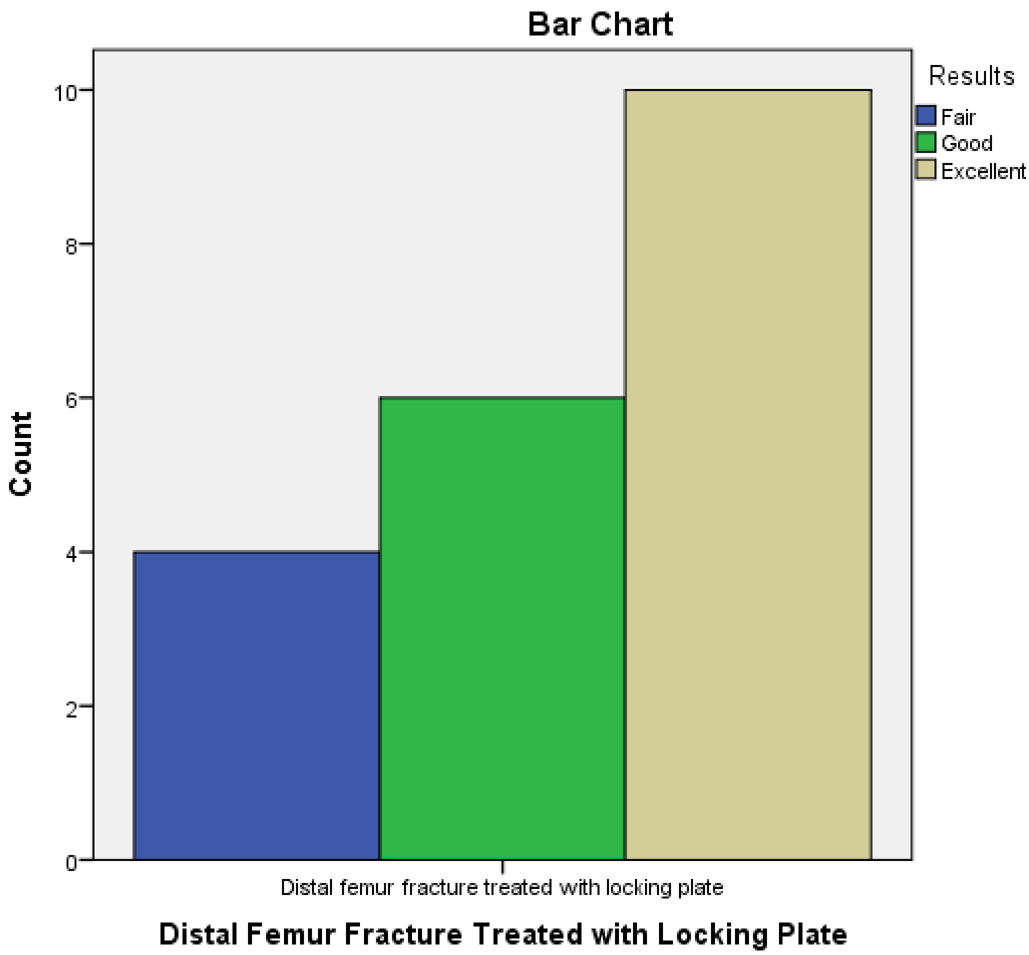


Figure 8. Post-operative result in the patient.

Table 9. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate* Surgery		
Variables	**Distal Femur Fracture Treated with Locking Plate**	**Statistic**
Surgery-Injury interval in days	Median	3.00
	Minimum	2
	Maximum	8
	Interquartile Range and 25-75th percentile	2 (2.25-4)

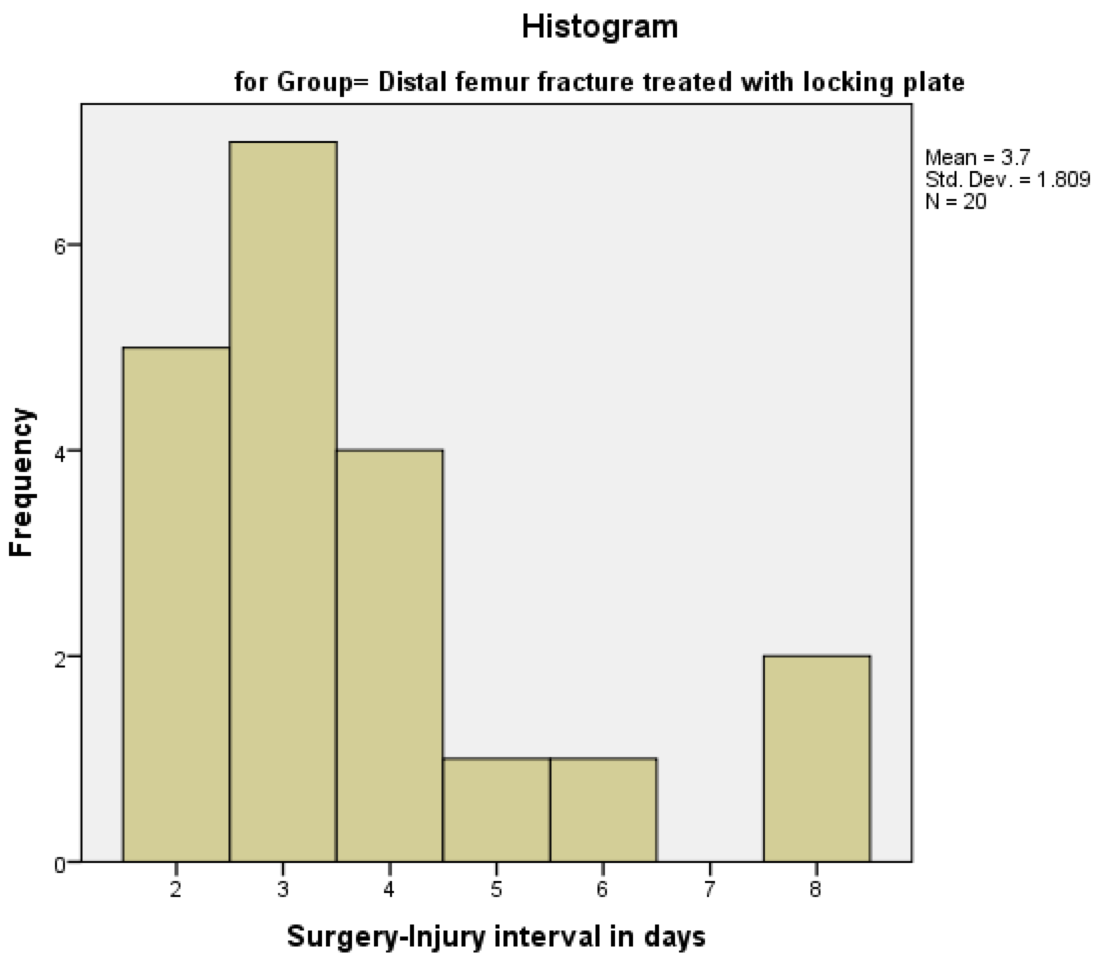


Figure 9. Surgery-injury interval in day

Table 10. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate* Duration of surgery in min			
Variables	**Distal Femur Fracture Treated with Locking Plate**		**Statistic**
Duration of surgery in min	Mean and Std. Error		101.75 (4.691)
	95% Confidence Interval for Mean	Lower Bound	91.93
		Upper Bound	111.57
	Std. Deviation		20.981

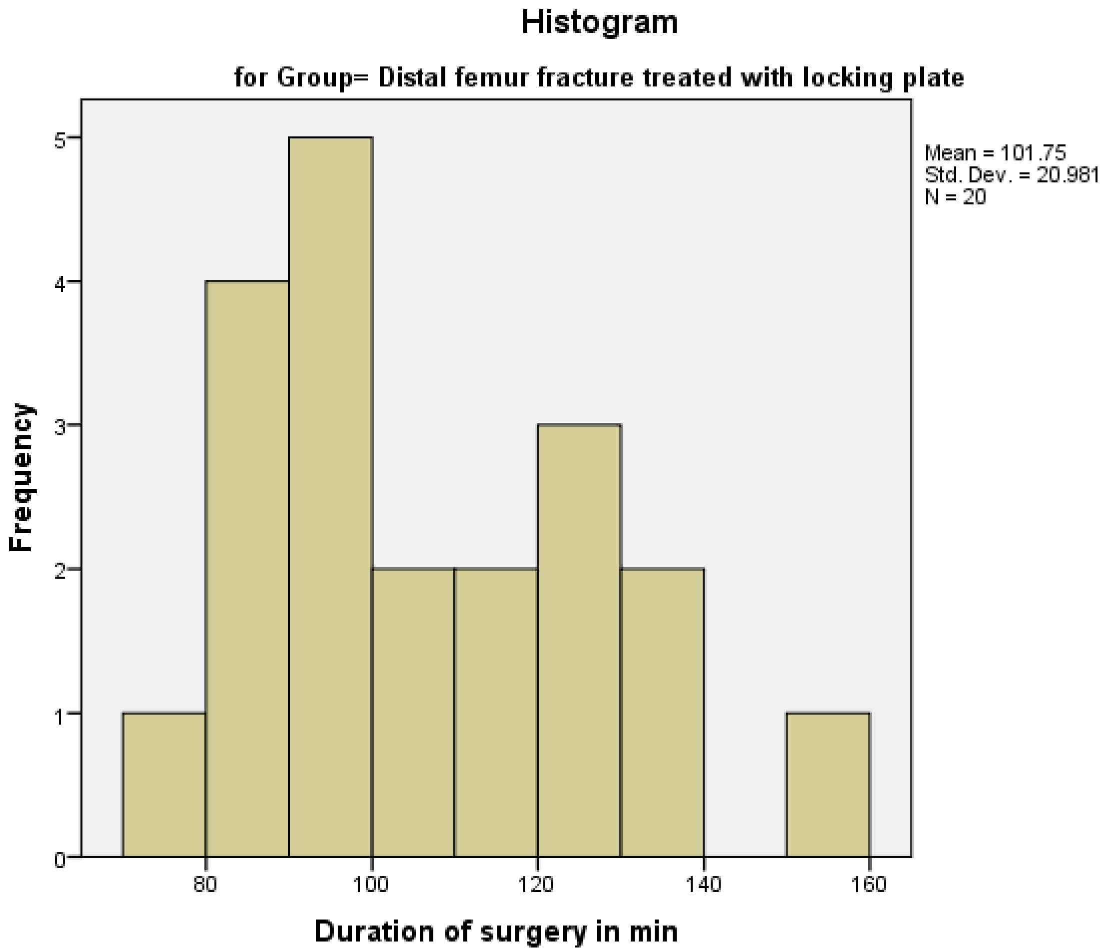


Figure 10. Duration of the surgery in mins

Table 11. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate* Full weight bearing in weeks			
Variables	**Distal Femur Fracture Treated with Locking Plate**		**Statistic**
Full weight bearing in weeks	Mean and Std. Error		15.80(.395)
	95% Confidence Interval for Mean	Lower Bound	14.97
		Upper Bound	16.63
	Std. Deviation		1.765

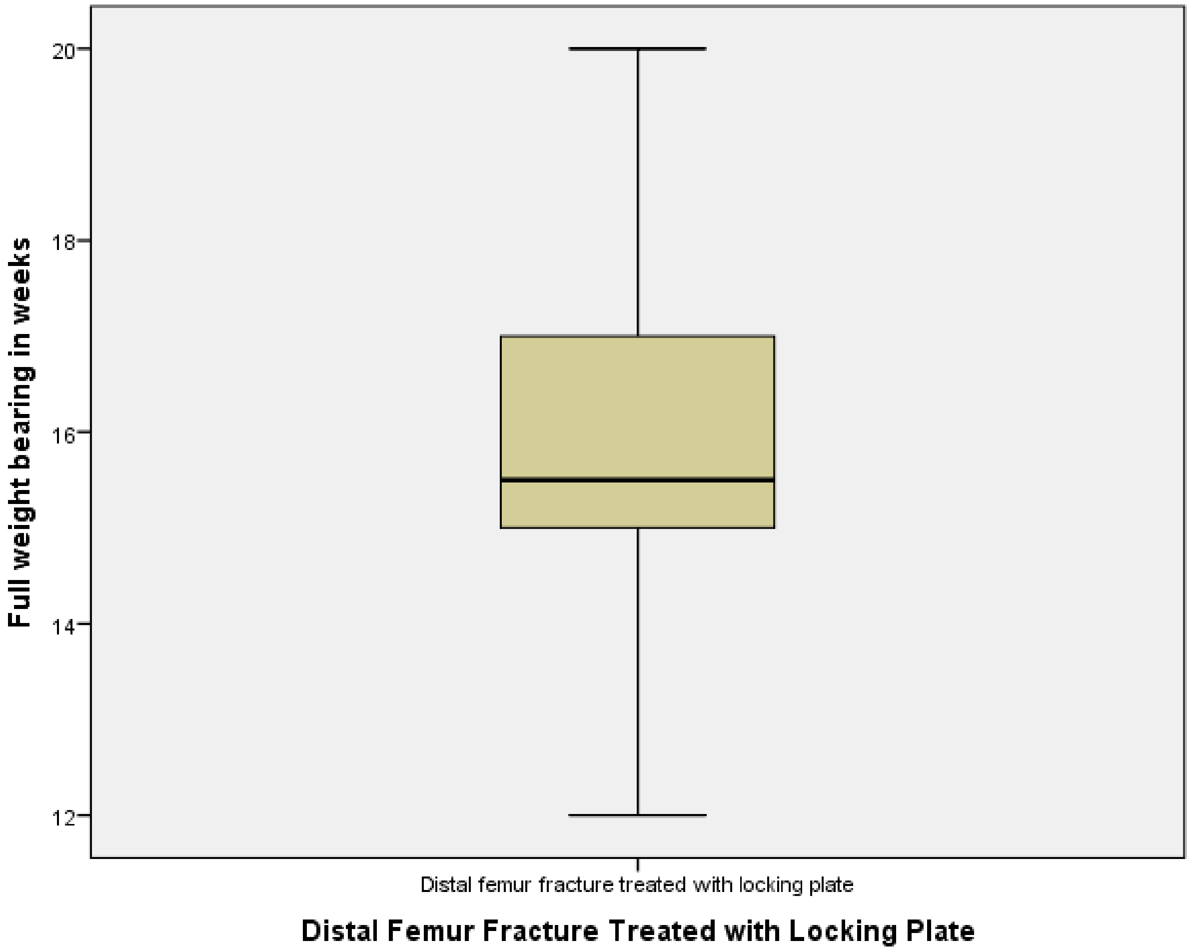


Figure 11. Box plot with fullweight bearing by patients.

Table 12. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate* Radiological union in weeks		
Variables	**Distal Femur Fracture Treated with Locking Plate**	**Statistic**
Radiological union in weeks	Median	17.00
	Minimum	16
	Maximum	20
	Interquartile Range and 25-75th percentile	3(16-19)

Figure 12. Box plot with radiological union of fracture.

Table 13. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate* Knee flexion in degrees		
Variables	**Distal Femur Fracture Treated with Locking Plate**	**Statistic**
Knee flexion in degrees	Median	110.00
	Minimum	50
	Maximum	130
	Interquartile Range and 25-75th percentile	19(100-118.75)

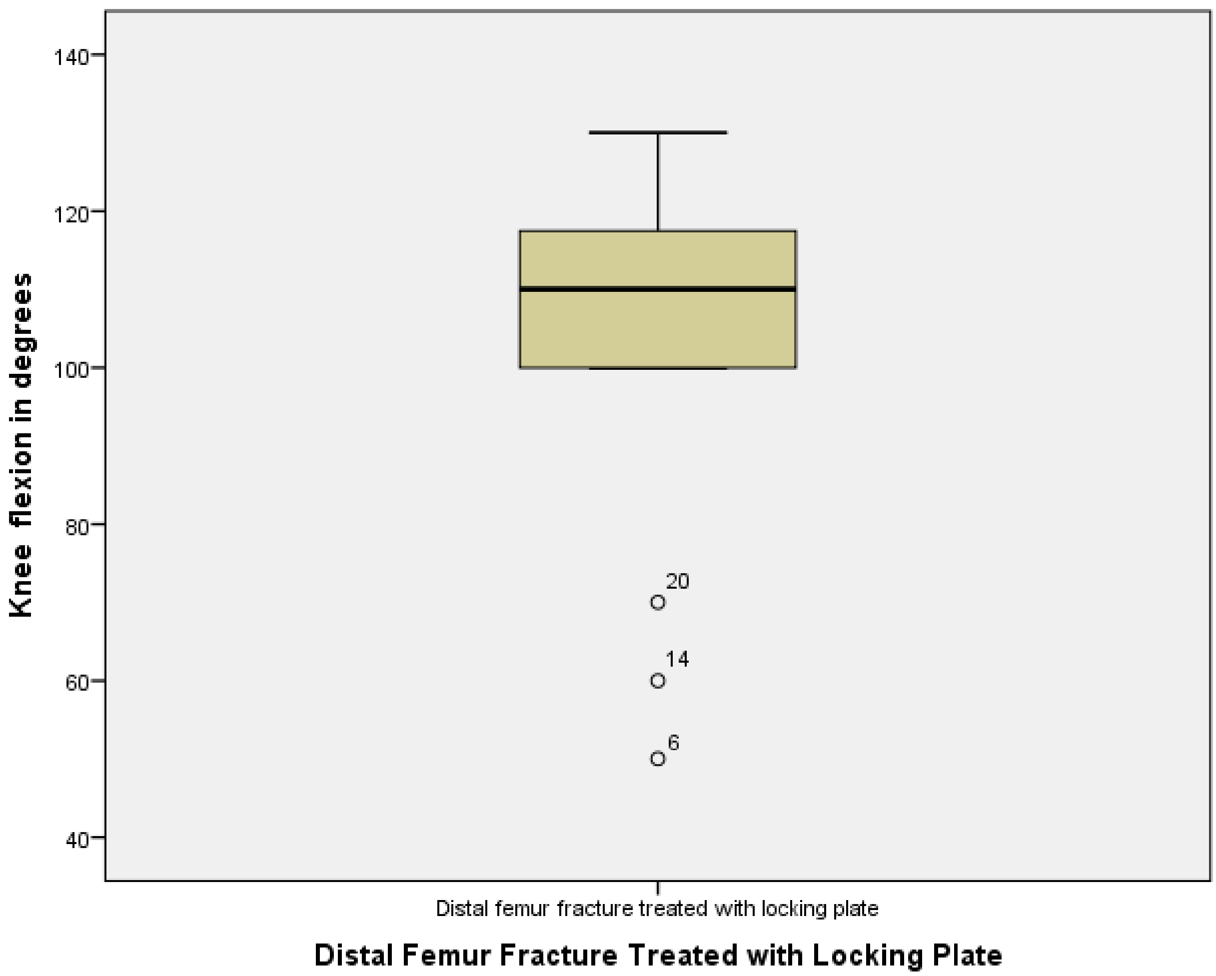


Figure 13. Box plot of knee flexion in degree post-operatively

Table 14. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate* Extensor lag		
Variables	**Distal Femur Fracture Treated with Locking Plate**	**Statistic**
Extensor lag	Median	5.00
	Minimum	0
	Maximum	20
	Interquartile Range and 25-75th percentile	10(0-9.5)

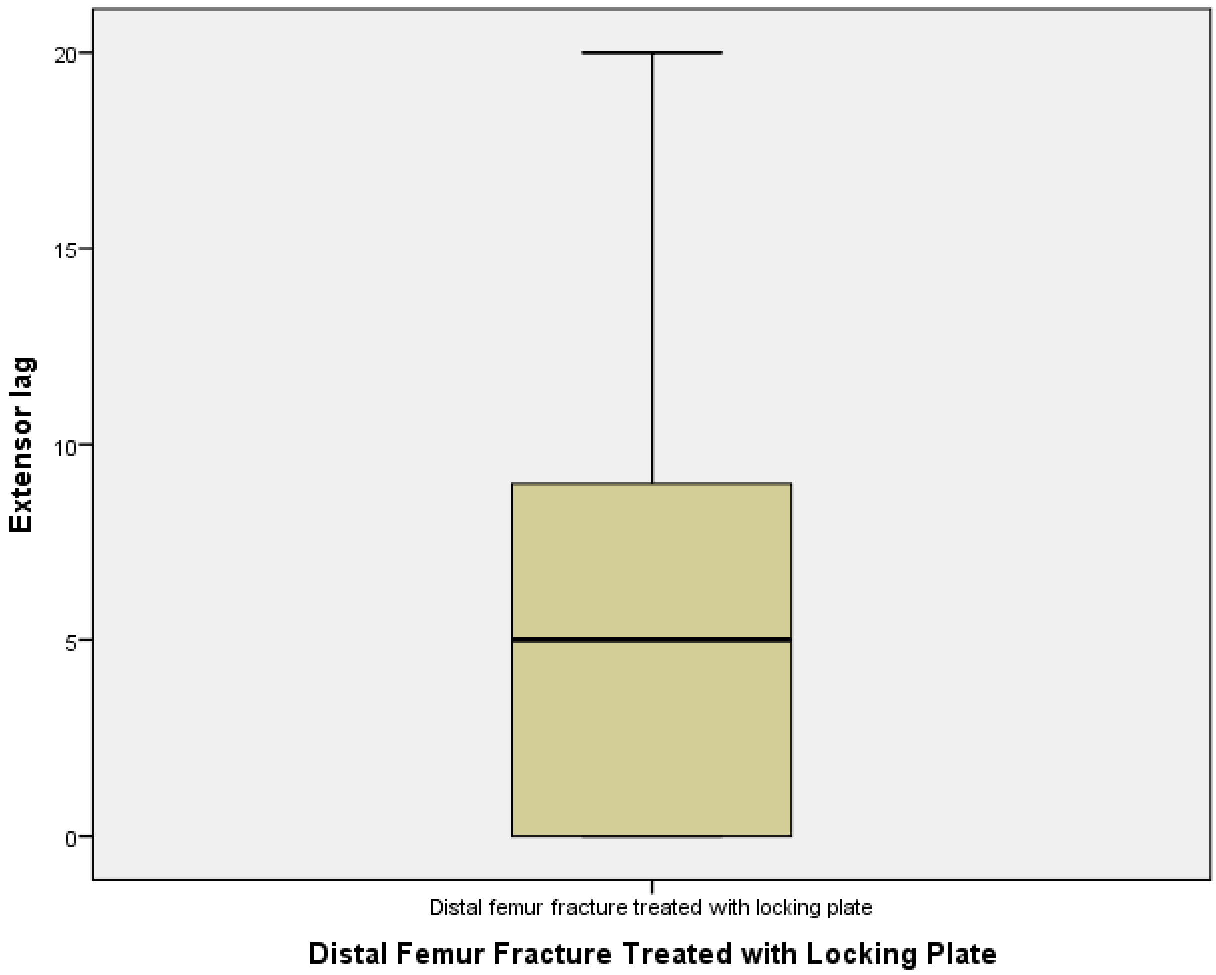


Figure 14. box plot with extensor lag in the limb

Table 15. Functional outcome factors after Distal Femur Fracture Treated with Locking Plate*NEER rating		
Variables	**Distal Femur Fracture Treated with Locking Plate**	**Statistic**
NEER Rating	Median	94.50
	Minimum	66
	Maximum	156
	Interquartile Range and 25-75th percentile	61(78.5-139.75)

Figure 15. Box plot of NEER rating.

Table 16. Type of fracture in patient*result of surgery using chi-square test				
Type of fracture	Results			Chi-square
	Fair	Good	Excellent	X^2 (p-value)
Muller's A1	0	0	2	21.358 (.019)*
Muller's A2	0	0	6	
Muller's A3	1	2	1	
Muller's C1	0	0	1	
Muller's C2	0	3	2	
Muller's C3	3	1	0	
p-value <.05 is considered statistically significant.				

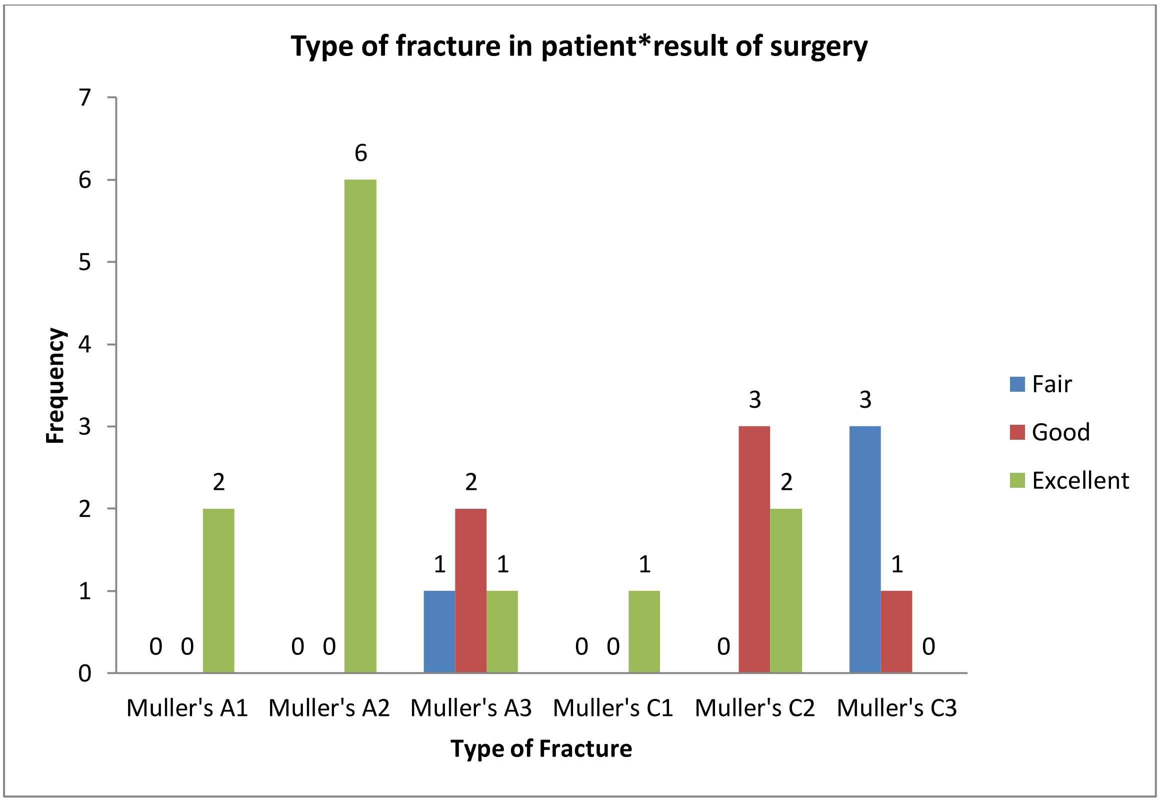


Figure 16: Type of fracture in patient v/s result of surgery

Table 17. Type of fracture*mal-alignment in patients using chi-square test					
Type of fracture	Varus/Valgus malalignment				Chi-square
	NA	5º Valgus	8º Valgus	10º Valgus	X^2 (p-value)
Muller's A1	2	0	0	0	19.90 (.268)
Muller's A2	6	0	0	0	
Muller's A3	2	1	0	1	
Muller's C1	1	0	0	0	
Muller's C2	5	0	0	0	
Muller's C3	1	0	1	2	
p-value <.05 is considered statistically significant.					

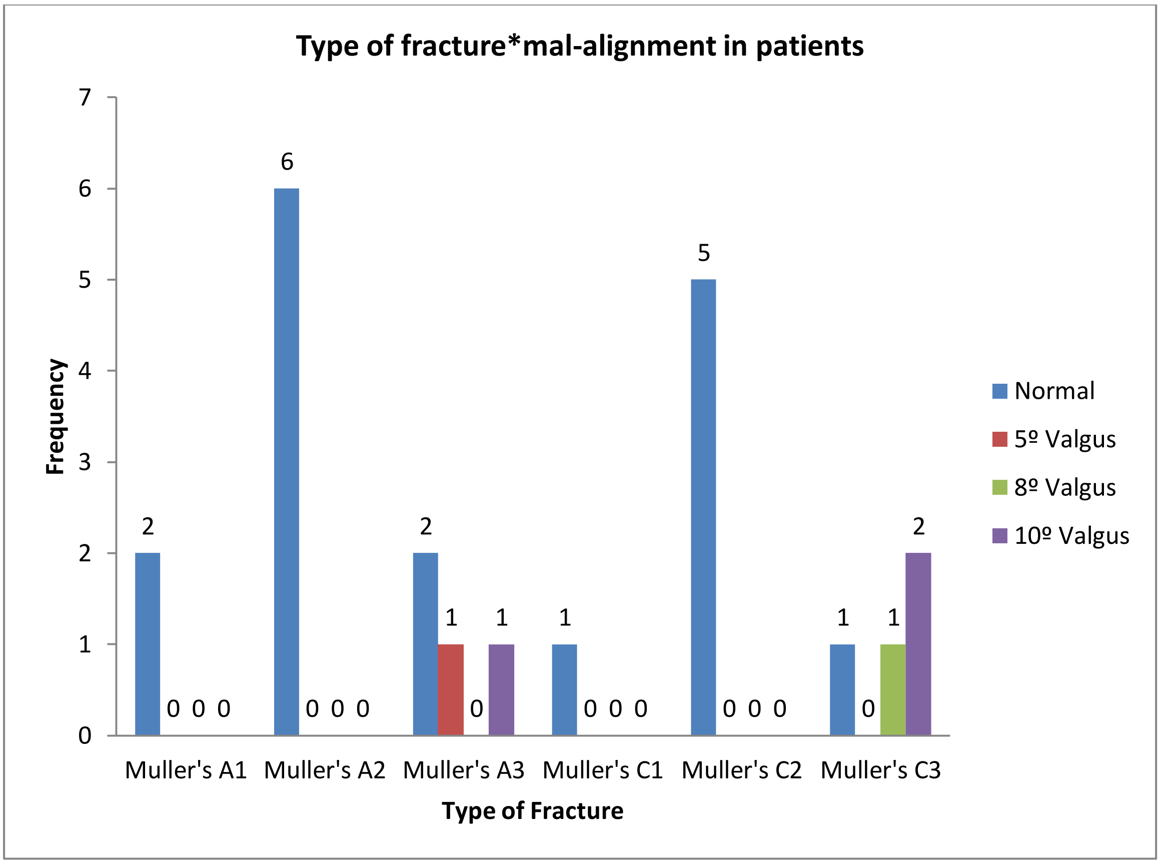


Figure 17: Type of fracture v/s mal-alignment in patients

Table 18. Type of fracture*Knee flexion in degree among operated patients.				
Type of fracture	Knee flexion in degrees			
	Mean	SD	Maximum	Minimum
Muller's A1	110	0	110	110
Muller's A2	120	6	130	115
Muller's A3	96	33	125	50
Muller's C1	120	.	120	120
Muller's C2	110	5	115	104
Muller's C3	83	21	100	60

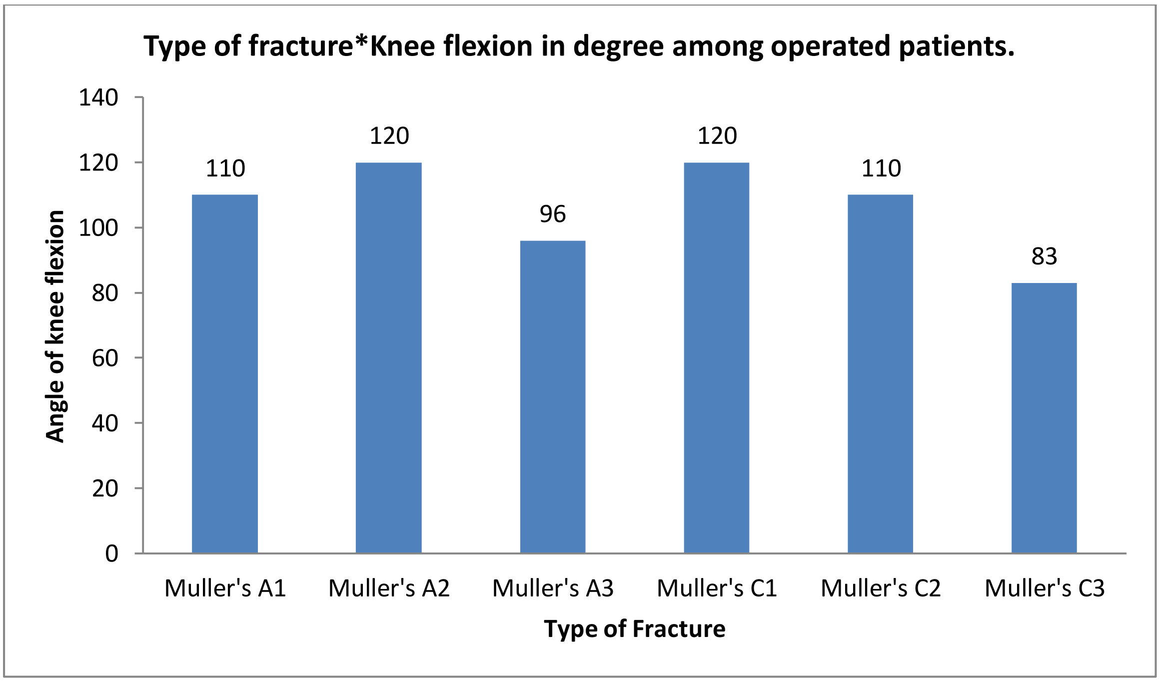


Figure 18: Type of fracture v/s Knee flexion in degree among operated patients.

Table 19. Complications in the patient at follow-up.		
	N	**%**
No complication	19	86.4
Screw cut-out	1	4.5
Superficial infection	2	9.1
Total	22	100.0

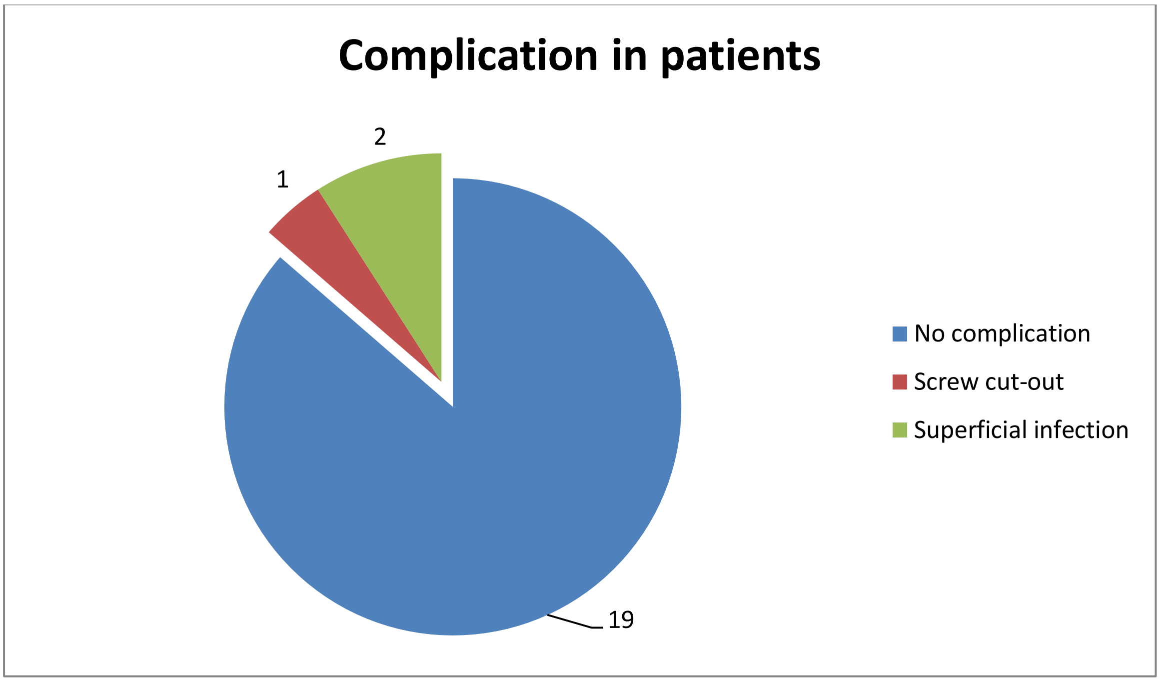


Figure 19. Showing complication in patients post treatment.

One two patients with Muller C3 type of fracture showed superficial infection and screw cut-out and one patient with Muller A3 fracture with superficial infection.

Figure 20. Showing pre operative radiograph

Figure 21 showing locking compression plates used for surgery

Fig 22 showing incision site

Fig 23 showing intra op plate placement

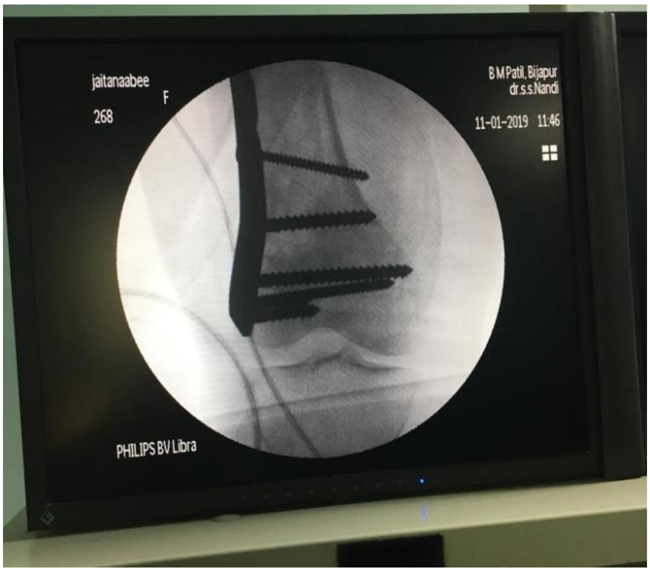


Fig 24 showing intra op fluoroscopic image

Fig 25 showing post operative radiograph

DISCUSSION:

Treatments of distal femur fractures have been controversial subject over two decades. In our study 22 fractures of distal femur were treated. Overall final outcome of the surgical management of fracture lower end of femur using locking compression plate was assessed in terms of regaining the knee function in term of weight bearing and the angle of rotation using NEER's score.

All 22 cases studied in our series were with 18 males and 4 females patients. 15 of the fractures were caused by road traffic accidents (RTA), 6 were due to fall and 1 were due to assault. 15 patients were with fracture on right side and 7 on left side.

In our study, of the 22 lower end femur fractures, 1 was Muller's type A1, 6 were Muller's type A2, 4 were Muller's type A3, 1 was Muller's type C1, 6 were Muller's type C2 and remaining 4 were with Muller's type C3. In a study by Schutz M, Muller M *et al.*.[5] Internal fixation using the LISS was performed at an average of 5 days (range: 0–29 days) after the injury. 48 fractures were operated on within the first 24 hours. Revision operations were required for 2 cases of implant breakage. 4 cases of implant loosening and 7 debridement's to deal with infections. The study showed clearly that when working with LISS, primary cancellous bone grafting is not necessary. This is comparable to the results of recent, retro-prospectively evaluated study using the retrograde IM nailing. The total follow up rate was 93%. 5% non union was observed.

Regarding the associated injuries, two patients had proximal tibia and patella fracture, one with fracture left ulna, one with proximal tibia fracture.

The duration of time required by patients to bear full weight was with mean of 15.8 weeks of time. The radiological union was seen at median of 17 weeks following surgery. Yeap, E.J., and Deepak, A.S[28] conducted a retrospective review on eleven patients who were treated for Type A and C distal femoral fractures (based on AO classification) between January 2004 and December 2004. All fractures were fixed with titanium distal femoral locking compression plate. The patient's ages ranged from 15 to 85 with a mean of 44. Clinical assessment was conducted at least 6 months post-operatively using the Schatzker score system. Results showed that four patients had excellent results, four good, two fair and one failure.

Zlowodzki *et al.*[(24)] combined these series (n=327) and evaluated the outcomes as part of a systematic literature review. Average nonunion, fixation failure, deep infection, and secondary surgery rates were 5.5%, 4.9%, 2.1%, and 16.2% respectively. Some of the technical errors that have been reported for fixation failure have involved waiting too long to bone graft defects, allowing early weight bearing, and placing the plate too anterior on the femoral shaft.

Locked implants are typically indicated in patients with osteoporosis, fractures with metaphyseal comminution where the medial cortex cannot be restored, or a short articular segment. Several case series have evaluated the use of locked implants in the treatment of distal femur fractures. The most commonly used implant in these case series has been the Less Invasive Stabilization System (LISS) with unicortical locking screws.[(29)]

On assessment of 22 fractures of lower end of femur outcome treated with open reduction and internal fixation, average duration of surgery was 101 minutes with shortest duration being 91mins and longest being 112mins. Radiological union of fracture was median of 17weeks.

Average flexion in the study of the limb was 110 º angles with more than 50% patients having knee range of motion more than 120º. The average knee extensor lag in present study was 5.0º. Out-of 22 patients, few patients had varus/valgus mal-alignment ranging between 5º, 8º and 10º of valgus in study. Patients with Muller's type C3 (n=5) showed valgus mal-alignment compared to other type of fractures in the present study.

Normal knee flexion is 140 degree. Laubethal has demonstrated that average motion required for:

Normal sitting	93 degree
Stair climbing	100 degree
Squatting	117 degree

Thus, acceptable knee flexion compatible with daily activity would be 110 degree.

Markmiller *et al.*[29] prospectively compared the outcomes of LISS and retrograde intramedullary nailing. At 12 months, no statistically significant differences were noted for nonunion, fixation failure, infection and secondary surgical procedures. However, this was a relatively small series and no power analysis was reported. Vallier *et al.*[30] concluded that locking plates should only be used when conventional fixed-angle devices cannot be placed. They also noted the significant added cost of locking plates. To decrease the risk of implant failure with locking plates, they recommended accurate fracture reduction and fixation along with judicious bone grafting, protected weight bearing, and modifications of the implant design.

Higgins *et al.*[32] compared the Locking Condylar Plate, with distal locking screw fixation and bicortical locking and nonlocking diaphyseal fixation, to the angled blade plate in axial load to failure and cyclic axial loading in a cadaveric 1 cm fracture gap model. The locking construct had a significantly higher load to failure and less permanent deformation with cyclic loading. All of these studies reveal that locking plates with unicortical or bicortical diaphyseal fixation have adequate axial stiffness but more flexibility when compared to conventional fixed-angle implants. Although they have less torsional stiffness, the studies that evaluated torsional stiffness have shown that the distal fixation in locked implants is typically maintained while conventional fixed-angle implants have a higher rate of distal cutout from the femoral condyles.

The outcome in form of regaining the knee function is assessed using NEER’s scoring system. The median NEER’s score in study was 94.5. Among 22 patients included, 12 patients showed excellent outcome, 6 with good and 4 with fair outcome at the follow-up. Poor outcome was found in patients with Muller’s type C3 and type A3 fractures.

CONCLUSION:

Locking compression plate is the optimal tool for many fractures in distal femur. It provides rigid fixation in the region of femur, where a widening canal, thin cortices and frequently poor bone stock make fixation difficult. Surgical exposure for plate placement requires significantly less periosteal stripping and soft tissue exposure than that of other techniques by use of LISS. Orthopaedic surgeons experience with locking compression plating technique will find the locking compression plate a useful technique, but requires attention to prevent complications.

To conclude, **Locking Compression Plate** is an important armamentarium in treatment of fractures around knee especially when fracture is severely comminuted and in situations of osteoporosis. Further study in large number of patients is required to comment regarding disadvantages and complications.

SUMMARY:

- Present study is prospective observational study conducted on 22 patients with distal femur fracture.
- Among 22 patients, 18 were males and 4 were female.
- Major portion of our patients were laborers and farmers.
- 15 patients sustained the fracture due to road traffic accidents on right side.
- All 22 patients treated with open reduction and internal fixation.
- Few patients were with additional fracture around the distal end of femur.
- Locking compression plate is a good fixation system for distal end femoral and proximal end tibia fractures, particularly intra-articular type.
- The operative-time is lessened with decrease in blood loss.
- Provides good angular stability by its triangular reconstruction principle.
- It is of great use in elderly patients with severe osteoporotic bone.
- Even with open reduction, there is less soft tissue trauma and less post-operative stiffness.
- Utmost care is required to avoid infection. Only 3 patients among 22 had minor superficial infections during the course of recovery.
- Non-requirement of bone graft decreases the morbidity associated with donor site.
- Early surgery, at least two screws in each fragment and early post-operative knee mobilization are essential for good union and good knee range of motion.
- There is no much difference in individual fracture type healing and weight bearing.

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PROFORMA

CASE NO. :

NAME :

AGE/SEX :

I P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized lymphadenopathy:	present/absent
Built:	poor/moderate/well
Nourishment:	poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Right/ Left Leg

Gait:

Inspection:

a) Attitude/ deformity

b) Abnormal swelling

- Site
- Size
- Shape
- Extent

c) Shortening

d) Skin

e) Compound injury if any

Palpation:

a) Local tenderness

b) Bony irregularity

c) Abnormal movement

d) Crepitus

e) Swelling

Movements: Active Passive

Knee:

Mesurements:

Femur Length

Neurological deficits:(if any)

Vascular deficits: (if any)

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INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH

I, the undersigned,_______________ , S/O D/O W/O ________________, aged ____years, ordinarily resident of ____________ do hereby state/declare that Dr. Abhishek Shenoy of Shri. B. M. Patil Medical College Hospital and Research Centre has examined me thoroughly on ______________ at ______________ (place) and it has been explained to me in my own language that I am suffering from ________________ disease (condition) and this disease/condition mimic following diseases. Further Dr informed me that he/she is conducting dissertation/research titled "A Prospective Study Of Functional Outcome Of Distal End of Femur Fracture treated by locking plate" under the guidance of Dr requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in evaluation of the results of the study which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same time I have been informed that I can withdraw from my participation in this study at any time if I want or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt ______________________________ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of patient:

Signature of doctor:

Witness: 1.

2.

Date:

Place: