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DISSERTATION

Titled

"STUDY OF SURGICAL MANAGEMENT OF DISTAL FEMUR FRACTURE USING LOCKING COMPRESSION PLATE"

Submitted

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF M.S. IN ORTHOPAEDICS

By

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DEDICATED TO

MY DEAR PARENTS,

PAGADPALLY SIDDAPPA & UMA DEVI,

For their selfless sacrifice to fulfil all my dreams,

AND

TO MY SISTERS, APARNA & MANJULA,

AND

TO MY BROTHER, DR. SRINIVAS,

AND

TO MY FIANCE, DR. JANHAVI for their everlasting love, support and encouragement,

AND

TO MY GUIDE AND MENTOR, DR. P.V MANOHAR.

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled

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is a bonafide and genuine research work carried out

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ABSTRACT

INTRODUCTION

Distal femur fractures occur at approximately one-tenth the rate of proximal femur fractures and make up 6% of all femur fractures. There is a bimodal distribution of fractures based on age and gender. Most high-energy distal femur fractures occur in males between 15 and 50 years, while most low-energy fractures occur in osteoporotic women >50 years. The most common high-energy mechanism of injury is a traffic accident (53%) and the most common low-energy mechanism is a fall at home (33%).[1,2] In the past two decades there has emerged another injury group coming out of periprosthetic fractures.[2]

Fractures of the distal femur are common, while tibial fractures are rare. Crucial for treatment is to distinguish fractures of the metaphysis above the femoral component. This remains firmly fixed, from those involving the knee joint replacement and component loosening. Distal fractures are almost always managed surgically, using methods of osteosynthesis with an angle condylar or dynamic compression plate (DCP), or a short retrograde-inserted supracondylar intramedullary nail. The recent use of implants such as locking compression plates (LCP) with angle-stable screws has offered good prospects.[3]

Locking compression plate offers all advantages of angle-stable implants. It is more effective for osteoporotic bone than a Dynamic compression plate implant or a condylar plate, because it provides better fixation stability for the distal fragment[3]. This study seeks to evaluate the various surgical management techniques for distal fracture femur using LCP in rural population in Kolar.

OBJECTIVES OF THE STUDY

1. To assess the fracture union and functional outcome following open reduction and internal fixation of distal femur fractures with locking compression plate.

2. To achieve restoration of the anatomical alignment of fracture fragments and stable internal fixation

METHODOLOGY:

SOURCE OF DATA:

The study was conducted on patients of distal femur fracture treated by locking compression plate in Department of Orthopaedics of R L Jalappa Hospital attached to Sri Devaraj Urs Medical College and Research Centre, Tamaka, Kolar commencing from Oct 2011 to April 2013.

Sample size – 30.

INCLUSION CRITERIA

1. Patients above 18 years of age

2. Distal 15 cms of the fracture femur

3. Extra articular fractures and also those with intra articular extensions

4. Closed fractures

5. Open fractures of type I, type II, type III A and III B

6. Pathological fractures

EXCLUSION CRITERIA

1. Patients who are not fit for surgery.
2. Patients with neuro vascular deficits

Muller's AO Classification of distal fracture femur[9] - 33

A) Extra articular fracture
  - A1 simple
  - A2 metaphyseal wedge
  - A3 metaphyseal complex

B) Partial articular fracture (unicondylar)
  - B1 lateral condyle, sagittal
  - B2 medial condyle, sagittal
  - B3 frontal – "Hoffa fracture"

C) Complex articular fracture (bicondylar)
  - C1 articular simple, metaphyseal simple
  - C2 articular simple, Metaphyseal complex
  - C3 Articular complex

Abbreviation: AO, Arbeitsgemeinschaft für Osteosynthesefragen.

A detailed history was collected including the presenting signs and symptoms as per the predesigned proforma. Data so obtained were compiled and analyzed. Patients were evaluated pre-operatively by both clinical and radiological examinations. Fracture care was provided by trained Orthopaedician at the hospital. Patients were followed up regularly by clinical examination and evaluated by Neer's Criteria. X rays were taken immediately after the operation, at 6 weeks, 12 weeks and 24 weeks after surgery.

RESULTS

Femur fractures were often the result of a high energy trauma in younger age group. In elderly population the fractures frequently occurred due to a trivial trauma through the osteoporotic bone. Most of the fractures were of open type.

The average age in the study was 41.53 years. However, most of the fractures occurred in the ages between 31- 40 years. The study showed a male preponderance.

Road traffic accidents were the major causes of these fractures followed by falls and few assaults. Associated injuries to the head, chest and abdomen in patients were common accounting for around 25%. Surgery for fracture femur was performed within 1-5 days in most of the patients. Radiological union was noted at an average of 14 weeks. The average range of movements at the knee was 114 degrees in 6 months follow up period.

Morbidity rate was around 25% which included minor complications like superficial wound infection. The end results were excellent in 17(57%), good in 9(30%), average in 3(6.6%), and poor in 1(3.3%) patients. Poor results were seen in comminuted and compound fractures with gross infection.

CONCLUSION

Our study analysis demonstrated that locking compression plate is a good method for treating distal femur fractures especially type A1, A2, A3, C1 and C2. Type C3 comminuted fractures and compound fractures had poor results. It provides a rigid fixation for the fracture. Additionally, it also provides a good purchase in osteoporotic bones. **Use of LCP in experienced hands is simple, reliable, and easy to apply implant and it seems to be appropriate for fixation of femoral fractures in a rural hospital set up with promising results.** We recommend the use of locking compression plate in Type A and C, and osteoporotic fractures. Lastly, proper awareness among the people, strict driving and traffic rules, adequate health education to seek medical aid, proper referral mechanism and transportation can reduce the incidences of high energy accidents and these fractures.

Keywords: ***Distal Femur Fracture, Locking Compression Plate.***

LIST OF ABBREVIATIONS

1. LCP – Locking Compression Plate
2. LISS – Less Invasive Stabilization System
3. MIPPO – Minimally Invasive Percutaneous Plate Osteosynthesis
4. AO - Arbeitsgemeinschaft für Osteosynthesefragen Classification
5. DCP – Dynamic Compression Plate
6. CPO - Closed Percutaneous Osteosynthesis
7. IMN – Intra Medullary Nail
8. ASIF – Alignment Of Supracondylar / Intercondylar fractures
9. DF – LCP – Distal Femur - Locking Compression Plate
10. ORIF – Open reduction and internal fixation.

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INTRODUCTION

Distal femur fractures occur at approximately one-tenth the rate of proximal femur fractures and make up 6% of all femur fractures. There is a bimodal distribution of fractures based on age and gender. Most high-energy distal femur fractures occur in males between 15 and 50 years, while most low-energy fractures occur in osteoporotic women >50 years. The most common high-energy mechanism of injury is a traffic accident (53%) and the most common low-energy mechanism is a fall at home (33%) [1, 2]. In the past two decades there has emerged another injury group coming out of periprosthetic fractures[2].

Fractures of the distal femur are common, while tibial fractures are rare. Crucial for treatment is to distinguish fractures of the metaphysis above the femoral component. This remains firmly fixed, from those involving the knee joint replacement and component loosening. Distal femur fractures are almost always managed surgically, using methods of osteosynthesis with an angle condylar or dynamic compression plate (DCP), or a short retrograde-inserted supracondylar intramedullary nail. The recent use of implants such as locking compression plates (LCP) with angle-stable screws has offered good prospects[3].

Locking compression plate offers all advantages of angle-stable implants. It is more effective for osteoporotic bone than a Dynamic compression plate implant or a condylar plate, because it provides better fixation stability for the distal fragment[3] . This study seeks to evaluate the various surgical management techniques for supracondylar fracture femur using LCP in rural population in Kolar.

OBJECTIVES OF THE STUDY

- To assess the fracture union and functional outcome following open reduction and internal fixation of distal femur fractures with locking compression plate.

- To achieve restoration of the anatomical alignment of fracture fragments and stable internal fixation

REVIEW OF LITERATURE

Distal femur fractures will continue to increase in incidence and complexity due to increasing road traffic accidents. The challenges faced in treating these fractures continue to include a short articular segment, bone loss in open fractures, and osteoporotic bone. As implants and techniques have evolved, the treatment goals include restoration of limb alignment, anatomic articular reduction, and early knee motion. These fractures are complex injuries and have been historically difficult to treat. These fractures are often a result of some trivial trauma in elderly because of osteoporotic bones.

As for the proximity of these fractures to the knee joint, the complete healing is of the fracture is difficult and regaining the full range of movements at the knee joint and functional outcome may be challenging[4].

Emphasis on “biological” or indirect reduction techniques to restore limb alignment has improved the rate of fracture healing and decreased infection rates, fixation failure, and the need for bone grafting when compared to earlier clinical series that used direct reduction techniques.

The distal femoral fractures are less common than the hip fractures. These constitute around 7% of all femoral fractures. Excluding the hip, 31% of femoral fractures involve the distal portion of femur[5].

Improvements in the surgical techniques and development of newer implants and methods in the last few decades have paved way towards the surgical managements of these fractures. Currently, many authors are in the view that distal femoral fractures are best treated by open reduction and stabilization[6].

Numerous approaches and methods have been used for the treatment of these fractures. Some of these include the implants like Angle blade plate, Zickel device, Rush pins, Ender's nail, Intramedullary Supracondylar interlocking nails and locking compression plates.

These implants are tried with varying success rates and are technically demanding. None of these have shown promising results in osteoporotic bones. Thin cortices, communition, osteopenic bones and a wide medullary canal make secure internal fixation difficult to achieve[7].

The long-term results of indirect reduction techniques of distal femoral fractures treated with the condylar plate are good to excellent. There seems no difference in results between the closed percutaneous osteosynthesis (CPO) and minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques[7].

Although the role of locking plates has continued to expand over recent years, clinical studies have yet to demonstrate a significant improvement in outcomes with their use. The development of locking plates has coincided with the advancement of minimally invasive plating techniques[8].

Complications of healing including non-union, delayed union, and implant failure are not infrequent and represent on-going problems with distal femur fracture treatment[9].

Anatomical reduction of the articular surface, stable internal fixation with minimal soft tissue stripping, early mobilisation and restoration of limb alignment have been shown to be effective way of managing these fractures[10].

HISTORICAL PROSPECTIVES

The earliest treatment for fracture femur dates back to about 350 BC, when Hippocrates first used bandages solidified with waxes and resins to treat these fractures. Stiffened linen was used for splinting by the Egyptians. The embalmer's bandage was linen, and gum or plaster the stiffening agent[11].

The Middle Age followed the Hippocrates, and bandages stiffened by dipping in egg and albumin and solidifying pastes were used. William Cheselden, a British Surgeon, popularised the technique further. Rhazes, in Arabia used lime and egg white[11].

Galen, in 200 AD first described the longitudinal traction technique to overcome the overriding of fractured fragments. Plaster of Paris bandages were first introduced by Matthhyse, a Dutch military surgeon, in 1852. In 1839, John Haddy James described treatment of fractures of lower limb with traction with weight and pulley. Buck's traction method of skin traction using adhesive tape was popularised in the American Civil war[11].

In 1873, Sir James Paget described about the pathology of the fracture and advocated the conception of early immobilization for the treatment of fracture[12].

Hugh Owen Thomas in 1876 first described the Thomas splint as a knee appliance for immobilization. This was used for the management of tuberculosis of the knee joint and is still used for the treatment of fractures of lower limb[13].

In 1907, Fritz Steinmann of Bern described a method of applying isotonic skeletal traction by means of pins driven into the femoral condyles. He described the use of through and through pin technique[14].

The use of continuous traction in the management of fractures appeared in around the middle of 19th century. The stirrup was introduced by Bohler. Both Steinmann pin and Bohler stirrup are still used in the treatment of factures even today[15].

Advancements were further made in the treatment of fractures with the introduction of anaesthesia, x rays and asepis in surgical practise. Lambotte in 1906 encouraged the methods of internal fixation using screws, pins, plates and circlage wires. Intramedullary surgery was developed by Kuntsher in 1940 with the introduction of Kuntsher nails[16].

The use of compression screws in fracture treatment was a major development. Danis in 1949 devised axial compression and rigid fixation of fractures. He advocated the tapping of treads for screwing into hard bone. He further demonstrated that rigid fixation and axial compression can lead to fracture healing without the radiological signs of callus formation. This type of healing was described by him as “Soundure Autogene” or primary bone healing[17].

Muller *et al.,* in 1958 developed a classification and formed AO/ ASIF group to develop internal fixation. The concept of compression at the fracture site to obtain a rigid internal fixation and primary bone union was emphasized. It was concluded that early mobilization of the fracture extremity is a must to prevent the fracture disease[10].

The choice of conservative vs. operative procedure has been debatable. In a review of 213 cases on treatment of supra and inter condylar fractures, complications of delayed union and non-union were seen more in the operative group compared to those who were treated conservatively [(18, 19)]. Since sufficient stability was not been able to be achieved, most of the cases post-operatively required immobilization and non-operative treatment was recommended.

Schatzker and Tile noted that non-operative management of isolated condylar fractures leads to less than satisfactory outcomes, but they did not describe any specific recommendations as to a management approach[20].

Supracondylar-intercondylar fractures of the femur should be analysed separately from other fractures of the distal end of the femur because of their intra-articular involvement and associated ligamentous injuries and patellar fractures. Rigid internal fixation permits early functional rehabilitation of the patient and decreases the incidence of malunion, non-union, and loss of fixation[21].

Open reduction and internal fixation constitute the standard of care for management of displaced distal femoral condylar fractures. The techniques most commonly used include conventional and locked plating with the primary goal of articular surface congruency[22].

Recent advances in sub-muscular plate applications using existing plate construct seem to offer the advantages of a lower infection rate and need for bone grafting[23]. The Less invasive stabilization system is an acceptable surgical option for treatment of distal femoral fractures.

Treatment of distal femur fractures with the “Less invasive stabilization system” (LISS) is associated with high union rates without autogenous bone grafting (93%), a low incidence of infection (3%), and maintenance of distal femoral fixation (100%)[23].

Fracture femur in an elderly with osteoporosis is challenging to treat. Fixed angle locking plates have become the most commonly used device for this indication replacing intramedullary nails, blade plates and condylar screws[24]. Locking plates have been developed in conjunction with a minimally invasive biologically friendly insertion technique which allows the plate to be placed without excessive soft tissue-stripping and with minimal disruption of the bone blood supply [24, 25].

These plates are used to span zones of comminution which then heals with an external callus. They have been designed to limit fracture gap strain with physiologic loads and have improved fixation in osteoporotic, cancellous, or comminuted bone [25, 26].

Henderson *et al.* [27], in their study in 2006 compared callus formation in distal femur fractures stabilized with locking plates and intramedullary nails and described that locking plates used to bridge fractures of the distal femur led on average to less callus formation than IM nails. High stiffness achieved by locking plate constructs may result in delayed healing or non-union because of limiting callus formation[27].

A systematic review comparing traditional plating, intramedullary nails, and locking plates found no observed differences between implants in the rate of non-union, infection, fixation failure, or revision surgery[28].

In a prospective study, intramedullary nails and locking plates were found to have equivalent functional outcome scores[29].

Sanders *et al.*, in their study observed more non unions in stainless steel plates, compared to titanium plates[30]. Locking plate constructs can be several folds stiffer than external fixators and they can be as stiff as traditional plating constructs designed to promote primary bone healing by restricting inter-fragmentary motion [31, 32, 33].

Some studies have indicated that locking plates can be substantially stiffer than intramedullary nails [34, 35].

Borgen D *et al.*[36], conducted a clinical study on supracondylar fractures of femur treated with early weight bearing and knee mobilization and observed good functional outcome in all patients.

Seinsheimer F, in their study concluded patients with supracondylar fractures without inter condylar extension had good range of movements when treated with traction and cast brace and patients with intercondylar fractures had better knee motions after operative fixation[37].

Treatment of supra and inter condylar fractures as treated by insertion of Rush pins also showed good results in a study conducted by Shelbourne KD *et al*[38].

Kayali *et al*., note that more recently locking plates have emerged as the most frequently used method for treating fractures of the distal femur, particularly when the involved bone is of poor quality, namely osteoporotic or comminuted [39].

Locking plates confer better stability than do traditional plates. Dynamic condylar screws and angled blade plates are associated with a higher incidence of nonunion than were locking plates [40]. Scolaro and Ahn found that locking plates are ideal for highly comminuted fractures, for which intermedullary nails (IMN) cannot provide sufficient reduction and stabilization [41].

Bellabarba *et al.*, [42] also support this finding in their study in which fractures in 18 patients with metaphyseal comminution and three with articular comminution healed after treatment with plating. Locking plates are also amenable to minimally invasive insertion, which helps preserve the vascular supply to the fracture site.

Giles JB *et al.*[43], demonstrated the advantages of stable internal fixation using supracondylar plate and lag screw over other types of fixation.

In a clinical study of patients with supracondylar fractures treated with ASIF techniques, good to excellent result was observed. However, high potential complications rate was seen with the same. An extensive surgical exposure of the multiplanar intra articular fractures was done[44].

The LISS (Less Invasive Stabilization System) was developed to address the potential complications of treatment of peri-articular fractures about the knee. LISS plates differ significantly from more traditional plating systems. LISS plate consists of all locking screws. The threaded screw head locks into the plate and can only be inserted at one angle. The angle between the plate and screw is therefore fixed in space, allowing each individual screw to function as a mini blade plate [45].

Each screw in the LISS is fixed to the plate, and there is no need for the plate to touch the bone, thus reducing the disruption to the bone's blood supply by decreasing the plate's footprint. Also, the plate can be inserted with a percutaneous technique, minimizing the disruption to the fracture's soft tissue envelope [46].

Furthermore, the plate's locking screw construct, alters the failure mechanics of the plate. The locked nature of the LISS plate screws makes sure that the plate fails only if all of the screws are pulled out together. This provides added structural support that is thought to be particularly important in osteoporotic bone [47].

The LCP is a single beam construct where the strength of its fixation is equal to the sum of all screw-bone interfaces rather than a single screw's axial stiffness and pull out resistance in unlocked plates[25]. Its unique biomechanical function is based on splinting rather than compression resulting in flexible stabilisation, avoidance of stress shielding and induction of callus formation. When applied via a minimally invasive technique, it allows for prompt healing, lower rates of infection and reduced bone resorption as blood supply is preserved[48].

In the mid to late 1990's LISS was introduced which further promoted the development of DF-LCP [49, 50]. LISS utilises an outrigger device for shaft holes, functioning essentially as a locking guide jig, which is attached to the distal part of the plate and guides the placement of the proximal locking screws. The shaft holes on the DF-LCP allow for the options of a compression screw or a locking screw. This leads to a more precise placement of the plate, as it is able to be compressed more closely to the bone[48].

Yeap EJ *et al*.[48], concluded that DF-LCP is a good implant to use for fractures of the distal femur. However, accurate positioning and fixation are required to produce satisfactory results. This implant can be successfully used in Type A and C, osteoporotic and periprosthetic fractures.

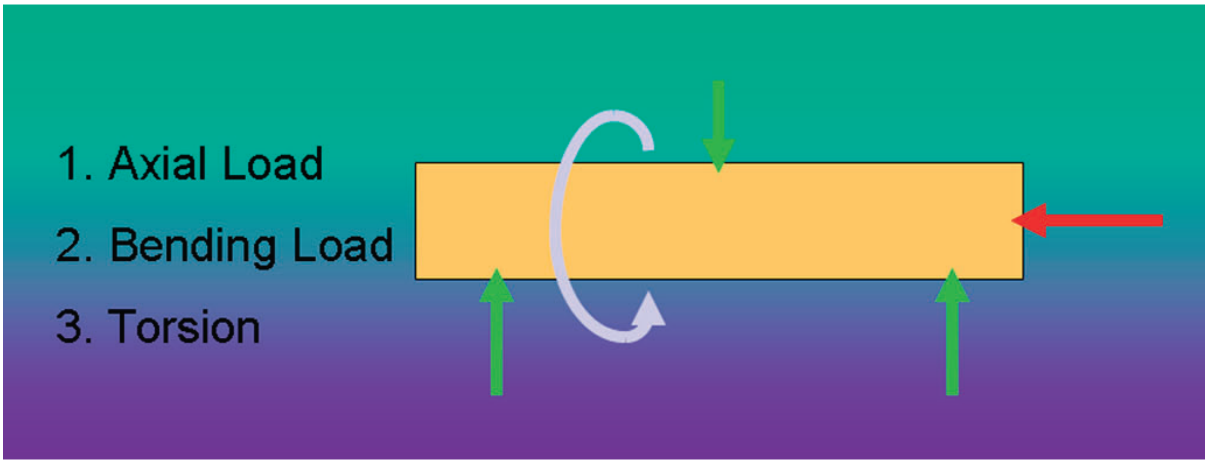
Indications for Locked (Fixed-Angle) Plates [24,51,52]

These plates were introduced in the late nineteenth century and were popularization by Danis and the Arbeitsgemeinschaft fur Osteosynthesefragen (AO) group in the 1960s.

The plate-screw-bone construct probably resists the physiological loads to permit fracture reunion by limiting fracture gap stress and provide adequate stability to permit early limb motion Failure is less in these instances. For optimal clinical results, disruption of the bone blood supply by the plate-screw-bone construct should be minimized by minimal operative dissection and periosteal contact to promote bone union [24].

Ideally, the plate-screw-bone construct will permit the restoration of the mechanical limb alignment and re-establish joint congruity to within <2 mm[51]. For successful alignment, plate fixation must deliver productive results, must be simple to perform, and must have broad clinical applicability. Fixation with conventional compression plates has its own limitations.

To achieve fracture stability, the axial, torsional, and three-point bending forces must be neutralized[24].



With the use of conventional non-locking plates, force friction between the plate and the bone counters the external forces experienced by the plate-screw- bone construct [24]. Therefore, the ability of conventional plates to achieve stability is limited by screw torque.

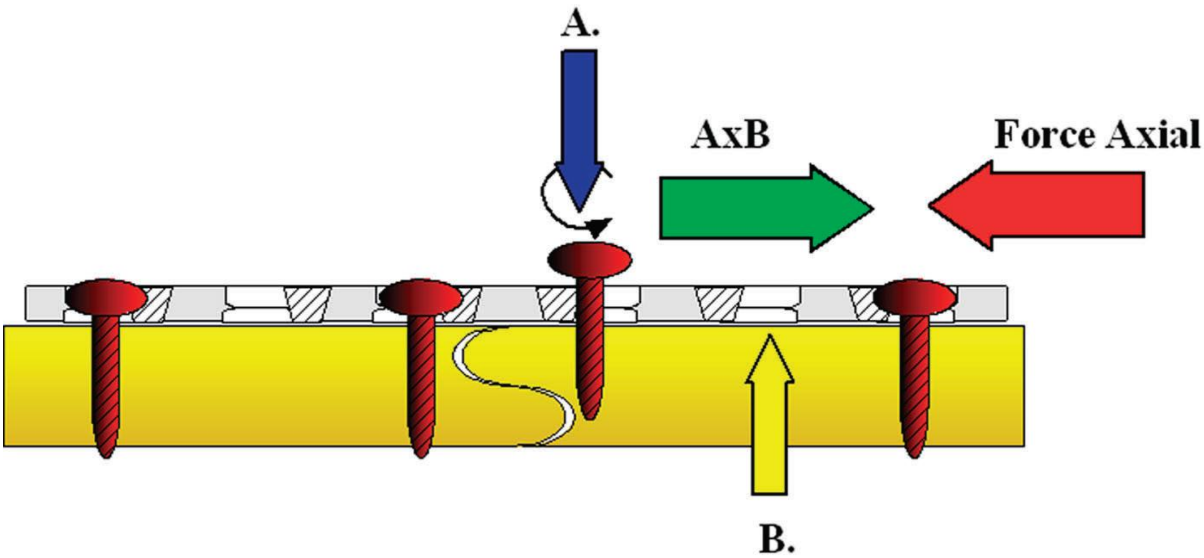


Fig. 2.Axial force is countered during compression plate fixation by the product of A (the normal force provided by screw torque) and B (the coefficient of friction between the plate and bone)[24].

Numerous attempts to improve fixation of conventional plates to compromised bone have been tried. This has included the use of cement to improve screw torque. When locked plates are used in a bridging mode, they should be pre dynamized by allowing at least two empty screw holes over the fracture gap. This increases the working length of the plate and decreases internal stress in the plate[24].

Locked plates have become an attractive alternative to conventional plates as they can be used as "bridge plates" to preserve fragmentary blood supply, they provide fixed angular stability with the potential for improved fixation in osteoporotic bone, and they reduce the risk of primary loss of reduction as exact plate-contouring is not required[24].

The present indications for the use of locked plate were described on the basis of biomechanical and limited clinical data by Gautier and Sommer[52]. These include

- Diaphyseal fractures
- Metaphyseal fractures
- Multifragmentary diaphyseal fractures
- Multifragmentary metaphyseal fractures
- Osteotomies
- Articular fractures Anatomical reduction
- Segmental with two different fracture patterns Compression/bridging
- Articular fractures with multifragmentary
- metaphyseal or diaphyseal fractures

Johnson EE [52], conducted a study on combined direct and indirect reduction of communites intra articular fractures of distal femur. The combination of direct reduction of condylar anatomy and indirect reduction of metaphyseal fragments was done using femoral distractor and fixation with 95^0 blade plate. Functional results were rated as good to excellent in all patients.

Mela G *et al.*[53], reported results of surgical treatment of supra and inter condylar fractures of the femur and comparison of efficiency of various methods used. They concluded that anatomical restoration of the joint line and firm stabilisation of the supra condylar fragments in correct alignment with the metaphysis were the important goals of the surgery to achieve satisfactory outcome.

A study comparing the in vitro stiffness of Straight-DCP, Wave-DCP, and LCP Bone Plates for Femoral osteosynthesis concluded that the more modern LCP should be chosen if there is no cost restriction, as it minimizes the injury to the tissue. LCP design minimizes contact with the bone, which reduces the damage to the periosteum and the resulting bone necrosis as well[54].

For osteosynthesis of osteoporotic bone, when it is not possible to apply the required 5N·mm torque, LCP with locking screws is the most appropriate choice [(55,56)] .

A locking compression plate (LCP) offers angular stability and better fixation of osteoporotic bone and fixation of periprosthetic femoral fractures with LCP-DF provides satisfactory results[57].

Among the patients subjected to LCP method, majority of them show good movements and resumed to their normal activities soon, when compared with the patients under other surgical options. Over all, the outcome measures in LCP group are comparatively better and have a major impact on the recovery of the patients with distal femur fractures. LCP provides a rigid fixation, early mobilization and no post-operative immobilization. The rate of union is high with low incidence of complications. Hence, locking compression plate method is better than the fixed-angle blade plate and the supracondylar nailing system[58].

ANATOMY [59, 60, 61,62]

FEMUR:

The (fe'mur; “thighbone”) is the longest, heaviest, strongest bone in the body. The striding gait, its strength with weight and muscular forces are all related to its length.

Like any other long bone it has two ends (upper and lower) and a shaft. Its shaft is cylindrical in most of its length and bowed forward. It has a proximal round, articular head projecting medially on its short neck[59].

The distal extremity is more massive and is a double 'knuckle' (condyle) that articulates with the tibia. In standing, the femoral shafts are oblique and their heads are separated by the pelvic width. The shafts converge downwards and medially to the knees. Femoral obliquity varies but is greater in women. This is due to the relatively greater pelvic breadth and shorter femora. Proximally the femur consists of a head, neck, and greater and lesser trochanters[59].

The linea aspera is a roughened vertical ridge on the posterior surface of the body of the femur. The distal end of the femur is expanded for articulation with the tibia.

Side determination[60]

- The upper end bears a rounded head, whereas the lower end is widely expanded to form two large condyles.
- The head is directed medially.
- The cylindrical shaft is convex forwards.

Anatomical position[60]

The head is directed medially, upwards and slightly forwards.

The shaft is directed obliquely downwards and medially, so that the lower surfaces of the two condyles lie in the same horizontal plane.

The upper end of femur consists of the head, the greater trochanter, the lesser trochanter, the intertrochanteric line and the intertrochanteric crest.

Shaft of femur

It is narrowest centrally and its long axis makes an angle of 10° with the vertical, and diverge 5-7° from the long axis of the tibia. Its middle third has three surfaces and borders. Nutrient foramina, directed proximally, appear in the linea aspera, one near its proximal end, a second usually near its distal end[59].

The shaft is surrounded by muscles and is impalpable. The distal anterior surface, for 5-6 cm above the patellar articular surface, is covered by a supra patellar bursa, between bone and muscle. The distal lateral surface is covered by vastus intermedius. The medial surface, devoid of attachments, is covered by vastus medialis[59].

The middle third of shaft has three surfaces and borders. The **anterior surface** is smooth and convex, between lateral and medial borders. The **lateral surface** is directed postero laterally and is between the lateral and posterior border. The **medial surface** is directed posteromedially and lies between the medial border and linea aspera.

In the lower third the shaft also has a fourth **posterior surface**. This is placed between the medial and lateral supracondylar ridges, which are continuous above with the corresponding edges of the linea aspera.

Distal end

It is widely expanded as a bearing surface for transmission of weight to the tibia. It has two massive condyles. Anteriorly the condyles unite and continue into the shaft and posteriorly they are separated by a deep intercondylar fossa.

The articular surface is a broad area, like an inverted U, for the patella and the tibia. The patellar surface extends anteriorly on both condyles. It is transversely concave, vertically convex and grooved for the posterior patellar surface. The tibial surface is divided by the intercondylar fossa. It is transversely convex in all directions. Patellar surface (trochlear groove) extends more proximally on the lateral side. It is separated from the tibial surfaces by two faint lateral and medial grooves.

Intercondylar fossa

The intercondylar fossa separates the two condyles distally and behind. In front it is limited by the distal border of the patellar surface, and behind by an intercondylar line, separating it from the popliteal surface. It is intracapsular and extrasynovial.

The capsular ligament and, laterally, the oblique popliteal ligament, are attached to the intercondylar line. The ligamentum mucosum (infrapatellar synovial fold or plica) is attached to the anterior border of the fossa.

Lateral condyle

Is laterally flat and is less prominent than the medial condyle. It is more massive and situated more directly in line with the femoral shaft and hence transmits more weight to the tibia. Its most prominent point is the lateral epicondyle to which the lateral collateral ligament is attached. A short groove separates the lateral epicondyle inferiorly from the articular margin and allows the tendon of popliteus to run deep to the lateral collateral ligament. The tendon of popliteus lies in the groove in full flexion; in extension it crosses the articular margin..

Medial condyle

It has a bulging convex medial aspect, which is easily palpable. Proximally its adductor tubercle, receives the tendon of adductor magnus. Medial epicondyle is antero-inferior to the tubercle. The lateral surface of the condyle is the medial wall of the intercondylar fossa

Lateral Supracondylar line

Is most distinct in its proximal two thirds, where the short head of biceps femoris and lateral intramuscular septum are attached. Its distal third gives origin to plantari**s.**

The medial supracondylar line:

The attachment of vastus medialis occurs in its proximal two thirds. Proximally it is crossed by femoral vessels entering the popliteal fossa from the adductor canal. It is sharp for 3 or 4 cms proximal to adductor tubercle and here the lower membranous expansion from the tendon of adductor magnus is attached.

OSSIFICATION

The femur ossifies from one primary and four secondary centres. The primary centre for the shaft appears in seventh week of intra uterine life. The secondary centres appear at ninth month of intrauterine life for lower end, sixth month of life for head, fourth year for greater trochanter and twelfth year for lesser trochanter. The upper epiphysis, lesser trochanter, greater trochanter and head in that order fuse with the shaft at about eighteen years. The lower epiphysis fuses by the twentieth year.

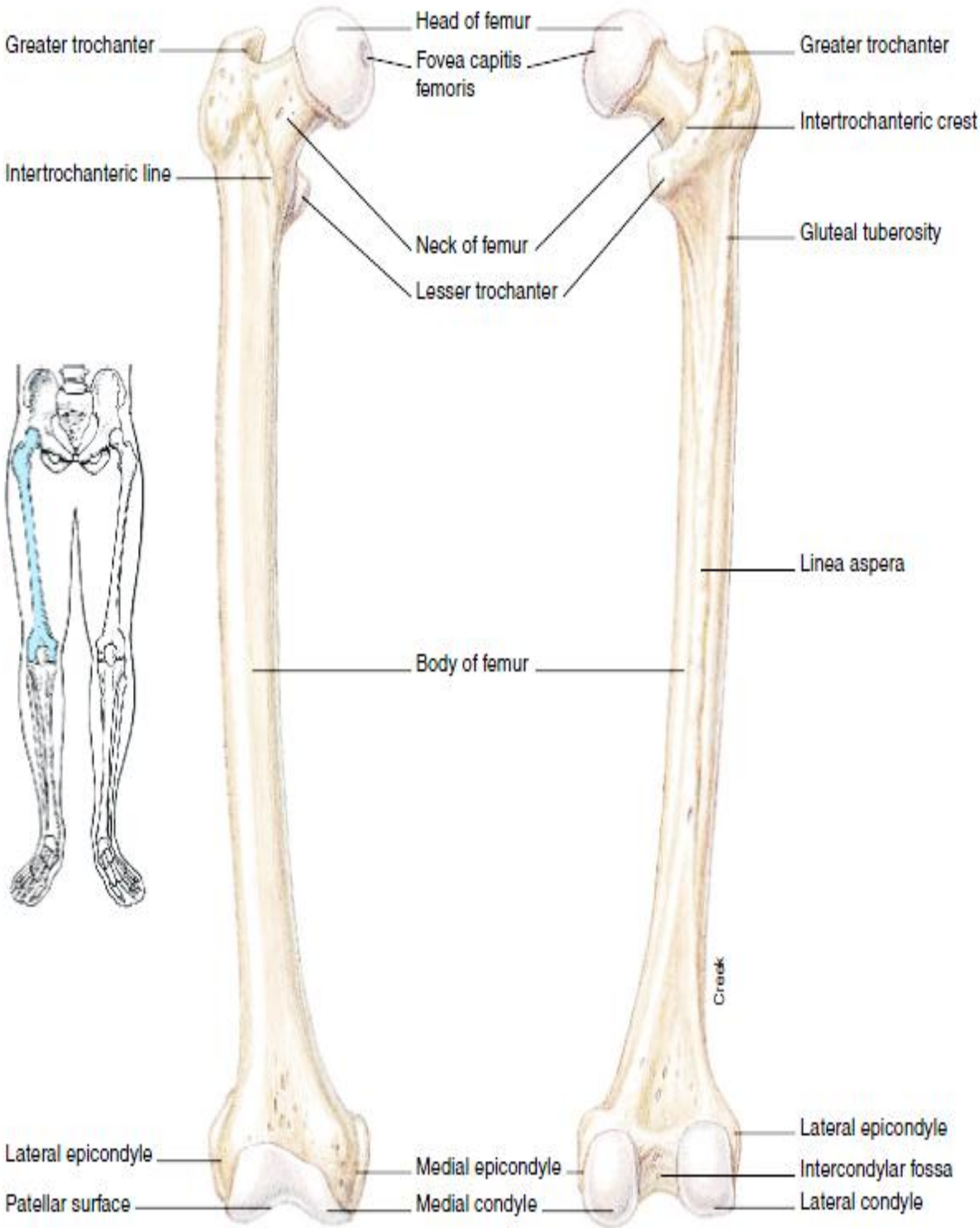


Fig.3. Femur - anterior and posterior surfaces[61]

1. Medial oblique groove. **2.** Semilunar area. **3.** Medial condyle. **4.** Patellar surface.
5. Lateral oblique groove. **6.** Intercondylar notch. **7.** Lateral epicondyle. **8.** Lateral condyle.

Fig. 4. Distal end of left femur: Articular Surface[59]

1. Attachment of plantaris. **2.** Attachment of lateral head of gastrocnemius.
3. Lateral epicondyle. **4.** Attachment of lateral collateral ligament.
5. Groove for popliteus in full flexion. **6.** Attachment of popliteus.

Fig5. Distal end of left femur: lateral aspect[59].

BLOOD SUPPLY OF FEMUR:

The main blood supply of femur is derived from the **nutrient artery**. The nutrient artery usually arises from the second perforating artery. The shaft of femur receives supply from small periosteal vessels. In case it is absent, it is replaced by two nutrient arteries derived from the first and the third perforating arteries.

Nutrient artery usually enters the bone proximally and posteriorly along the linea aspera and travels proximally and distally to provide the endosteal circulation to the shaft. Periosteal vessels enter the bone along the linea aspera and align themselves to the cortical surface. As for this perpendicular orientation, they are hardly ever extensively stripped during fractures.

The endosteal vessels are thought to provide circulation to the inner two thirds to three quarters of the cortex of femur. These anastomose with the scattered blood vessels of periosteal circulation.

Since the nutrient artery and periosteal vessels enter the bone close to linea aspera, stripping of muscular attachments from the linea aspera during surgery may hinder the blood supply of the femur and may lead to impaired osteogenesis[59].

KNEE JOINT[59,60,62]

The knee joint is located between the femur and tibia and is the largest, most complex, and probably the most vulnerable joint in the body. It is a complex hinge joint that is a result of the fusion of three joints in one. It permits limited rolling and gliding movements in addition to flexion and extension. It is formed by the fusion of the lateral femorotibial, medial femorotibial and femoropatellar joints[59,60].

It is a compound synovial joint, incorporating two condylar joints between the condyles of femur and tibia, and one saddle joint between the femur and the tibia[60].

On the anterior side, the knee joint is stabilized and protected by the patella and the patellar ligament, forming a gliding patella-femoral joint[62].

The level of the joint is at the (palpable) proximal margins of the tibial condyles. The articular surfaces of femoral condyles are convex, with a curvature increasing posteriorly. The tibial articular surface is separated by inter-condylar region[59].

Articular surfaces[60]

- Condyles of the femur
- Condyles of the tibia
- Patella

Ligaments[60]

- Fibrous capsule (Articular Capsule) - Coronary ligament and Short lateral ligament
- Ligamentum Patellae
- Tibial Collateral (Medial) ligament
- Fibullar Collateral ligament
- Oblique Popliteal ligament

- Arcuate Popliteal ligament
- Cruciate ligaments
- Menisci (semilunar cartilages) – medial and lateral
- Transverse ligament
- Synovial membrane

In addition to the patella and the patellar ligament on the anterior surface, the tendinous insertion of the quadriceps femoris muscle forms two supportive bands called the **lateral and medial patellar retinacula**.

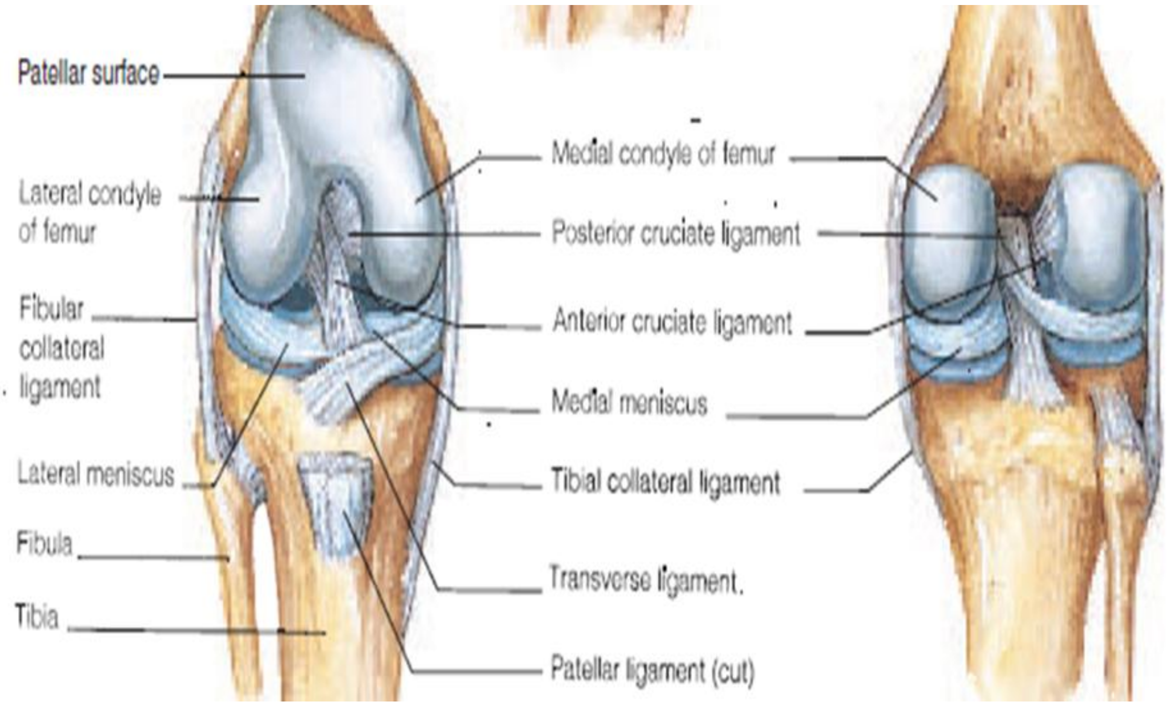


Fig6. Anterior and Posterior view of the knee joint [62]

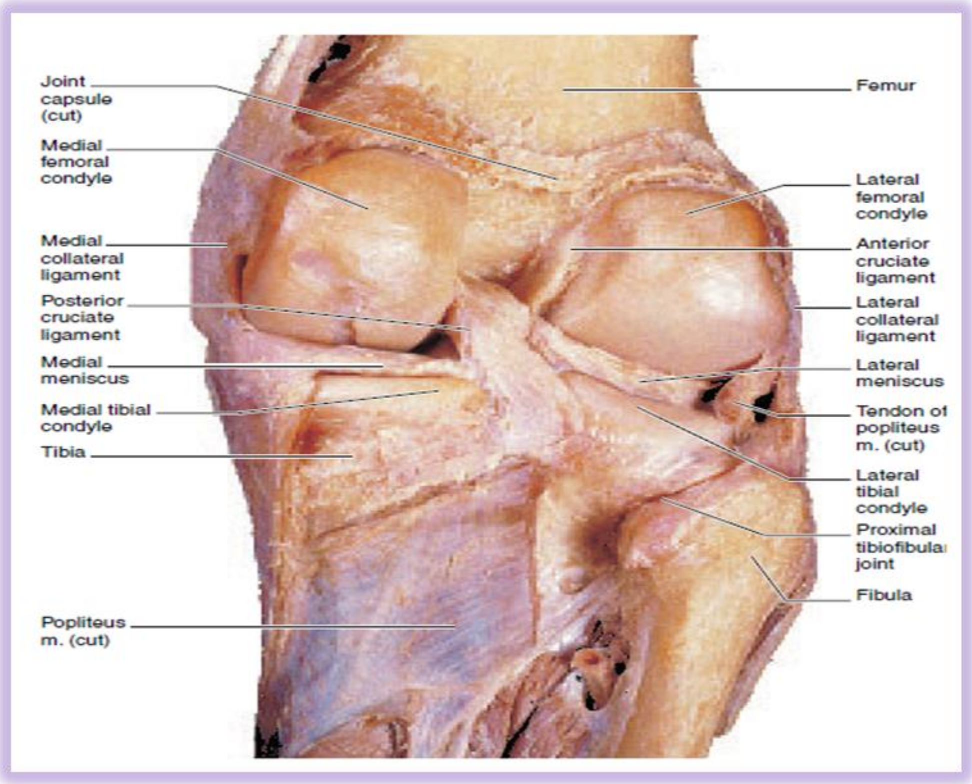
The femoro-tibial congruence is enhanced by the menisci. The articular surface of patella is adjusted to the femoral surface, which extend onto the anterior surfaces of both condyles. An oblique groove, descending a little laterally, divides the femoral patellar surface into a large lateral and smaller medial area.

Fibrous capsule:

Anteriorly, the capsule is deficient and is replaced by quadriceps femoris, the patella and the ligamentum patellae. Posteriorly, it is attached proximally to the posterior margins of the femoral condyles and the inter-condylar fossa and distally to the posterior margins of tibial condyles and intercondylar area. It is strengthened by oblique popliteal ligament. Medially it is attached to tibial and femoral condyles just beyond their articular margins where it blends with tibial collateral ligament[59].

Laterally it is attached to femur just above popliteus. It blends with the extensor expansion and is attached to the patellar margins and patellar ligament, extending back to the corresponding collateral ligaments and distally to the tibial condyles. They form the medial and lateral patellar retinacula, the lateral being augmented by the iliotibial tract[59].

The capsular ligament is weak and is strengthened anteriorly by the medial and lateral patellar retinacula, laterally by the ilio-tibial tract, medially by the expansions from the tendons of Sartorius and Semimembranosus and posteriorly by the oblique popliteal ligament. The capsule has two openings one leading to the suprapatellar bursa and another for the exit of popliteus tendon[60].



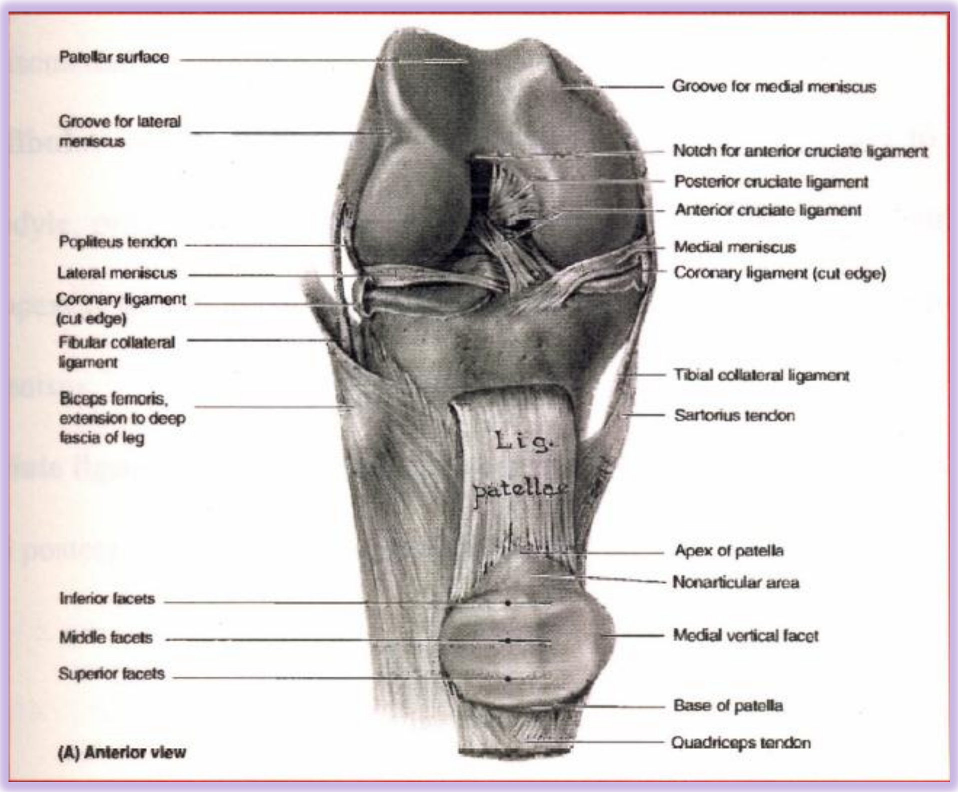


Fig. 7. A) Posterior view of the knee B) Right knee in flexion: Anterior view - cruciate & collateral ligaments[62]

Synovial membrane

It is more extensive and intricate and lines the capsule except posteriorly where it is reflected forwards by the cruciate ligaments. At the proximal patellar border, it forms supra-patellar bursa between the quadriceps femoris and the femur. It is an extension of joint cavity. Distal to patella, the infra-patellar pad of fat separates the synovial membrane from the patellar ligament. At the sides of the joint, the synovial membrane lines the capsule as far as the menisci, whose surfaces having no synovial covering. The synovial membrane almost covers the cruciate ligaments[59,60].

Relations of knee joint[59,60]

Anteriorly:

- Anterior bursae
- Ligamentum patellae
- Patellar plexus of nerves

Posteriorly:

At the centre:

- Popliteal vessels
- Tibial nerve
- Middle genicular vessels and nerves

Posteromedially:

- Medial head of gastrocnemius
- Semitendinosus
- Semimembranosus

- Gracilis
- Popliteus

Posterolaterally:

- Lateral head of gastrocnemius
- Plantaris
- Common peroneal nerve

Medially:

- Sartorius, Gracilis and Semitendinosus
- Great saphenous nerve and vessels
- Semimembranosus
- Inferior medial genicular vessels and nerve

Laterally:

- Biceps Femoris
- Tendon of popliteus
- Inferior lateral genicular vessels and nerve

The posterior relations are more abundant. The popliteal artery with its attached lymph nodes lies on the oblique popliteal ligament. The popliteal vein lies postero-medial or medial to the artery and the tibial nerve is posterior to both vessels. The nerve and blood vessels are overlapped by the adjoining edges of the two heads of gastrocnemius and on the lateral side by plantaris[59].

On each side of the vessels the corresponding head of gastrocnemius comes to intimate relation with the capsule and on the medial side, medial side of semimembranosus intervenes between the capsule and semitendinosus[59].

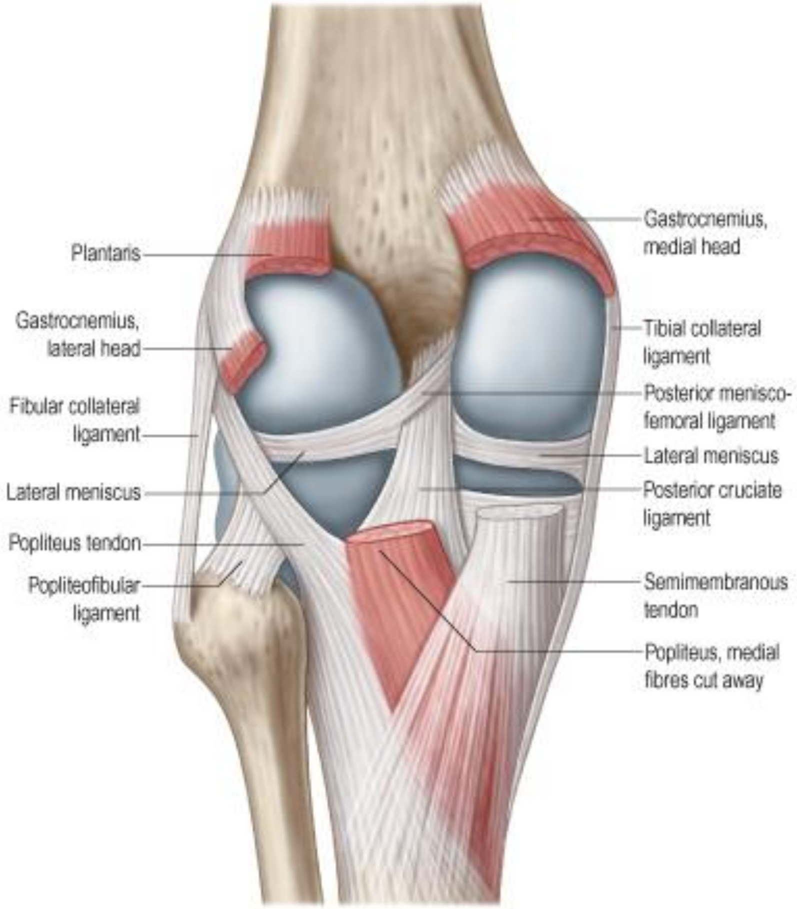


Fig.8. Posterior dissection of the left knee[62]

Blood supply of the knee joint[59,60]:

The arteries supplying the knee joint are the descending genicular branches of the femoral, superior, middle and inferior genicular branches of the popliteal, anterior and posterior recurrent branches of the anterior tibial, the circumflex fibular artery and the descending branch of the lateral circumflex femoral artery.

Nerve supply to the joint:

Nerves are from the obturator, femoral, tibial and common peroneal nerves.

Movements of knee joint[59,60]

The active movements at the knee joint are **flexion**, **extension**, **medial** and **lateral rotation**. The range of extension is about *5* to 10 degrees beyond a vertical femero-tibial axis.

With hip extended, flexion at the knee joint is about 120 degree. When the hip is flexed, it is 140 degree flexion at the knee joint and 160 degree when a passive element such as sitting on heels. Passive rotation is about 60 degrees but conjunct rotation occurs only about 20 degree[59].

Muscles producing movement at the knee joint[59,60]

- **Flexion***:* Biceps femoris, Semitendinosus, Semimembranosus. It is assisted by Gracilis, Sartorius and Popliteus and Gastronemius.
- **Extension***:* Quadriceps femoris. It is assisted by Tensor fascia lata.
- **Medial rotation of flexed leg*:*** Popliteus, semiembranosus and semitendinosus. It is assisted by Sartorius and Gracillis.
- **Lateral rotation of flexed leg*:*** Popliteus and biceps femoris.

ANATOMY OF THIGH[60,62]

The superficial fascia of the thigh has two layers. The **superficial** layer has loose areolar tissue which contains variable amount of fat. It is continuous with abdominal superficial layer. The **deep** layer is thin and fibroelastic.

The fascia lata is the deep fascia of the thigh. It is thick proximally and laterally, thin posteriorly and over the adductor muscles. It is thicker around the knee.

Attachments of fascia lata:

Superiorly - anteriorly to the inguinal ligament and superior ramus of pubis, posteriorly to the back of the sacrum and coccyx, laterally to the iliac crest and medially to the inferior ramus of pubis, the ramus and tuberosity of ischium and the lower border of sacro-tuberous ligament.

Inferiorly – anteriorly and on the sides of the knee, it is attached to subcutaneous bony prominences and capsule of knee joint. Posteriorly it forms the strong popliteal fascia which is continuous below with the fascia of back of the leg[60,62.]

The fascia lata is thickened to form a strong band, the ilio tibial tract over the lateral surface of thigh. The upper end of the ilio tibial tract splits into two layers, where it encloses and anchors tensor fascia lata and receives the tendon of gluteus maximus at the back. Distally, the ilio-tibial tract is attached to anterolateral facet on the lateral condyle of tibia.

The major function of ilio-tibial tract is stabilization of the knee both in extension and in partial flexion. The fascia lata is continuous with both medial and lateral intermuscular septa[62].

Compartments of the thigh:

The thigh is divided into three compartments by three intermuscular septae. These are -

Lateral intermuscular septum – It separates the anterior from the posterior compartments of the thigh. It is the thickest and extends from fascia lata to lateral lip of linea aspera, above with the attachment of gluteus maximus and below to the lateral supacondylar line.

The **medial intermuscular septum -** It is attached to medial lip of linea aspera and separates the anterior from the medial compartment of the thigh.

The **posterior intermuscular septum** – It is poorly defined. It separates the medial from the posterior compartment of the thigh.

<u>Muscles of the Thigh:</u> These are divided into three groups.

Anterior group: This includes

- Tensor fascia lata,
- Sartorius,
- Quadriceps femoris (rectus femoris and three vasti) and the
- Articularis genu.

Medial group: This includes:

- Gracillis,
- Pectineus,
- Adductor longus, adductor brevis and the adductor magnus.

Posterior group: This includes:

- Biceps femoris, Semitendinosus and Semimembranosus.

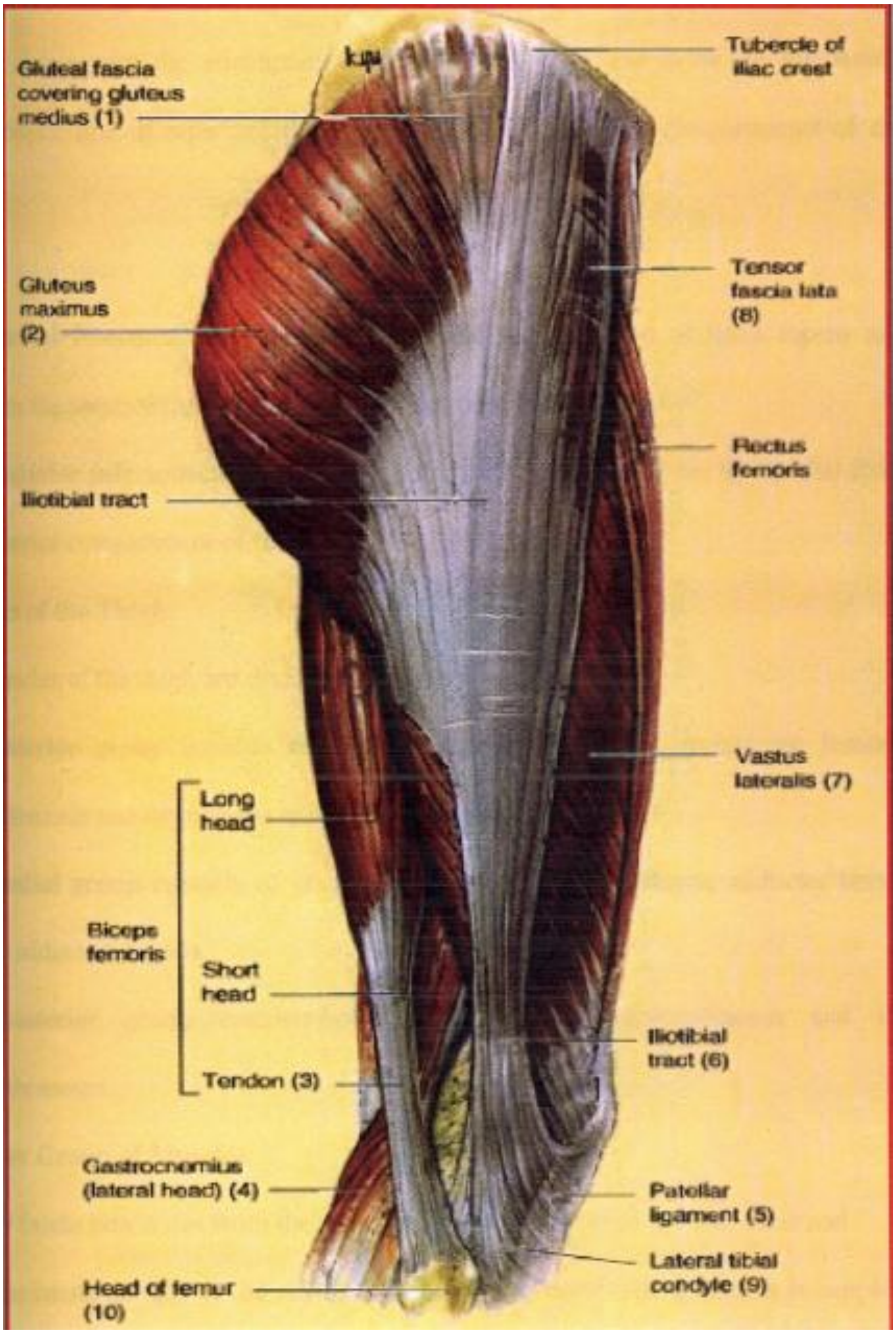


Fig.9. Lateral View of Thigh

Anterior Group of Muscles:

Anterior 5 cm of outer lip of the iliac crest gives rise to the tensor fascia lata. It also arises from the lateral surface of the anterior superior iliac spine. It is inserted to the iliotibial tract. It is supplied by superior gluteal nerve.

Actions: through iliotibial tract it extends the knee with lateral rotation of leg. It also assists in abduction and medial rotation of thigh.

Sartorius is a narrow strap muscle. It is longest muscle in the body. It arises from the anterior superior iliac spine and the upper half of the notch below it. It crosses the thigh obliquely over to the medial side, and then descends more vertically to the medial side of the knee. It is inserted to the proximal medial surface of the tibia, anterior to Gracillis and Semitendinosus. Femoral nerve supplies the muscle (L2 and 3).

Actions: Sartorius assists in flexion of knee and flexion of thigh. It also helps to abduct the thigh and in lateral rotation.

Quadriceps Femoris:

It is the great extensor muscle of the leg. It covers the femur anteriorly and on the sides. It consists of four parts. **Rectus femoris** arises from the ilium downwards. The other three arise from the shaft of the femur and surround it. **Vastus lateralis** lies laterally to the femur, **Vastus medialis** medial to it and **Vastus intermedius** anterior to it.

The **Rectus femoris** originates from two heads, the **straight head** arises from anterior inferior iliac spine and the **reflected head** from a groove above the acetabulum and from the capsule of hip joint. The two heads unite and spread into an aponeurosis. Muscular fibers arise from the aponeurosis. The fibres terminate in a thick aponeurosis that tapers into thick, flat tendon which is attached to base of patella.

The **vastus lateralis** is the largest component of quadriceps femoris. It originates from a broad aponeurosis from the upper part of intertrochanteric line, the anterior and inferior borders of greater trochanter, lateral lip of gluteal tuberosity, and proximal half of lateral lip of linea aspera. The muscular mass is attached to a strong aponeurosis that narrows to a flat tendon which is attached to the base and lateral border of the patella. This blends into the compound quadriceps femoris tendon and also contributes to the capsule of the knee joint. It further runs down to the lateral condyle of the tibia.

The **vastus medialis** originates from the lower part of the intertrochanteric line, spiral, medial lip of linea aspera, proximal part of medial supracondylar line and medial intermuscular septum. It is attached to the medial border of patella and quadriceps tendon. An expansion from this reinforces the capsule of the knee joint and is attached below to the medial condyle of tibia.

The **vastus intermedius** arises from the anterior and lateral surface of the upper two thirds of the femoral shaft, and from the lower part of lateral intermuscular septum. Its fibres end in an aponeurosis on the anterior surface of the muscle. This aponeurosis forms the deep part of quadriceps femoris tendon. In addition it is attached to the lateral border of patella and lateral condyle of the tibia.

The articularis genu is a small muscle. It arises from the anterior surface of the lower part of the femoral shaft and is attached to proximal reflexion of the synovial membrane.

Actions:

- **Quadriceps femoris**: extention of the knee.
- **Rectus femoris**: flexion of the hip. Rectus can flex the hip and extend the knee simultaneously.
- **Vastus medialis**: Its lower fibers during the terminal phase of extension of the knee joint help to retain patella in its groove on the patellar surface of the femur by counteracting the natural tendency of lateral displacement of the patella.

The Posterior Group of Muscles:

1) **Biceps femoris**: This occupies the posterolateral position in the thigh. It has two attachments, the long head and the short head. The long head originates from the inferomedial impression on the ischial tuberosity along with semitendinosus and from lower part of sacrotuberous ligament. The short head arise from the lateral lip of linea aspera, between adductor magnus and vastus lateralis, the attachment extending proximally up to gluteus maximus and distally along upper part of the lateral supracondylar line, and from the lateral intramuscular septum. Both heads combine to form a fleshy belly which terminates in a rounded tendon. This splits around fibular collateral ligament and is attached to the head of the fibula. Part of the muscle splits into three slips. One is attached to the fibular collateral ligament, and the other two to the lateral condyle of tibia.

   The innervation is by the sciatic nerve (L5, S 1 and 2). The long head is supplied by the tibial division and the short head by the common peroneal division.

2) **Semitendinosus**: It arises from an inferomedial impression on the upper area of the ischial tuberosity by a tendon shared with the long head of biceps femoris. The tendon

curves around the medial condyle of the tibia and passes over the tibial collateral ligament of knee and inserts into upper part of the medial surface of tibia, behind the attachment of sartorius and distal to that of gracilis.

It is innervated by the tibial division of sciatic nerve (L5, S1 and 2).

3) **Semimembranosus:** It is situated in the posteromedial aspect of the thigh. It arises from a supero-lateral impression on the ischial tuberosity. It is inserted into the groove on the posterior surface of medial condyle of tibia. It is supplied by tibial division of sciatic nerve (L5, S I and 2).

4) **Gastrocnemius:** It arises from two heads. **Medial head** arises from a depression at the upper and posterior part of the medial condyle behind the adductor tubercle and from a small area on the popliteal surface of the femur just above the medial condyle.

   The **lateral head** arises from lateral surface of the lateral condyle and from the supracondylar line. The two origins form a discrete aponeurosis. This aponeurosis narrows down to a tendon of insertion which unites with that of soleus to form the tendocalcaneus.

5) P**lantaris:** It is thin and long tendon that arises from lower part of the lateral supracondylar line of the femur and oblique popliteal ligament. It lies between gastrocnemius and the soleus, crossing from lateral to medial side. The insertion is to the posterior surface of calcaneum, medial to tendocalcaneus. It is a rudimentary muscle and its functional importance is negligible in humans.

THE VESSELS OF THE THIGH

The main artery of the lower limb is external iliac artery which courses from the inguinal ligament to the lower border of popliteal fossa. Here it divides into the anterior and posterior tibial artery. Proximally it forms the femoral artery and distally it is the popliteal artery.

The Femoral Artery:

It begins posterior to the inguinal ligament, midway between the anterior superior iliac spine and symphysis pubis and passes downwards in the front and medial side of the thigh. It terminates at the junction of the middle and lower thirds of the thigh where it passes through an opening in the adductor magnus to become the popliteal artery. Above, the femoral artery is in the femoral triangle and below in the adductor (Hunter's) canal.

The femoral artery branches are - superficial epigastric, superficial circumflex iliac, superficial external pudendal, deep external pudendal, muscular branches and the arteria profunda femoris.

The anterior profunda femoris:

This is a large branch which arising from the lateral side of femoral artery. It runs downwards between pectineus and adductor longus and then between the latter and adductor brevis. It continues to descend between adductor longus and magnus and passes through an opening in the adductor magnus insertion ending as the fourth perforating artery. It gives medial and lateral circumflex femoral artery branches, various muscular branches and three perforating arteries. The medial and lateral circumflex femoral arteries supply the muscles at the upper end of thigh and the hip joints.

Perforating arteries: These are three in number. They perforate the insertion of the adductor magnus to reach the posterior aspect of the thigh. They pass close to linea aspera and give numerous branches. They pass deep to short head of biceps femoris and pierce the lateral intermuscular septum and enter the vastus lateralis. The first perforating artery is given above the adductor brevis, the second in anterior to it and the third immediately below it. The perforating arteries with descending branch of the inferior gluteal artery and the termination of profunda femoris artery form a longitudinal chain of vessels·posteriorly along the linea aspera and freely anastomose.

The nutrient artery of femur when single arises from the second perforating artery. Occasionally when present double, they arise from the first and the third perforating artery.

The popliteal artery extends from the junction of the middle and lower thirds of the lower border of the popliteus. It starts from the lower most opening in the insertion of the adductor magnus, where the vessel passes through the fibro osseous opening and is least mobile and liable to compression caused by fractures.

THE NERVES OF THE THIGH

The main nerves of the thigh are the femoral nerve, obturator nerve and the sciatic nerve.

The femoral nerve which supplies the extensors of the knee joint enters the thigh below the inguinal ligament, it lies lateral to femoral artery and terminates one inch in the femoral triangle by dividing into the various muscular branches.

The obturator nerve which supplies the muscles of the medial aspect of thigh leaves the pelvis from the .obturator foramen. Near the foramen it divides into the anterior and posterior branch. The anterior division is in between the adductor longus and brevis and supply the gracilis, adductor longus and brevis and hip joint. The posterior division descends between the adductor brevis and the magnus, it supplies both the muscles and also sends a branch to the knee joint.

The sciatic nerve is the largest nerve in the body. It leaves the pelvis through the muscles and the greater sciatic foramen and then passing posterior to hip joint and deep to gluteus maximus. It enters the thigh, between the greater trochanter and ischial tuberosity. At the lower third of the thigh, it divides into the tibial and the common peroneal component. In the gluteal region, it is deep to the gluteus maximus being separated from the hip joint by the quadratus femoris. Lower down it lies on the adductor magnus muscle being crossed obliquely by the long head of the biceps muscle.

The sciatic nerve in the thigh is represented by a line connecting the midpoint between greater trochanter and ischial tuberosity to the apex of the popliteal fossa. It supplies the biceps femoris, semimembranosus, semitendinosus and the adductor magnus. It also sends an articular branch to knee joint.

Cutaneous nerves of the thigh are lateral cutaneous nerve, intermediate cutaneous nerve; medial cutaneous nerve and posterior cutaneous nerve plus a branch from obturator nerve.

MECHANISM OF INJURY[6]

The mechanism of injury in most distal fractures is axial loading with varus, valgus or rotational force. The injury typically occurs after high-energy trauma in younger patients. In elderly patients, these often result after a trivial trauma, a minor slip or a fall on flexed knee. These are frequently comminuted fractures through a compromised osteoporotic bone.

The initial fracture displacement and secondary pull of the muscles leads to deformity. Spasm of quadriceps and hamstrings generally leads to limb shortening, the strong pull of the adductors causes varus deformity, and the gastrocnemius muscle often produces posterior angulation of distal fragment.

FRACTURE HEALING WITH RIGID FIXATION[17]

Primary bone repair occurs where the fracture ends have been rigidly immobilized by a plate. Lane (1914) and Danis (1949) described the concept of primary bone healing and defined fractures that healed without radiographically visible callus formation. The structure of the newly formed bone depends on the width of the gap. When the gap is less, the gap is filled by lamellar bone. When the gap exceeds 1mm it is not bridged in a single jump by woven bone and complete filling in is significantly delayed. The bone filling inter fragmentary gap appears de-novo without intermediate formation of connective tissue or fibrocartilage. It is this absence of an intermediate tissue which distinguishes primary bone repair from that seen under other circumstances[17].

When the inter fragmentary gap is small, the lamellae are aligned at right angles to the gap and because woven bone is being laid de novo, the rate of filling the gap is considerably faster. This type of gap healing is completely intolerant of any movement and will only fill very small gaps (< 1mm).Once the inter fragmentary gap has been filled in by lamellar bone, normal remodelling occurs[17].

CLASSIFICATION OF DISTAL FEMUR FRACTURES

Distal femur includes the supracondylar area involving the distal 9cm of the femur, as measured from the articular surface. It is defined as the zone between the femoral condyles and the junction of the metaphysis with the femoral shaft.

Fractures of distal femur may be classified as:

1. Fractures of the distal part of the femoral shaft.
2. Supracondylar fractures.
3. Unicondylar fractures.
4. Supracondylar, intercondylar fractures.

Numerous classifications have been used to describe the fractures of the distal femur. Few of these are classification described by Neer and associates, Stewart and co-workers, Schatzker and Tile, Seinsheimer, and Muller and colleagues.

- **Müller et al. classification of distal femoral fractures**[64,65]

It 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

Type A fractures involve the distal shaft only with varying degrees of comminution.

Type B fractures are condylar fractures

Type C fractures are T-condylar and Y-condylar fractures

A = **Extra articular fracture**

A1- Extra articular fracture simple.

I. Apophyseal.

2.Metaphyseal oblique or spiral.

3.Metaphyseal transverse.

A2- Extra-articular fracture, metaphyseal wedge.

I. Intact.

2. Fragmented, lateral.

3. Fragmented, medial

A3- Extra articular fracture, metaphyseal complex.

I. With an intermediate split segment.

2. Irregular, limited to the metaphysis.

3. Irregular, extending in to the diaphysis.

B=Partial articular fracture:

Bl-Partial articular fracture, lateral condyle, sagittal.

I. Simple, through the notch.

2. Simple, through the load bearing surface.

3.Multifragmentary.

B2 - Partial articular fracture, medial condyle, sagittal.

I. Simple, through the notch

2. Simple, through the load bearing surface.

3. Multifragmentary.

B3 - Partial articular fracture, frontal.

I. Anterior and lateral flake fracture.

2.Unicondylar posterior (Hoffa).

3.Bicondylar posterior.

C = Complete articular fracture:

CI- Complete articular fracture, articular simple, metaphyseal simple.

I. T or Y shaped, with slight displacement.

2.T or Y shaped, with marked displacement.

3.T - Shaped epiphyseal.

C2-Complete articular fracture, articular simple, metaphyseal multifragmentary.

I. With an intact wedge.

2. With a fragmented wedge.

3. Complex.

C3-Complete articular fracture, multifragmentary.

I. Metaphyseal simple.

2. Metaphyseal multifragrnentary.

3. Metaphyseo-diaphyseal rnultifragmentary.

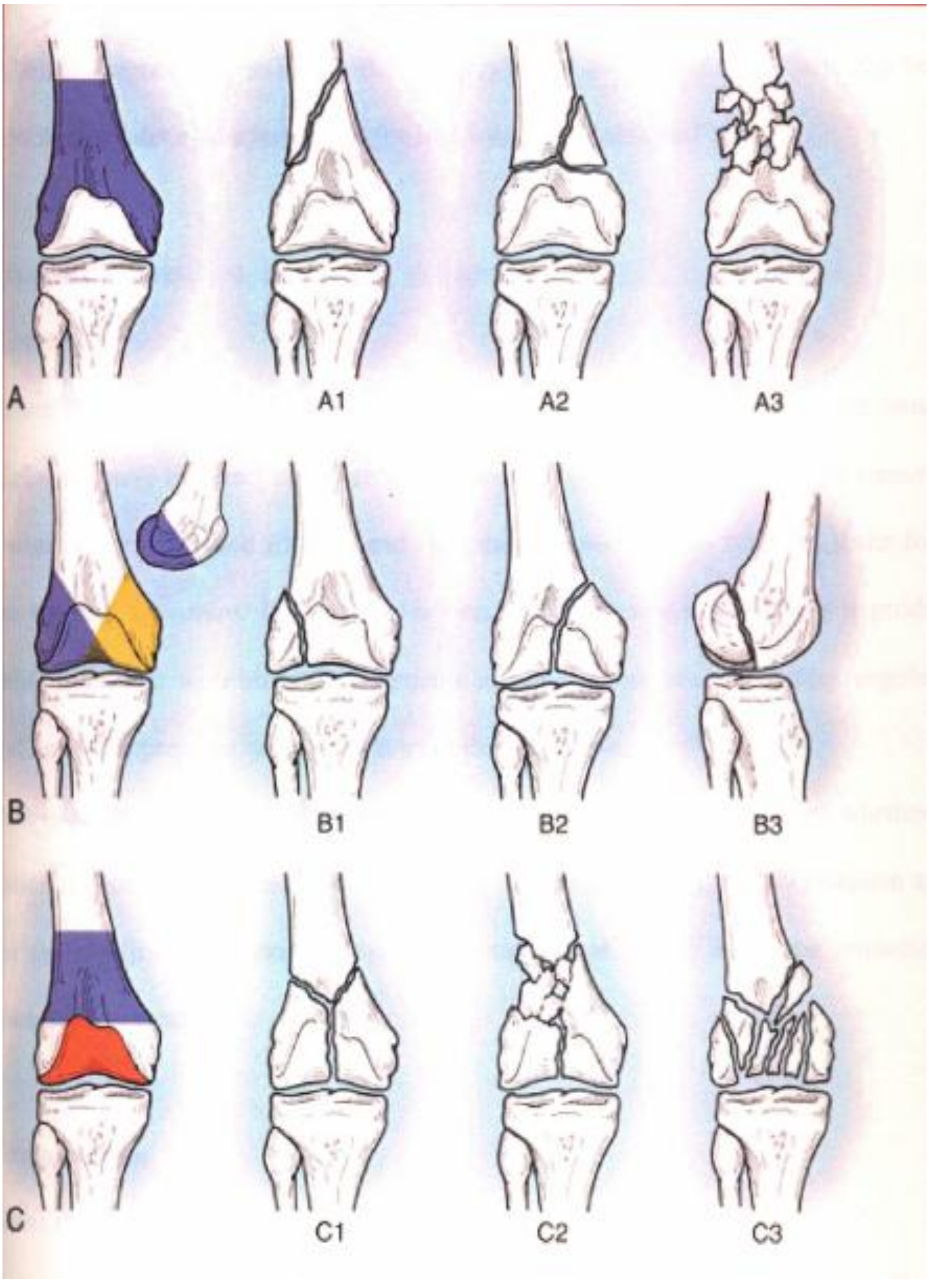


Fig.10. Classification of fractures of distal femur described by Müller et al[64,65].

- **Neer and associates classification**[19]

In 1967 a classification based on direction of displacement of the distal fragment was developed. In this four anatomical patterns were recognized. It is based on the relationship of the condyles to the proximal fragment and does not take into account associated intra-articular fracture or joint incongruity.

Type-I: 'T' or 'V' shaped fractures of condyles with no displacement. .

Type-IIa:'T' or 'V' shaped fractures with medial displacement of condyles.

Type-llb: 'T' or 'V' shaped fractures with lateral displacement of condyles.

Type-III: Conjoined supracondylar and shaft or communication extending proximally into shaft and distally into condyles.

- **Shelbourne KD classification**[38]**:** This consists of 5 types.

Type I: Tor Y shaped intercondylar fractures.

Type II: Transverse fractures.

Type III: Oblique fractures.

Type IV: Spiral fractures.

Type V: Comminuted fractures with large fragments.

Muller and colleagues classification of fractures of the distal femur is the most widely accepted classification.

CLINICAL FEATURES

History:

Mode of injury and nature of the trauma causing the fracture must be elicited. It may be direct or indirect trauma, the former often produces transverse fracture or comminuted fracture and the latter produces spiral fractures if the forces are twisting in nature. If the force is bending with axial compression it causes an oblique fracture with butterfly fragments. A short oblique fracture occurs as a result of the combination of twisting, angulation and axial compression.

Symptoms:

Pain is predominant symptom usually felt at the fracture site. History of whether the patient is able to use the injured limb after trauma should be elicited.

Swelling is the next important symptom. Time taken for the swelling to occur following the trauma is also significant. Immediate swelling following the trauma indicates fracture.

Examination:

Gait of the patient: Patient may not be able to walk and may cry in severe pain.

Inspection:

Attitude of the limb: Injured limb is externally rotated. Diffuse swelling is present over lower third of thigh and knee joint and deformity of the limb. In case of an open fracture or a compound injury, an external wound may be seen.

Palpation:

Local rise of temperature may be present. Tenderness, bony irregularly, crepitus and abnormal mobility at the distal 3rd of femur are the diagnostic features of a distal femoral fracture. If there is widening at the condylar region of femur, an intercondylar fracture is suspected.

Movements:

Movements of knee and hip may not be able to be tested as patient has severe pain. However, to rule out any nerve injury, movements of the ankle and toe of the affected limb can be tested.

Measurements:

True shortening of the thigh segment is observed. It is measured, from the tip of the greater trochanter to the joint line of knee.

Other associated injuries such as ligamentous injuries of knee, fracture of patella, fracture of tibial condyles, or upper third of tibia, and fractures or dislocation of ipsilateral hip joint, or fractures and injuries elsewhere in the body are also looked for.

Radiological Examination:

This is important for proper evaluation of the fracture. It is essential to obtain adequate radiographs of the limb. X-ray of full length of the femur with both knee and hip joints, in antero-posterior and lateral views is obligatory. X-rays including knee and hip joints, rules out any associated fractures and dislocations around knee and hip.

COMPLICATIONS

These can be divided into:

A. Early complication:

1. **Shock**: this may be hypovolemic or neurogenic.

Hypovolemic Shock:

This occurs as a result of bleeding. The patient becomes ill, toxic and thirsty. There is tachycardia and tachypnoea with shallow and rapid breathing. The extremities become cold and clammy. As compensation fails the pulses becomes rapid and feeble while the blood pressure drops. Treatment of shock is an emergency and resuscitation of the patient is crucial. The goals include arrest of bleeding and to replace lost blood. Giving oxygen, early reduction and splintage of fractures are of utmost importance. Blood may be transfused until the systolic blood pressure reaches 100mmHg.

2. Fat Embolism: This is a fatal complication and occurs usually in fracture of long bones especially fracture of the femur. The fat globules gain entrance to the circulation from the medulla of the injured bone through the ruptured walls of blood vessels. The emboli lodge in the lungs or brain, or are scattered throughout the body. This can lead to death.

3. Infection: This complication is common in open type fractures with grossly contaminated wounds. Prompt and meticulous excision of all dead and contaminated tissue and prophylactic antibiotics can reduce the rate of infection.

4. Injury to soft parts: this occurs as a result of crushing of the soft tissues due to direct violence during the fracture. The area may be devitalized. The aim should be to prevent further soft tissue injury and protecting the area further by immobilization

5. Injury to muscles: Muscles and tendons in the vicinity of a fracture may be injured or even severed by the fracture fragments. In cases of prolonged immobilization, the muscles undergo atrophy or disuse.

6. Injury to blood vessels: Posterior displacement of distal fragment may damage and disrupt the popliteal artery, as it passes behind the posterior surface of the femur.

7. Injury to nerves: The sciatic nerve (peroneal division usually) may be contused or stretched across, either by fracturing force or by the displaced bone at the time of the injury or during manipulation under an anaesthesia. This occurs in open type of fractures and very rarely in closed fractures.

8. Gangrene: This may be due to an arterial injury or pressure over the artery. If there are signs of ischemia, fracture site should be opened and the necessary operation done.

B. Delayed complications:

1) Joint stiffness: Adhesions during fracture healing process often lead to joint stiffness especially in those fractures that are near the joint and within the joint, or there will be injury to the quadriceps expansion. As a result of prolonged immobilization, oedema fluid collects in the tissues, binding together the individual connective tissue such as joint capsule and ligaments. It also impairs the free gliding of the muscle fibres one upon the other causing joint stiffness.

2) Delayed union and non-union: Since the distal end of the femur is cancellous and is richly supplied by blood these complications are not very common in distal femoral fractures. However, non-union and delayed union might occur due to distraction of the fragments by heavy traction and by infection in a compound fracture.

3) <u>Deformities</u>: Deformity and limb shortening can occur due to:

1. Mal-union of the fractured fragments with overlapping or with marked angulation

2. Crushing or actual loss of bone.

3. Interference with the growing epiphyseal cartilage (in children).

Imbalance of the muscle groups acting on the fragments causes some definite deformities. Backward angulation in slight varus deformity may also occur, due to the pull of the gastrocnemius. Slight varus deformity may also occur due to the pull of the adductor magnus, which result in bowleg.

4) **Early osteoarthritis of the knee joint:** This is a painful complication occurring in the fractures involving the articular surface of the femur due to the incongruence of the joint surface.

<u>Post - operative Complications</u>:

- Incomplete reduction;
- Unstable fixation;
- Failure to bone graft;
- Wrong size implant;
- Loss of knee motion;
- Infection;
- Non-union;
- Implant breakage;
- Post traumatic arthritis;
- Deep vein thrombosis and Pulmonary embolism

DISTAL FEMUR FRACTURE[64]

The treatment of supracondylar and intercondylar fractures of the distal femur historically has been challenging. These fractures often are unstable and comminuted and tend to occur in elderly or multiply-injured patients. The incidence is highest in women older than 75 years and in adolescent boys and men 15 to 24 years old.

Because of the proximity of these fractures to the knee joint, regaining full knee motion and function may be difficult. The incidences of malunion, nonunion, and infection are relatively high in many reported series. In older patients, treatment may be complicated by previous joint arthroplasty[64].

Once diagnosed, treatment decisions are based on both the characteristics of the fracture and patient factors. Treatment challenges are presented by patients with osteoporotic bone, open fractures with significant bone loss, and fractures with short articular segments[66,67].

MANAGEMENT

Conservative treatment[67]

Non-operative treatment may be preferred for non- or minimally-displaced fractures in elderly patients. Non-operative treatment may consist of either skeletal traction or initial splinting and mobilization with limited weight bearing and eventual transition to either a cast or functional brace. Radiographs are typically obtained at weekly to biweekly intervals for the first 6 weeks to ensure that the fracture reduction is maintained. Gradual progressive weight bearing and joint mobilization are allowed based on the clinical and radiographic progression of fracture healing. However, non-operative treatment may not be well suitable for displaced fractures.

In the 1960, non-operative treatment methods, such as traction and cast bracing, produced better results than operative treatment because of the lack of adequate internal fixation devices. In 1966, Stewart, Sisk, and Wallace recommended two-pin traction as the treatment of choice. In 1967, Neer, Grantham, and Shelton compared operative and non-operative treatment in supracondylar and intercondylar femoral fractures and recommended non-operative treatment[64].

Butt et al in their study recommended operative treatment for displaced distal femur fractures in elderly patients. Non-operative treatment for displaced fractures was advised for those patients who cannot tolerate surgery. They randomized patients into groups evaluating operative versus non-operative treatment for displaced distal femur fractures in elderly patients. Good or excellent results were obtained in 53% of the operatively-treated patients compared to 31% in the non-operative group[68].

Indications for conservative treatment:

Absolute Indication: Fractures without joint involvement.

Relative indications:

- Non displaced or incomplete fractures.
- Impacted stable fractures in elderly osteoporotic patients.
- Lack of modern internal fixation devices.
- Unfamiliarity or inexperience with surgical techniques.
- Significant underlying medical diseases.
- Advanced osteoporosis.
- Spinal cord injury with fractures.
- Severely contaminated open fractures (Type - III B)

The goal of non-surgical treatment is not anatomical reduction but restoration of overall length and axial alignment.

Methods of conservative management:

1. Skin traction- usually in children.

2. Fixed traction in Thomas splint.

3. Skeletal traction.

Two pin method of skeletal traction[69]: This method included longitudinal traction to the tibia combined with vertical pin traction to the supracondylar fragment Vertical traction is applied against a counter-pull of a canvass sling over the front of the knee. This type of traction is given if posterior angulations persist even after 3 or 4 days of tibial traction.

Cast brace: This can be used in non-displaced, impacted and well aligned fractures in elderly patients who are unfit for the surgery.

Disadvantages:

- Prolonged immobilisation.
- Time consuming and expensive.
- Not well suited for patients with multiple injuries or for elderly patients.
- Increased incidence of malunion and other complications.
- Knee stiffness.

With the development of improved internal fixation devices by the AO group, treatment recommendations began to transform.

The most critical aspects of the femoral anatomy to understand for operative treatment of distal femur fractures include the shape of the articular block and the anterior bow of the femoral shaft. The distal articular segment has a trapezoidal shape on axial section.

With both conventional and locked fixed-angle implants, unawareness of this geometry can lead to medialization, anterior displacement, and external rotation of the femoral condyles, articular penetration by implants, or excessive penetration of the medial cortex[67].

External Fixation[66]

This is typically reserved for patients with open fractures and bone loss, associated with vascular injury and significant soft tissue injuries, or extensive comminution. Advantages of external fixation include decreased operative time and blood loss, and less disruption of the blood supply to fracture fragments. Most commonly used ones are monolateral external fixators and circular or ring fixators. It can be used as a temporary device for initial management of the fracture. Later, delayed internal fixation should be considered.

For fractures with articular involvement, articular reconstruction is done first, using either open reduction and limited internal fixation or closed reduction and percutaneous fixation with independent screws. Articular reconstruction is then performed using external fixator.

Complications due to the use of external fixation include septic arthritis, osteomyelitis, and pin tract infection, loss of reduction, delayed union or non-union requiring bone grafting, and limited knee motion requiring either manipulation under anaesthesia or quadricepsplasty.

Timing of external fixator removal may be difficult to determine in complex fractures. Time to bony union has been reported to require up to an average of 25 weeks. Furthermore, external fixator removal may require anaesthesia and may lead to a risk of refracture[66,67].

Operative treatment[67]

The goals of operative treatment of distal femoral fractures are precise anatomical alignment, stable internal fixation, rapid mobilization and early functional rehabilitation of the knee.

Operative treatment is recommended for displaced fractures, open fractures, and those associated with a vascular injury. Treatment goals include anatomical reduction of the articular surface, restoration of limb alignment, early postoperative knee range of motion (important for articular cartilage nutrition), and early patient mobilization[67].

Initial management of distal femur fractures typically comprises of a well-padded long leg splint to improve patient comfort and prevent further soft tissue injury. Temporary stabilization of the fracture with a knee-spanning external fixator until definitive management can also be done. Other alternatives for temporary stabilization comprise a skeletal traction pin through the proximal tibia or calcaneus[67].

Numerous options exist for the definitive treatment of distal femur fractures and include external fixation, intramedullary nailing, and plate osteosynthesis with either open reduction or internal fixation or minimally invasive plate osteosynthesis.

Different plating options available include conventional buttress plates, fixed-angle devices, and locking plates

Absolute indications:

1. Displaced intraarticular fractures.

2. Patients with multiple injuries.

3. Most open fractures.

4. Associated vascular injuries.

5. Severe ipsilateral injuries.

6. Major associated ligament injuries.

7. Irreducible fractures.

8. Pathological fractures.

Relative indications:

1. Displaced extra articular supracondylar femoral fractures.

2. Marked obesity.

3. Advanced age.

4. Fractures around total knee arthroplasty.

Contraindications:

1. Active infection.

2. Massive comminution or bone loss.

3. Severely comminuted open fractures (type III B).

4. Patients with unstable multiple injuries.

5. Osteopenia.

6. Inadequate facilities.

7. Inexperience surgeons.

Implants available for internal fixation:

Plate and Screw Fixation[64]

The blade plate designed by the AO group in Switzerland was the first plate-and-screw devices to gain wide acceptance for treatment of fractures of the distal femur. The technique is technically demanding. Although it provides stable fixation of most fractures, early problems included infection and inadequate fixation in osteoporotic bone and refracture after plate removal. In 1972, Olerud used an extensile Y-incision with elevation of the tibial tubercle. Schatzker and Lambert found good or excellent results with stable plate fixation.

The Evolution of Plate Fixation

Conventional Plating

Plating techniques for the distal femur have evolved significantly over the past 50 years. The complications related to direct reduction techniques led to the development of indirect fracture reduction techniques. Indirect reduction techniques include reliance on soft tissue attachments to restore the mechanical axis, length, and rotation of the fracture without direct exposure of the fracture site, and the implant functions as an internal splint. The advantage is that the blood supply to the fracture fragments is maintained[67].

In the 1990s, conventional implants including the dynamic condylar screw, angled blade plate, and condylar buttress plate were used with successful results. The use of a lateral approach to the distal femur but avoiding direct fracture exposure and medial dissection led to early fracture callus formation and decreased implant failure rates, infection rates, and need for bone grafting except in open fractures with bone loss[67].

Additionally, to decrease the risk of varus collapse and implant failure, use of either a medial plate or an intramedullary plate was recommended in fractures with significant medial comminution or osteoporosis[67].

Supplemental use of a two pin medial external fixator has also been described[70]. Successful use of these indirect techniques was reported by Bolhofner et al who.[67,70].

Concept of biological plate fixation led to the development of minimally invasive plate osteosynthesis, also termed “minimally invasive percutaneous plate osteosynthesis

(MIPPO)." These techniques including buttress plate or dynamic condylar screw were initially reported in the late 1990s by Krettek et al.[71]

MIPO includes indirect fracture reduction techniques for the metaphyseal and diaphyseal fracture components, limited lateral surgical dissection, passage of the plate submuscularly under the vastus lateralis in a retrograde fashion, and proximal screw insertion through small incisions through the muscle[71].

Passing the plate submuscularly under the vastus lateralis preserves the perforating arteries and shows superior periosteal and medullary perfusion when compared to the classic lateral approach to the femur, which elevates the vastus lateralis and disrupts the perforating arteries. It also lowers the incidence of infection and implant failures, decreases the need for secondary bone grafting, and leads to early callus formation.

Trans-articular approach with percutaneous plate osteosynthesis has been used for distal femur fractures with articular involvement[71]. Anatomic reduction of the articular component is crucial for these fractures. A lateral parapatellar arthrotomy reduces the articular surface and fixes the articular surface anatomically and rigidly. Later minimally invasive plate osteosynthesis is performed to secure the articular block to the femoral shaft[71].

Locked Plating

These are known as the "locked internal fixators". These devices create a fixed angle at each screw hole where the individual screw head is secured to the plate by different locking mechanisms. The plate does not have to contact the bone directly as it does not depend on the friction created at the bone-plate interface to provide stability. It preserves the periosteal blood supply[71].

Distal femoral locking plates have multiple locking screw options distally to allow for secure fixation in the typical short condylar segment. The development of anatomically-contoured plates, with insertion jigs that allow for percutaneous insertion of the screws in the shaft of the plate, allows these systems to be more readily used in a minimally invasive fashion.

Locked implants are typically indicated in patients with osteoporosis and fractures with metaphyseal comminution where the medial cortex cannot be restored, or a short articular segment [71].

Presently, two types of locking plates exist.

Unidirectional plating systems allow for a locking screw to be placed in one trajectory and typically use a threaded locking mechanism to create a fixed angle at the screw-plate interface.

Multidirectional plating systems allow for the locking screw to be placed at variably-angled positions based on the locking mechanism used.

Various plating techniques can be used when using locking plates.

Locking technique - All of the screws are placed in a locked fashion after fracture reduction is completed.

Hybrid fixation – This includes the use of bicortical locking screws and placement of compression and locking screws in the same plate. This technique uses non-locked screws to either aid in coronal plane fracture reduction using the plate's anatomic contour, compress the fracture site in simple fracture patterns, or for diaphyseal fixation that theoretically increase screw pull out strength[67].

95^0 Condylar Blade Plate[72]

This is a one - piece device. It restores the alignment and provides stable internal fixation, but placement of the blade plate is a technically demanding procedure, as the surgeon is required to place the blade correctly in 3 planes simultaneously.

Disadvantages:

- Requires an extensive dissection and exposure.
- Not suitable for osteoporotic bones.
- Likely chances of splintering the lateral condyle while passing the implant into the condyles.
- Valgus or Varus malalignment.
- Occurrence of fracture proximal to the plate or a re-fracture after plate removal.

Condylar buttress plate[64]

Blade plates and condylar screws are unsuitable for use in fractures with less than 3 to 4 cm of intact femoral condylar bone and in fractures with a large amount of articular comminution. For these fractures, the **condylar buttress plate** is the most commonly used implant. This is a one - piece device specifically designed for the lateral distal femur. It is a broad dynamic compression plate with a clover leaf shaped distal portion designed to accommodate upto six cancellous screws (6.5mm). However, the implant is not as strong as a blade plate, condylar screw and side plate and does not provide as rigid fixation as a blade plate or condylar screw.

The multiple holes in the distal end of the plate allow multiple screws to be directed into comminuted fragments. Fractures with a comminuted medial buttress or segmental bone loss or very low transcondylar fractures may angulate into varus because of movement at the screw-plate interface.

Devices developed to lock the screws into the plate may increase the stability of the construct. Use of methylmethacrylate to improve screw purchase in osteopenic bone is also tried. If medial instability is present after application of a lateral buttress plate, the addition of a medial plate is recommended.

Condylar plates with special screws that are locked to the plate have been used. These plates provide stability similar to the DCS and avoid the varus angulation that is present with a medial femoral defect.

The Less Invasive Stabilization Technique (LISS) plate[64]

It uses locked screws and percutaneous fixation. The LISS allowed higher elastic deformation than the other systems, placing it between rigid fixation and intramedullary nailing.

Fig.11. Condylar locking plate for femoral fracture

Fig.12. Dynamic condylar screw

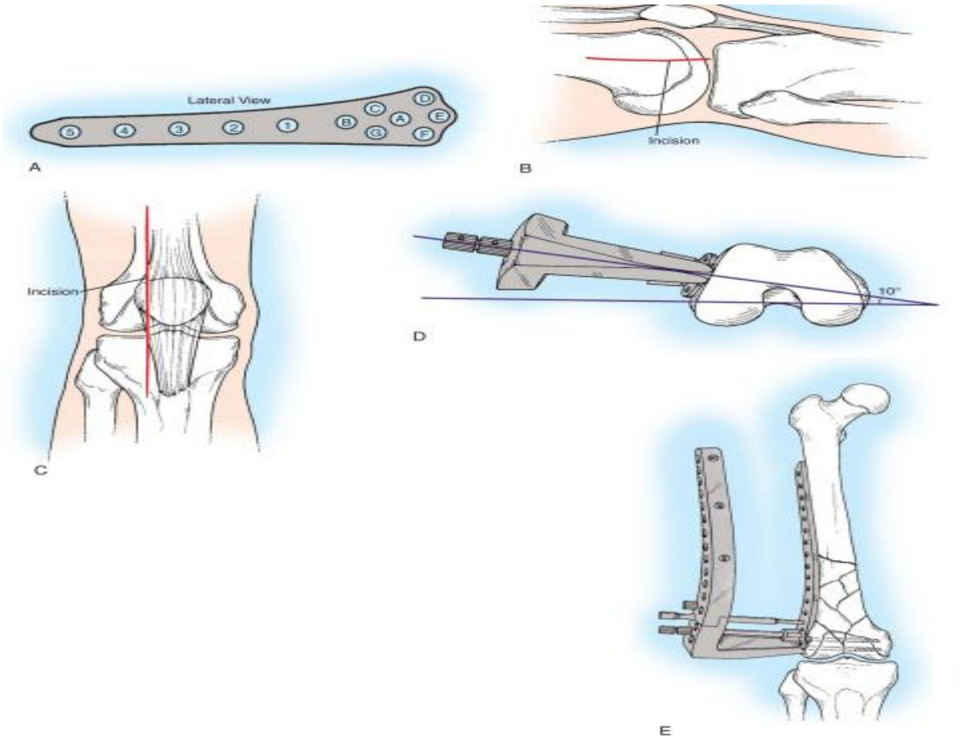


Fig. 13. Less Invasive Stabilization Technique (LISS) plate technique[64].

Dynamic Condylar Screw Fixation[4,6,64,71]

It is less technically demanding alternative to the blade plate. The blade plate requires accurate insertion in three planes simultaneously, whereas the DCS allows freedom in the flexion-extension plane. A minimum of 4 cm of uncomminuted bone in the femoral condyles above the intercondylar notch is necessary for successful fixation. This provides inter fragmentory compression across the femoral condyles, better purchase of compression screw in osteoporotic bones and needs only 2 plane alignment.

Giles et al., Pritchett, and more recently Sanders, Regazzoni, and Rüedi reported results similar to those obtained with blade plates.

Disadvantages:

- Extensive approach is needed and the insertion of the condylar lag screw requires removal of a large amount of bone, which makes revision surgery, should it be necessary, more difficult.
- Bulky size of the implant at the screw plate junction. Shoulder of this device is more prominent than that of blade plate and in many patients this causes knee symptoms as the iliotibial band slides over the prominent edge of the implant.
- In low supracondylar fractures the condylar screw may not provide rotational control of the distal fragment.
- Valgus or varus deformity if, there is wrong insertion of condylar screw.
- Chances of backing out of screws in elderly patients with osteoporosis.
- Occurrence of fracture proximal to plate or refracture after removal.

Intramedullary Nailing[64,67,73]

These devices obtain more "biological" fixation than plates because they are load-sharing, rather than load-sparing, implants. They offer greater soft-tissue preservation, and bone grafting is required less often. The major disadvantage of nail fixation is that it provides less rigid stabilization of distal femoral fractures than plate fixation in biomechanical testing.

a. Supracondylar Femoral Nail:

This is a retrograde intramedullary interlocking nail designed specifically for supracondylar and intercondylar fractures of distal femur.

b. Flexible and semi rigid Nails:

Rush Pins*:* These pins are passed by closed technique.

The complications include pin migration, knee irritation, loss of reduction and malunion. ***Ender Nails:*** These nails are connected to cancelleous screws by a coupling device. This technique allows anatomical reduction of the femoral condyles using screws, as well as a semi rigid connection of the condyles to the femoral shaft. Dynamic controlled motion at the fracture site occurs, which is thought to encourage healing. This requires a cast or cast brace for 8 weeks after surgery. This is also not a recommended method of treatment[67,73].

Zickel Nairn*:* This nail "has a flexible stem and a rigid curved condylar end allowing it to be anchored by transfixation screws into the femoral condyles. This is inserted by open method. Nail alone cannot prevent shortening in comminuted fracture patterns and cerclage wires are necessary. Therefore use of this nail is restricted to noncomminuted supra condylar fractures[67,73].

MATERIALS AND METHODS

A prospective clinical study was conducted on 30 consecutive patients who presented to the emergency department of R. L. Jalappa Hospital and Research Centre, Tamaka, Kolar with presentation of distal femur fracture.

Study period was from October 2011 to April 2013.

SOURCE OF DATA:

The study was conducted on patients with distal femur fracture who were treated by ORIF with locking compression plate in Department of Orthopaedics of R L Jalappa Hospital attached to Sri Devaraj Urs Medical College and Research Centre, Tamaka, Kolar from Oct 2011 to April 2013.

Sample size was 30.

❖ METHOD OF COLLECTION OF DATA:

All patients who were admitted to orthopedic wards as above were considered according to inclusion and exclusion criteria.

30 cases of Distal Femur fractures treated with locking compression plate were prospectively followed up during 6 months period in R L Jalappa Hospital based on the following inclusion and exclusion criteria. Patients were admitted and examined according to protocol both clinically and radiologically. Fracture care was provided by trained Orthopaedician at the hospital. They were followed up regularly by clinical examination and evaluated by Neer's Criteria. X rays were taken immediately after the operation, at 6 weeks, 12 weeks and 24 weeks after surgery.

✓ **INCLUSION CRITERIA**

1. Patients above 18 years of age

2. Fracture of distal 15 cms of the femur

3. Extra articular fractures and also those with intra articular extensions

4. Closed fractures

5. Open fractures of type I, type II, type III A and III B by Gustilo Anderson's classification

6. Pathological fractures

× **EXCLUSION CRITERIA**

1. Patients who are not fit for surgery.
2. Patients with neurovascular deficits.

❖ **Muller's AO Classification of distal fracture femur**[9] - 33

A) Extra articular fracture
   - A1 simple
   - A2 metaphyseal wedge
   - A3 metaphyseal complex

B) Partial articular fracture (unicondylar)
   - B1 lateral condyle, sagittal
   - B2 medial condyle, sagittal
   - B3 frontal – "Hoffa fracture"

C) Complex articular fracture (bicondylar)
   - C1 articular simple, metaphyseal simple
   - C2 articular simple, Metaphyseal complex
   - C3 Articular complex

Abbreviation: AO, Arbeitsgemeinschaft für Osteosynthesefragen.

A detailed history was collected including the presenting signs and symptoms as per the predesigned proforma. Data so obtained were compiled and analyzed.

STUDY TOOLS:

A. **CLINICAL EXAMINATION**: A thorough physical examination was done. The injured limb was examined for swelling, tenderness, crepitus, abnormal mobility and deformity. The patient was hemodynamically stabilized and splinting of the affected limb was done. Other systemic examination was also performed.

B. **LABORATORY ASSESSMENT**: Routine investigations included the complete hemogram with blood grouping and RH typing, renal function tests, electrolytes, bleeding and clotting time, HIV and HBSAg, random blood glucose and erythrocyte sedimentation rate.

C. **IMAGING STUDIES**: Included the following:

- X ray femur with knee joint - Anterior posterior view.
- X-ray femur with knee joint – lateral view
- CT scan and 3 D reconstruction if required
- Chest X- ray AP
- X ray pelvis AP
- CT Brain and CT spine if clinically head and spinal trauma was suspected.
- USG Abdomen to rule out associated abdominal trauma.

The preoperative preparation essentially consisted of resuscitation of the patient, correction of dehydration and shock if it was present, naso-gastric aspiration, urinary catheterization, parenteral broad spectrum antibiotic coverage and tetanus prophylaxis.

The surgical technique to be adopted in each case was decided by the operating surgeon.

SURGERY: Wound debridement and Open Reduction and Internal Fixation and Bone grafting if necessary was done.

In most of the cases antibiotics started preoperatively were continued post-operatively for 5-7 days.

FOLLOW UP: Immediate post-operative x ray and x ray at 6 weeks, 12 weeks and 24 weeks after the surgery. Patient was followed on the OPD basis after discharge. Fracture healing and range of movements were assessed every 3 months.

SAMPLE SIZE

Total number of cases studied - 30

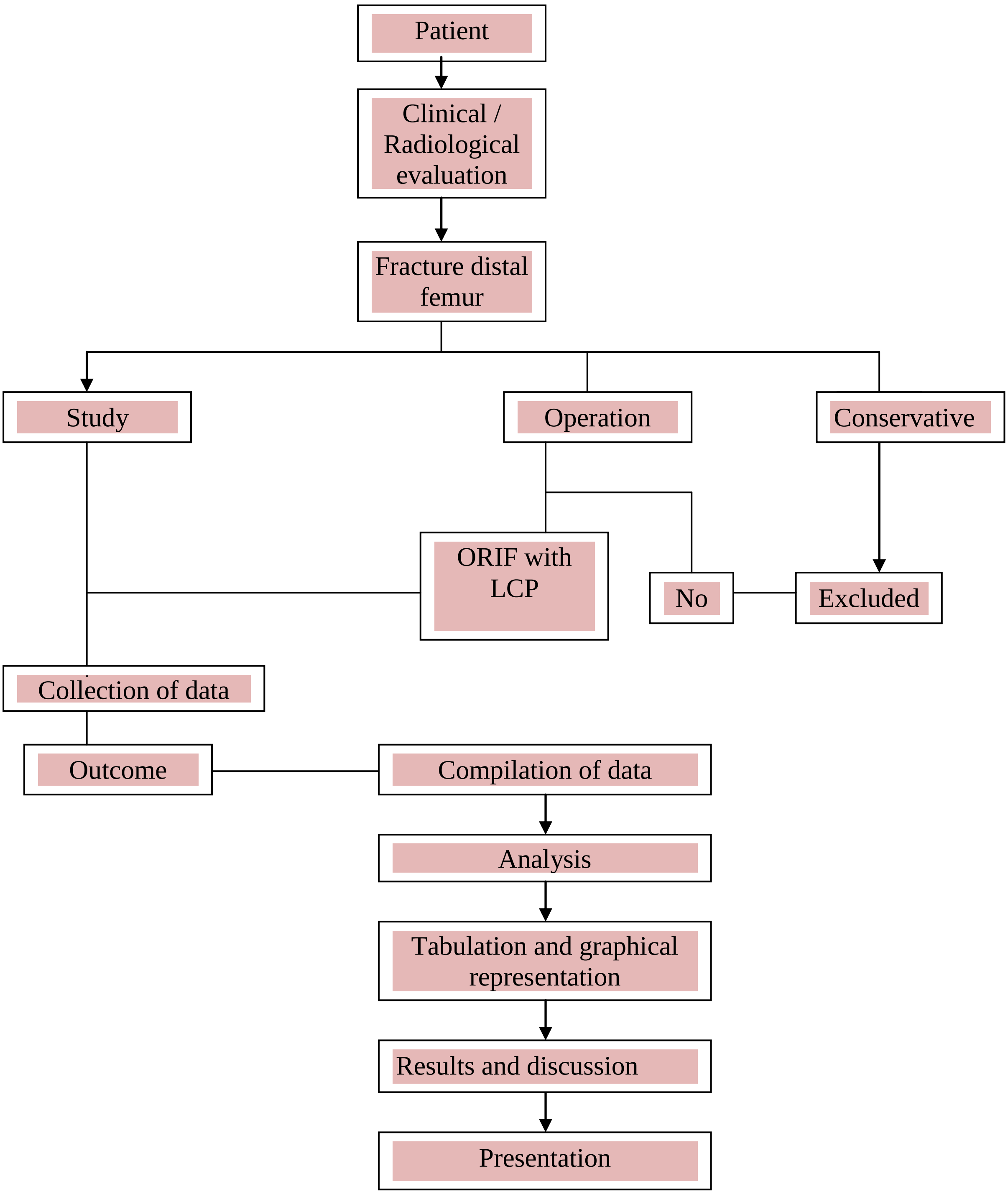
STATISTICAL ANALYSIS

The data obtained from the present study were tabulated and the percentage calculated accordingly using Microsoft Excel.

ETHICAL CLEARANCE:

Institutional Ethical clearance was obtained from the ethical review committee of Sri Devaraj Urs Medical College prior to the commencement of the study.

STUDY OUTLINE:

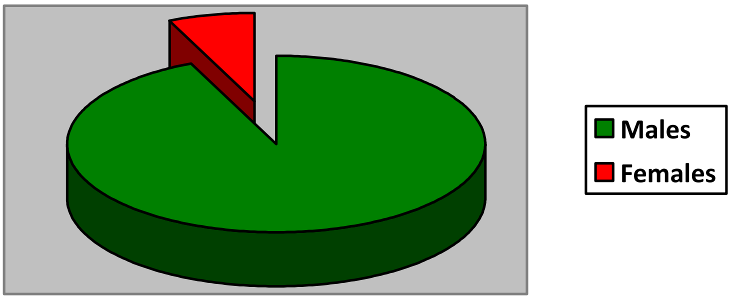


RESULTS AND ANALYSIS

This was a hospital based prospective clinical study conducted on patients admitted in R L Jalappa Hospital and Research Centre, Kolar, Karnataka with fracture distal end of femur.

Study duration was from October 2011 to April 2013.

The total number of cases studied was 30, in which 28 were male and 2 were female patients.



Graph 1. Pie chart showing the male and female distribution in the study group

❖ PATIENT FACTORS

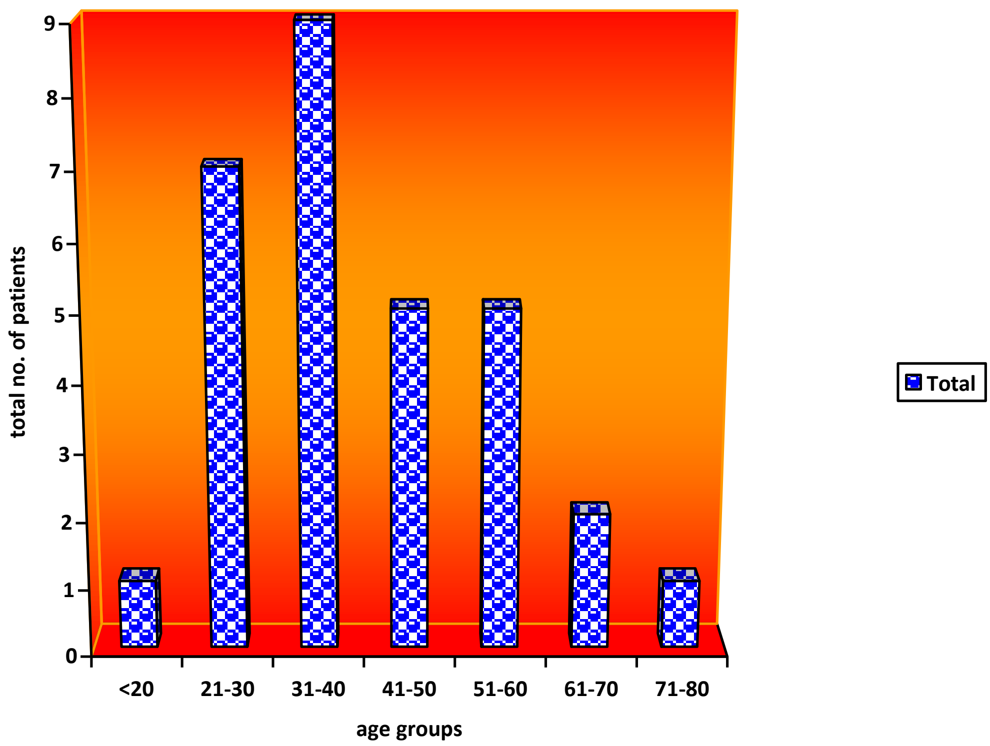
- **AGE**

The patients with age ranging from 18 years – 80 years were studied. Maximum number of patients was in young and middle age group (21 – 40 years), total 16 patients. The higher incidence in the younger age group could be attributed to the negligent rash driving practices, over enthusiasm and peer pressure leading to more number of road traffic accidents leading to high energy trauma and subsequent fractures. The fractures in the elderly could be attributed to trivial trauma/ fall due to osteoporosis.

Table No. 1

Age (years)	Total
11 – 20	1
21 – 30	7
31 – 40	9
41 – 50	5
51 – 60	5
61 – 70	2
71 – 80	1
Total	30

Table 1. Shows the distribution of patients in various age groups.



Graph 2. Column chart showing the distribution of patients in each age group.

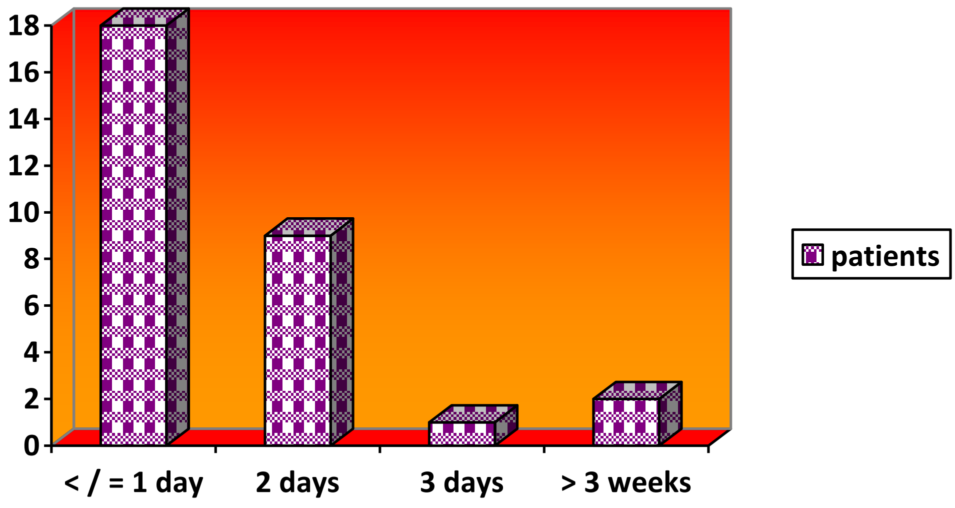
- **TIME OF INTERVENTION**

The time of intervention for definitive fixation ranged from ≤ 24 hours to > 3weeks. Maximum patients were intervened in less than 1day. The delay in intervention more than 2 days was in view of associated major injuries like head trauma, chest injuries and abdominal injuries etc. These patients were taken up for definitive stabilization after clearance of other systemic injuries.

Table No. 2

Time of intervention	Total
≤ 24 hours	18
2 days	9
3 days	1
More than 3 weeks	2
Total	30

Table 2. Shows the time of intervention.



Graph 3. Column chart showing the time of intervention.

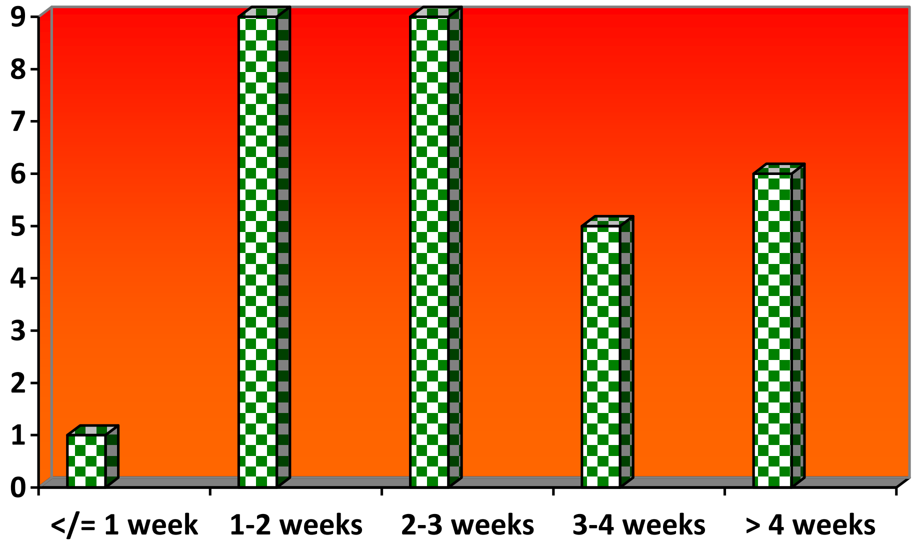
- **DURATION OF HOSPITAL STAY**

This was calculated to assess the time of healing. However, in view of associated systemic injuries in few patients, this parameter could not be appropriately assessed as some patients had a prolonged admission in hospital because of concomitant head trauma. Most patients were discharged in 20 days and followed up there after post-operatively on an OPD basis.

Table No. 3

Duration of hospital stay	Total
$\leq$ 1 week	1
1-2 weeks	9
2-3 weeks	9
3-4 weeks	5
More than 4 weeks	6

Table 3. Shows total no. of days of hospital stay



Graph 4. Duration of hospital stay

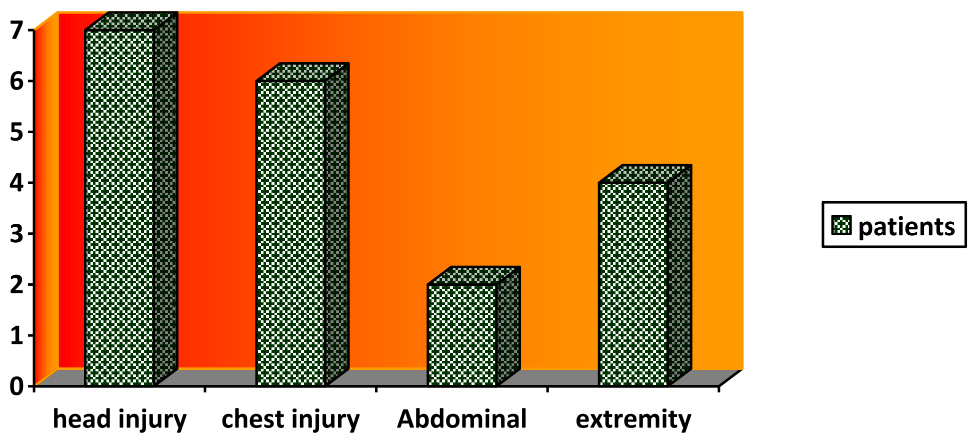
- **ASSOCIATED INJURIES**

The frequency of associated other systemic injuries with fracture femur varies. In our study, associated head injury was noted in 7 patients (23.33%). Among these 5 patients were managed conservatively and 2 required surgical interventions for cranial decompression. Associated chest injuries were observed in 6 patients (20%), all of whom were treated with intercostal chest drains. 4 patients had associated other long bone injuries. These were managed appropriately with initial splinting, casts and surgical intervention. Abdominal blunt trauma was noted in two patients; however, both the patients were managed conservatively for the same. There was no associated vascular or neurological injury in this study.

Table No. 4

INJURY	NO. OF PATIENTS	INTERVENTION
Head injury	7	5- conservative / 2-surgical
Chest injury	6	ICD insertion
Abdominal injury	2	Conservative
Extremity trauma	4	Splinting / Plaster cast / surgical

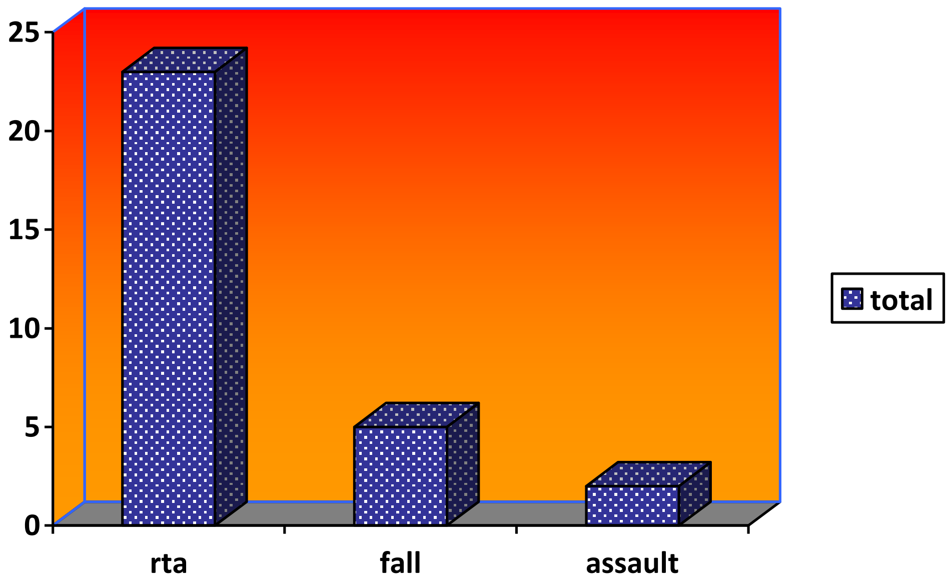
Table 4. Shows associated injuries



Graph 5. Shows associated injuries and their frequencies

- **MODE OF INJURY**

Maximum no. of patients in the study group sustained injuries due to high velocity trauma, road traffic accidents. These included 23 patients (76.6%). 5 patients had sustained injury following a fall (16.6%), in which 2 patients were elderly who had trivial fall and 2 patients were victims of assault injury (6.6%).



Graph 6. Shows the mode of injury

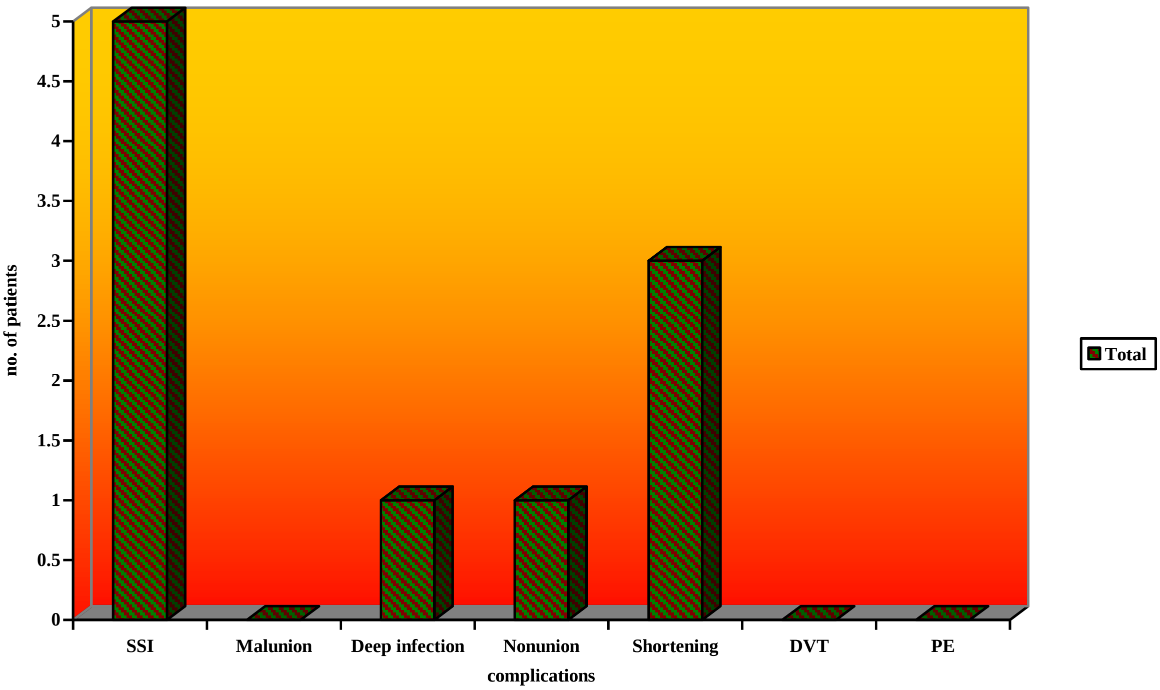
- **EVALUATION OF MORBIDITY**

The morbidity was assessed in terms of complications developed by the individual patients. 7 patients developed complications (23.33%). Surgical site infection was the commonest complication seen in 6 patients (20 %) followed by shortening in 3 patients (10%) and non-union in 1 patient (3%). Few patients among these 7 developed more than one complication.

Table No.5

COMPLICATION	TOTAL NO.
Surgical site infection	5
Deep seated infection	1
Shortening	3
Gross malunion	0
Non union	1
DVT	0
Pulmonary embolism	0

Table 5. Complications studied and their rates



Graph 7. Column chart showing the morbidity and the no. of patients

DISCUSSION

Fracture distal femur is a high energy trauma commonly occurring due to road traffic accidents and major falls. In elderly population osteoporosis may be a major contributing factor. Supracondylar and intercondylar fractures of the distal femur historically have been difficult to treat. These fractures often are unstable and comminuted and tend to occur in elderly or patients with polytrauma.

High incidence is noted in elderly women, older than 75 years and in adolescent boys and men 15 to 24 years old. Because of the proximity of these fractures to the knee joint, regaining full knee motion and function may be difficult. The incidences of malunion, nonunion, and infection are relatively high in many reported series. In older patients, treatment may be complicated by previous joint arthroplasty.

30 patients of distal femoral fractures were treated by open reduction and internal fixation using locking compression plate in the study. Patient demographics, type of fracture, treatment, complications, results achieved, and follow-up assessment were reviewed.

The fractures were classified with the AO system. The functional outcome was rated according to Neer's criteria. They were followed up for 6 months. The purpose of the study was to evaluate the treatment outcome in these patients.

I. STUDY OF PATIENT FACTORS

AGE

Age appears to be a significant factor influencing the outcome of the patient. The most vulnerable age group in the present study was 21 – 40 years which is the most productive population group of the society. Lack of strict traffic regulations, the poor infrastructure of the existing roadways, drunk driving and over enthusiasm among the younger generation are few causes for increased road traffic accidents in this age group leading to the femoral fracture. The mean age in the study was 41.53 years. This is comparable with the study conducted by many groups as described below in the table.

Table No. 6

STUDY	MEAN AGE (in years)
Present study (2013)	41.53
Kolb K. et. al (2008) [7]	51
Sie EJB et.al. (2012)[74]	44
Nayak RM et.al. (2011)[75]	42
Siliski JM, Mahring M, Hofer HP (1989)[21]	47.2
Giles JB et. al. (1982)[43]	54.5
Shewring DJ, Meffitt BF (1992)[76]	62.8

Table 6. Shows comparision of various study groups for mean age for treatment of distal femur fractures

The decreasing age group in the recent studies indicates probably an increase in the no. of youngsters involved in these high velocity traumas and sustaining femoral fractures.

Elderly people had increased morbidity rates and decreased range of movements at knee and delayed healing. This in part is due to the osteoporotic bones in older people. This is in agreement with other studies. Decreased flexion in young people is also attributed to their unwillingness to bear the pain during their early range of movement exercises. The morbidity rate seemed to be increasing exponentially after the age of 50 years in the study.

SEX

In the present study males outnumbered the females. The male to female ratio was 14:1. The more no. of male patients may be due to the fact that males are the primary labor force involved in driving, construction works, outdoor activities etc. and are almost exclusively the fatalities of these accidents. On the contrary, females are less involved in outdoor activities involving working at heights and driving. A couple of patients were targets of local violence and assaults owing to the lack of self-conduct and illiteracy among the prevalent rural population. The sex distribution is in agreement with the studies conducted by other authors.

Table No. 7

STUDY	MALES	FEMALES
Giles JB et al (1982)[43]	69%	31%
Pritchett JW (1984)[77]	55%	45%
Shewring DJ et al. (1992)[76]	26%	74%
Present study	93.3%	6.6%

However, few studies have shown female preponderance with most of the patient being in the elderly age group [76].

MODE OF INJURY

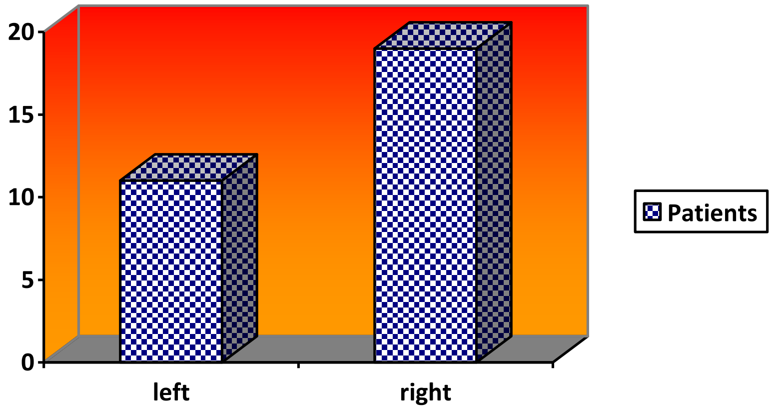
Majority of the patients sustained femur fracture due to polytrauma. These were high velocity trauma like the road traffic accidents. Few patients were victims of fall from heights and these included mainly the elderly patients.

Most of the authors have reported the mode of injury in their series being road traffic accidents. It is established that high energy trauma is needed to produce femoral fractures especially in younger patients and low energy trivial trauma can cause fracture in elderly with osteoporotic bones.

The frequency of associated head injuries varies in various patient populations. Those who are injured in traffic accidents and falls run a particular risk of sustaining a concomitant head injury. In our study, associated head injury was noted in 7 patients (23.33%). Among these 5 patients were managed conservatively and 2 required surgical interventions. Associated chest injuries were observed in 6 patients (20%), all of whom were treated with intercostal chest drains. 4 patients had associated other long bone injuries. These were managed appropriately with splinting, plaster casts and surgery. There was no associated vascular or neurological or ligamentous injury in this study.

SIDE AFFECTED:

Left side femoral fracture was noted in 11 patients (36.66%) as compared to 19 patients with right side fractures (63.33%) showing preponderance to right side.



Graph 8. Column chart showing the frequency of the side involved

II) STUDY OF DISEASE PROCESS

Duration of hospital stay:

The average duration of hospital stay of the patients in this study was 21.3 days. This is similar to the duration noted in most of the other studies.

Table No. 8

STUDY	MEAN DURATION OF STAY
Present study	21.3 days
Giles JB et. al[43].	17
Stewart et. al.[18]	33
Neer et. al.[19]	21

Table 8. Shows the comparison between various study groups for the mean duration of hospital stay

MORBIDITY

In the present study the overall complication rate noted was 23.33%. This is in agreement with the study conducted by Sidhu AS et al. in which the overall complication rate was 26.6%.

The common complications seen were superficial surgical site infections, shortening and non-union. None of the patient had any evidence of mal-union, pulmonary embolism, DVT or pressure sores.

Other studies reported infection rates as follows:

Table No. 9

STUDY	INFECTION RATE (%)
Present study	20%
Giles JB et.al[43]	0%
Siliski JM et. al.[21]	12%
Sidhu AS et.al.[78]	10%

Table 9. Shows the infection rates in various study groups

Deep infection was noted in 1 patient in the study. Deep infection rate in other study are also similar. (In study conducted by Sidhu et. al., the deep infection was seen in 2 patients).

NON-UNION

1 patient had non-union in the study (3.33%). The probable reason attributed may be due to associated co morbidity like diabetes mellitus and increased age which lead to surgical site infection and delayed healing [79,80,81]. Other series reported similar results.

Table No. 10

STUDY	NON- UNION
Present study	3.33%
Giles JB et. al[43]	0%
Shewring DJ et. al.[76]	10%
Sidhu AS et.al.[78]	33.3%

Table 10. Shows incidences of non- union in various study groups

SHORTENING AND DEFORMITY

3 patients in the present study had shortening ranging from 1 to 2 cms. The average shortening observed was 1.3cms.

The valgus deformity seen in the study accounted for 6.6%. Valgus deformity of 10^0 to 15^0 occurred in these patients.

Table No. 11

STUDY	DEFORMITY
Present study	10%
Sie EJB et.al[74].	20.8%
Kolb K et.al[7].	12.1%
Giles JB et.al[43]	13%

Table 11. Shows comparison of deformity in various study groups

IMPLANT FAILURE:

1 patient in the study had secondary implant failure due to a second trauma (self fall). Implant removal was done and limb immobilization was done in plaster cast.

Table No. 12

STUDY	IMPLANT FAILURE
Present study	3.33%
Giles JB et.al[43].	0%
Schatzker et.al[20]	15%
Sidhu AS et.al[78]	3.33%
Ogbemudia AO et.al[82]	3.4%

Table 12. Implant failure rates in various study groups

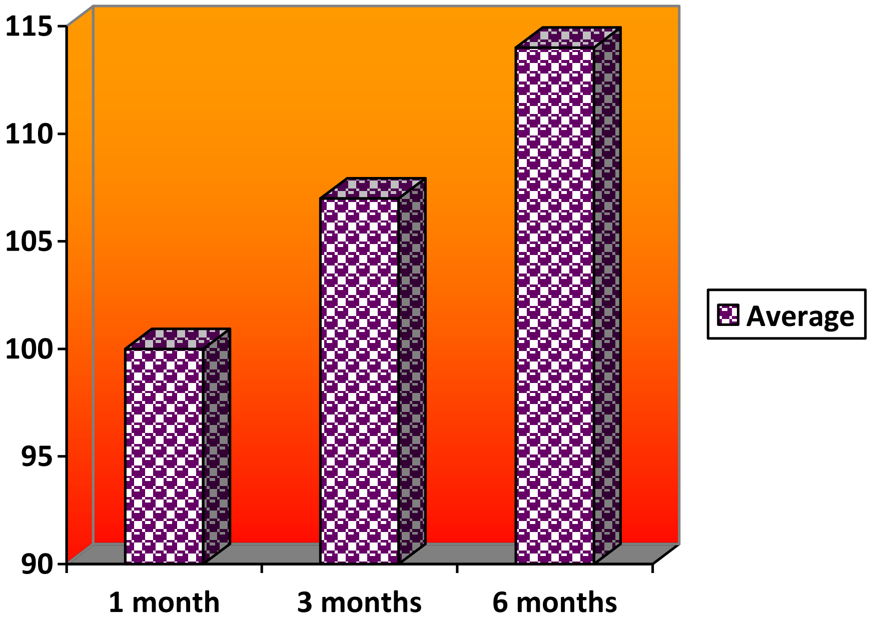
OSTEOARTHRITIS OF THE KNEE

None of the patients in our study had osteoarthritis of the knee. This aspect could not be appropriately commented in this series since it requires a longer time period to develop the complication and hence it was not feasible in our study as the follow up duration was short.

MOVEMENTS OF THE KNEE JOINT

The range of movements of the patients at 6 month follow up was in the range of around 100^0-120^0. The mean range of movement around the knee joint in the study was 114.33^0.

One patient had flexion range of movement of 50^0-60^0 because of extensive knee stiffness. 3 patients had extensor lag of 10^0 - 15^0. The average range of movements in other series was comparable. The average range of movements in the present study was 99.6, 100 and 114 degrees at 1, 3 and 6 months respectively.



Graph 9. Shows the average range of movements at 1, 3 and 6 months

Table No. 13

STUDY	RANGE OF MOVEMENTS (in degrees)
Sie EJB et. al[74].	100
Luechoowong M[83].	70
Sidhu AS et.al [78]	115
Present study	114
Yeap EJ et al., [48]	108

Table 13. Comparison of range of knee movements at 6 months follow up in various study groups

RADIOLOGICAL UNION

The average time taken for union in the present study was 14 weeks with range of 12-18 weeks. This is in agreement with other studies.

Table No. 14

STUDY	IMPLANT	UNION in weeks
Present study	LCP	14 weeks
Schandelmaier et al.,[49]	LCP	14.3 weeks
Schutz et al.,[84]	LCP	13 weeks
Sharma V et al., [85]	LCP	16 weeks
Sie EJB et al[74]	LCP	16 weeks
Markmiller et al.,[86]	LCP	13.8 weeks
Yeap EJ et al.,[48]	LCP	18 weeks

Table 14. shows the mean time in weeks for radiological union of fracture in various study groups

OUTCOME

In our study excellent to good results were noted in 26 patients (86.6%) including excellent outcomes in 17(56.6%) patients and good outcome in 9(30%) patients. Average to poor results were observed in 4(13.33%) patients. These patients had severe comminuted fractures. Comparison of outcomes with different implants in various studies has been shown in table below. Our study showed acceptable results with the use of locking compression plate implant.

Table No. 15

STUDY & IMPLANT	EXCELLENT	GOOD	MODERATE	POOR
Present study (LCP)	57%	30%	6.6%	3.3%
Gellman et al., (IMSC)[87]	17.4%	65.2%	8.7%	8.7%
Sharma V et al., (LCP)[85]	82%	-	18.2%	-
Christodoulou A (IMSC)[88]	51%	31%	9%	9%
Yang et al.(95^0 blade plate)[89]	61.3%	23.7%	9.7%	5.3%
Yeap EJ et al., (LCP)[48]	72.7%	-	-	27.3%
Pritchett JW, (DCS)[74]	53.4%	26.6%	6.7%	13.3%
Shelbourne KD et al., (rush pin)[38]	53.1%	30.6%	11.2%	5.1%

Table 15. Shows outcomes in various study groups

SUMMARY AND CONCLUSION

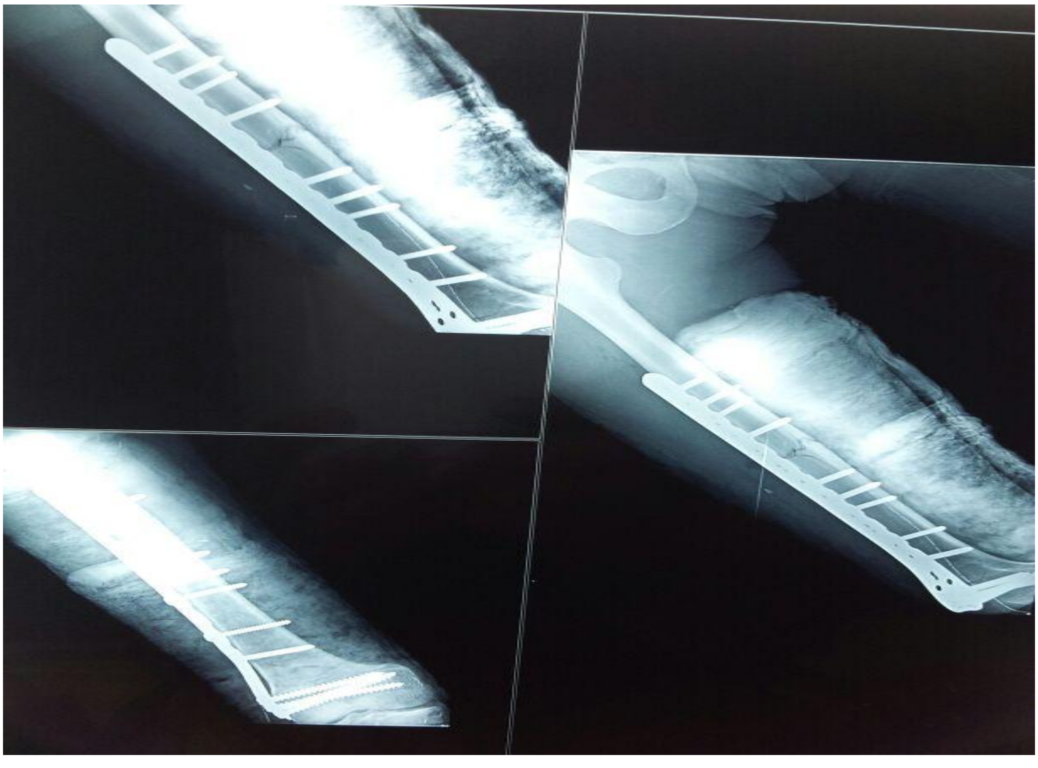
- *This was a hospital based prospective study done on 30 patients treated with open reduction and internal fixation using locking compression plate for distal femur fracture in R L Jalappa Hospital of Sri Devaraj Urs Medical College, Kolar, Karnataka.*
- *The objective of the study was to assess the fracture union and functional outcome following open reduction and internal fixation of distal femur fractures with locking compression plate and to achieve restoration of the anatomical alignment of fracture fragments and stable internal fixation.*
- *The aim was to treat these fractures by rigid fixation and achieve an early mobilization with good functional outcome.*
- *The mortality and morbidity rates in the group were analyzed.*
- *It was found that majority of these fractures were comminuted and were often result of high energy trauma in younger age group. In elderly population the fractures frequently occurred due to a trivial trauma through the osteoporotic bone. Most of the fractures were of open type.*
- *The average age in the study was 41.53 years. However, most of the fractures occurred in the ages between 31- 40 years.*
- *Our study showed a male preponderance.*
- *Road traffic accidents were the major causes of these fractures followed by falls and few assaults. Majority were caused by a high energy trauma.*
- *Associated injuries in patients were common accounting for around 25%. These included injuries to the head, chest and abdomen. These injuries were managed appropriately either conservatively or operatively.*

- *Surgery for fracture femur was performed within 1-5 days in most of the patients. Few patients in whom operative procedure was delayed were in view of associated systemic injuries. These patients were subsequently taken up for the fixation after the systemic injury was treated and patient was stabilized.*
- *Radiological union was noted at an average of 14 weeks.*
- *The average range of movements at the knee was 114 degrees. The follow up period was 6 months.*
- *Minor complications like superficial wound infection was noted in the study with overall morbidity rate around 25%.*
- *The end results were excellent in 17(57%), good in 9(30%), average in 3(6.6%), and poor in 1(3.3%) patients.*
- *Poor results were seen in comminuted and compound fractures with gross infection.*
- *Our study analysis demonstrated that locking compression plate is a good method for treating distal femur fractures especially type A1, A2, A3, C1 and C2. Type C3 comminuted fractures and compound fractures had poor results.*
- *Complications in the form of superficial and deep infection, non-union, and implant failures are reported in various studies; however, their rates are very low. Fortunately in our study we did not encounter any gross malunion affecting the functional outcome or a primary implant failure.*
- *Although the study duration and follow up of the patients was short, we followed the patients within the time frame and had encouraging results.*
- *The locking compression plate gives a rigid fixation for the fracture. Additionally, it also provides a good purchase in osteoporotic bones. Early ambulation and physiotherapy can further augment the outcomes.*

- *This study was a concise surgical audit of the patients presenting with distal femoral fractures in rural population. The study should be logically extended to compare the outcomes of various other implants used for treating these fracture and to choose among them the most feasible, cost- effective and best implant for better functional outcome.*
- *Distal femoral locking plates offer more fixation versatility without an apparent increase in mechanical complications or loss of reduction*
- *There is wide scope for use of locking compression plate in treatment of distal femoral fractures with a stable internal fixation.* ***Use of LCP in experienced hands is simple, reliable, and easy to apply implant and it seems to be appropriate for fixation of femoral fractures in a rural hospital set up with promising results.***
- *The DF-LCP is a good implant to use for fractures of the distal femur. Nevertheless, accurate positioning and fixation are crucial to produce acceptable outcomes.*
- *We recommend the use of locking compression plate in Type A and C, and osteoporotic fractures.*
- *Last but not the least, proper awareness among the population, strict driving and traffic rules, adequate health education to seek medical aid, proper referral mechanism and transportation can reduce the incidences of high energy accidents and these fractures. The delayed presentation and in turn both the mortality and morbidity can be decreased by creating proper awareness among the people.*

PICTURE GALLERY

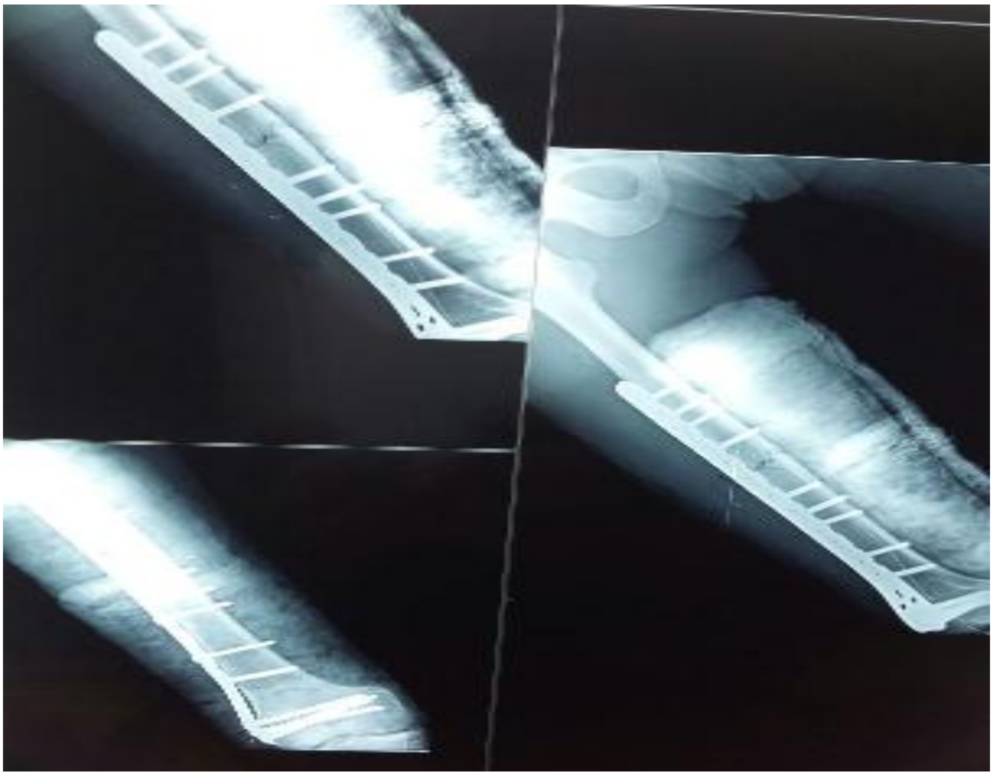
X rays showing comminuted fracture of distal third of femur



X ray shows LCP insitu used for fixing the fracture femur

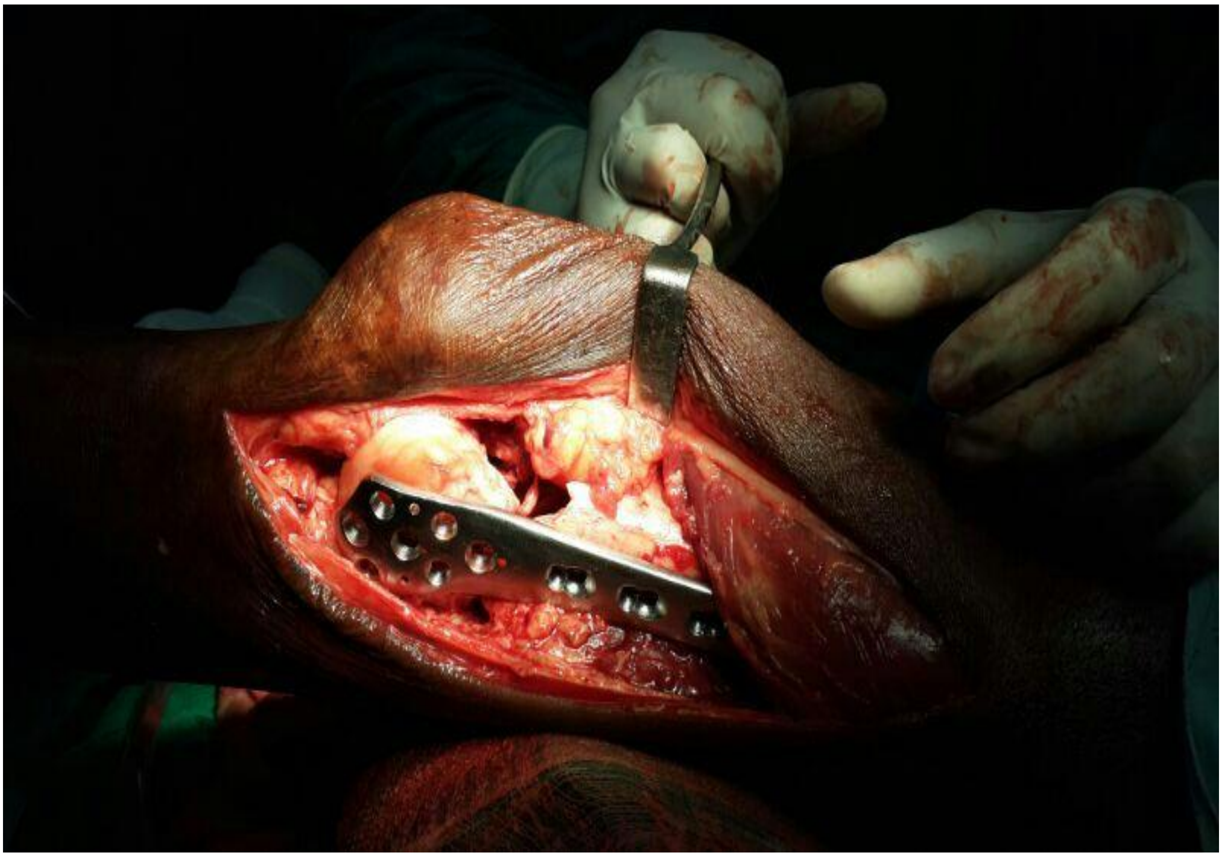
Fracture distal femur in an elderly female treated with LCP

X ray showing distal third femur fracture treated with LCP



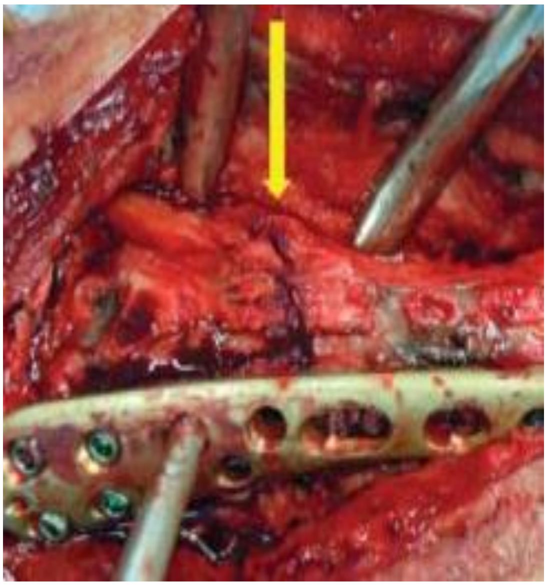
X rays showing distal femur fractures treated with LCP

Intraoperative placement of LCP for distal femur fracture



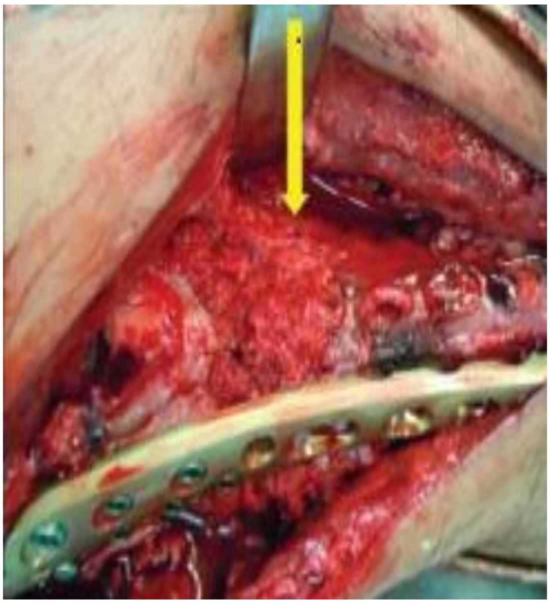
Intra operative placement of LCP for distal femur fracture fixation

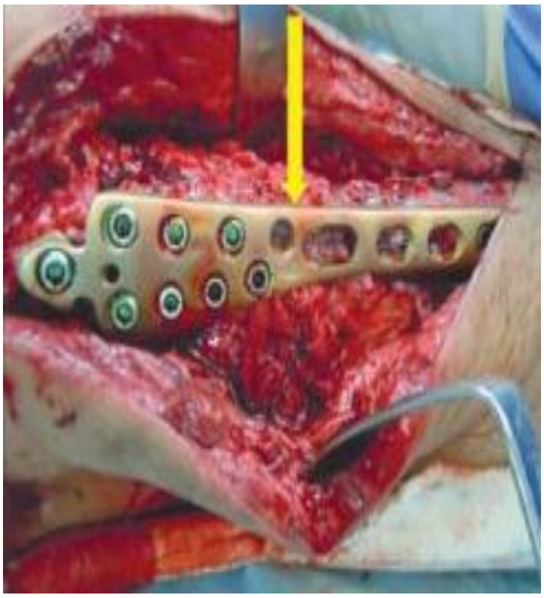
PLATE



Incision with exposure of fracture site

Placement of the plate





Insertion of screws to fix the plate

Locking compression plate with screws

Intraoperative placement of locking compression plate of distal femur fracture (Arrow shows the fracture)

110 degree flexion in patient no. 10.

Full extension in the same patient

100 degree flexion in a patient (patient no.4.)

Full extension in the same patient

NEER'S CRITERIA FOR THE EVALUATION OF RESULTS

	FUNCTIONAL	UNIT			ANATOMICAL	UNIT
	PAIN (20 points)				**GROSS ANATOMY (15 points)**	
5	No pain	20		0.	Non-union or chronic infection	0
4	Intermittent or bad weather	16		1.	Union but with greater deformity	3
3	With fatigue	12		2.	15 degree angulation or rotation, 3 cm short	6
2	Restrict function	8		3.	10 degree angulation or rotation, 2cm short	9
1-0	Constant or at night	4-0		4.	5 degree angulation or rotation, 0.5 cm short	12
				5.	Thickening only	15
	FUNCTION (20 units)					
5.	As before injury	20			**ROENTGENOGRAM (15 points)**	
4.	Mild restriction	16		0.	Non-union or chronic infection	0
3.	Restricted stairs sideways	12		1.	Union but with greater deformity	3
2.	Cane or severe restriction	8		2.	15 degree angulation or rotation, 2cm displacement	6
1-0	crutches or brace	4-0		3.	10 degree angulation or rotation, 2cm displacement	9
				4.	5 degree angulation or 0.5 cm displacement	12
				5.	Near normal	15
	MOTION (20 points)					
5.	Normal/135 degrees	20				
4.	100 deg	16				
3.	80 deg	12				
2.	60 deg	8				
1.	40 deg	4				
0.	20 deg	0				
	WORK (10 points)					
5.	As before injury	10				
4.	Regular but with handicap	8				
3.	After work	6				
2.	Light work	4				
1-0.	No work	2-0				

ANALYSIS OF OUTCOME

Excellent – Above 85 units

Good – 70 units

Average – 55 units

Poor – below 55 units

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PROFORMA FOR FRACTURES OF DISTAL FEMUR TREATED BY LOCKING COMPRESSION PLATE(LCP)

1. CASE NO. :
2. NAME :
3. AGE :
4. SEX :
5. ADDRESS :

6. IP NO.:
7. D.O.A :
8. D.O.T :
9. D.O.D :
10. D.O.S :

11. **HISTORY OF PRESENTING ILLNESS**

A. Side involved : Right / left

B. Mode of trauma : RTA / industrial / fall / domestic

C. Pain in the thigh and knee region : present / absent

D. Inability to move the limb : present / absent

E. Symptoms of head injury or any other organ system involvement : yes / no

F. Associated with any long bone fracture : present / absent

G. Able to walk before accident? : with support / without support

H. Treatment received immediately after reaching the hospital / method of first aid given / treatment given outside :

12. **PAST HISTORY**

a. History of chronic illness – DM / HTN / BR. ASTHMA / TB/EPILEPSY

b. Past medical history -------

13. **FAMILY HISTORY**: upper middle class / lower middle class

14. **PERSONAL HISTORY:**

1. Married / unmarried :
2. Nature of work :
3. Menstrual history (in case of females) :
4. Habits : smoker / non smoker
    a. Alcoholic / non alcoholic
5. Bladder function : normal / altered :

15. CLINICAL EXAMINATION

A. GENERAL PHYSICAL EXAMINATION

a. Built : obese / moderate /poor

b. Nourishment : good / moderate / poor

c. Pallor : icterus : cyanosis: Clubbing : lymphadenopathy :

d. Vital signs :

- Pulse rate :
- Respiratory rate :
- Blood pressure :
- Temperature :

B. <u>OTHER SYSTEMS</u>

a. CVS :

b. RESPIRATORY SYSTEM :

c. PER ABDOMEN :

d. CENTRAL NERVOUS SYSTEM:

C. <u>LOCAL EXAMINATION</u>

1. Evidence suggestive of distal femur fracture:

- Local rise of temperature : Yes / no
- Swelling around the distal thigh : yes / no
- Tenderness : yes / no
- Crepitus : yes / no
- Deformity : yes / no
- shortening : yes / no

2. Type of fracture: closed / open

3. Severity of soft tissue damage / external wound condition:

4. Neurovascular examination of the distal extremity:

- distal pulsations
- sensations

5. Associated injury of the other long bones or same bone or joints : yes / no

6. Any other associated injury

- Vascular injury : yes / no
- Neurological injury : yes / no
- Ligament injury : yes / no

16. <u>INVESTIGATIONS</u>

a. X-RAY of distal femur with knee joint– AP & LATERAL VIEW

b. Screening chest x-ray

c. ECG

d. Routine blood investigations :

- Hb% :
- Total count :
- Differential count :
- Blood Urea :
- S. Creatinine :
- RBS :
- Blood grouping & typing :

- Any other specific investigations :

17. <u>FINAL DIAGNOSIS</u>:

18. MANAGEMENT

A. PRE OPERATIVE TREATMENT

a. Duration of injury to the time of definite fixation :

b. Skeletal traction :

c. Knee aspiration : done / not done

d. Blood transfusion : yes / no

B. PERIOPERATIVE TREATMENT

a. Date of operation :

b. Type of Anesthesia :

c. Type of Approach :

d. Type of implant :

e. Blood Transfusion :

f. Bone grafting :

- done / not done :
- site of graft taken :

g. Intra operative complications :

C. POST OPERATIVE TREATMENT

a. Antibiotics :

b. Analgesics :

c. Blood transfusion :

d. Follow up X-ray :

e. Suture removal on :

f. Limb length measurement :

D. <u>POST OP REHABILITATION</u>:

a. Static quadriceps exercises started on :

b. Active range of motion started on :

c. Ambulation started on :

   - non weight bearing
   - weight bearing

E. <u>POST OPERATIVE COMPLICATIONS</u>

IMMEDIATE

- Swelling of the limb.
- Other complications

EARLY –

- wound infection
- deep vein thrombosis
- pulmonary embolism

LATE -

- deformity
- shortening/ lengthening

- knee stiffness
- malunion/nonunion

19. <u>Assessment at the time of Discharge</u> :

a. Wound : healthy / not healthy

b. Range of movements :

c. active

d. passive

e. Shortening :

f. Any other complaints :

20. Advice given: knee immobilizer / cast

21. <u>Follow up:</u>

Feature	After 1 month	After 3 months	After 6months
Tenderness at fracture site			
Abnormal mobility at the fracture site			
Range of movements (knee)			
X-ray findings			
Any other complications			

21. Neer's criteria Score:

22. Final Result: Excellent/Good/Average/Poor.

<u>NEER'S CRITERIA</u>

S.no	Name of the patient	OP. No	Age	Sex	Date of admission	Date of surgery	Date of discharge	Side	Duration of injury	Diagnosis	Type of implant					Range of movts		FOLLOW UP			OUTCOME
												SSI	deformity	shortenin	nonunion	active	passive	1 month	3 months	6 months	
1)	Sheikh noorulla	740366	55	M	1.10.11	28.10.11	15.11.11	left	I month	closed , mullers C2	9 hole LCP	-	-	0	-	90 -100	10	100	110	110	excellent
2)	Narayanappa	751804	75	M	11.11.11	12.11.11	12.12.11	right	1 day	open II, mullers C2	7 hole LCP	+	+	0	+	90 - 100	10	100	110	110	average
3)	Veeranna	761986	50	M	16.12.11	19.12.11	30.12.11	right	4 1/2 years	mullers C2,oldcase, implant failure	9 hole LCP	-	-	0	-	100 - 110	10	110	110	120	excellent
4)	Govindappa	763090	38	M	20.12.11	21.12.11	10.1.12	right	1 day	open II,mullers C2	5 hole LCP	-	-	0	-	80 - 90	10	90	100	110	good
5)	venkataramappa	762785	40	M	20.12.11	20.12.11	6.1.12	left	1 day	open I,mullers C2	7 hole LCP	-	-	0	-	80 - 90	10	100	110	120	excellent
6)	Jayaram	767828	26	M	6.1.12	8.1.12	28.1.12	right	2 days	open II, mullers C2	7 hole LCP	+	-	0	-	90 - 100	10	100	110	110	good
7)	Krishnappa	775886	50	M	5.2.12	8.2.12	27.2.12	right	3 days	open I,mullers C2	9 hole LCP	-	-	0	-	70 - 80	10	80	100	110	good
8)	Venkateshappa	781804	60	M	26.2.12	27.2.12	14.3.12	right	1 day	open III B, mullers C2	7 hole LCP	-	-	0	-	80 - 90	10	90	100	110	good
9)	Venkateshappa	781824	45	M	22.4.12	22.4.12	6. 5.12	right	1 day	open III A, mullers C2	9 hole LCP	-	-	0	-	80 - 90	10	100	100	110	good
10)	Shivraj reddy	802147	23	M	10.5.12	14.5.12	25.6.12	right	15 days	open III A, mullers C2	7 hole LCP	-	-	0	-	90 - 100	10	100	100	110	excellent
11)	Allu male	816774	26	M	30.6.12	30.6.12	20.8.12	right	2 days	open IIIB,mullers C3	9 hole LCP	+	+	+ 2 cms	-	30 - 40	5	40	50	60	poor
12)	Harisha	818160	25	M	6.7.12	9.7.12	7.8.12	right	2 days	open III B, mullers C1 , segmental #	13 hole LCP	+	-	0	-	80 - 90	10	100	110	120	good
13)	Gopal	819664	19	M	11.7.12	12.7.12	8.8.12	left	1 day	open III A, mullers C2	5 hole LCP	-	-	0	-	90 - 100	10	110	120	120	excellent
14)	Muniyamma	826927	70	F	13.8.12	14.8.12	18.8.12	right	2 days	closed , mullers C2	5 hole LCP	-	-	0	-	100 - 110	15	110	120	120	excellent
15)	syed mehboob	832388	40	M	21.8.12	21.8.12	29.8.12	right	2 days	closed, mullers C1	9 hole LCP	-	-	0	-	100-110	10	120	120	130	excellent
16)	Narayanswamy	837905	22	M	6.9.12	6.9.12	18.9.12	left	2 days	open II, mullers C2	9 hole LCP	-	-	0	-	80-90	10	100	100	110	good
17)	Kondappa	858572	54	M	13.9.12	13.9.12	27.9.12	left	1 day	open II, mullers C2	9 hole LCP	-	-	0	-	80-90	10	100	110	120	excellent
18)	Abbayappa	896209	35	M	8.10.12	9.10.12	25.10.12	right	1 day	open II, mullers C2	9 hole LCP	-	-	0	-	90-100	10	110	120	130	excellent
19)	Raghavendra	896224	27	M	8.10.12	8.10.12	22.10.12	left	2 days	open II, mullers C2	10 hole LCP	-	-	0	-	90-100	10	100	110	120	excellent
20)	Krishnappa	911308	55	M	16.10.12	17.10.12	3.11.12	left	1 day	open II, mullers C2	10 hole LCP	-	-	0	-	90-100	10	100	110	120	good
21)	Towkheer	913981	31	M	26.10.12	26.10.12	9.11.12	left	1 day	open I,mullers C2	9 hole LCP	-	-	0	-	90-100	10	110	120	120	excellent
22)	Kadirappa	913986	37	M	24.11.12	26.11.12	10.12.12	left	1 day	open III A, mullers C2	9 hole LCP	-	-	0	-	90-100	10	110	110	120	excellent
23)	Venkataeshappa	925952	45	M	8.12.12	9.12.12	20.12.12	right	1 day	closed, mullers C1	7 hole LCP	-	-	0	-	90-100	10	110	120	130	excellent
24)	Munishamappa	926204	65	M	8.1.13	9.1.13	27.1.13	right	1 day	closed, mullers C3	7 hole LCP	+	-	1 cm	-	60- 70	5	80	80	90	average
25)	Srinivas	935953	35	M	13.2.13	14.2.13	4.3.13	left	1 day	open II, mullers C2	9 hole LCP	-	-	0	-	90-100	10	110	110	120	excellent
26)	Yellamma	939955	55	F	19.2.13	20.2.13	12.3.13	left	2 day	closed, mullers C2	7 hole LCP	-	-	0	-	90-100	10	110	120	120	excellent
27)	Nanjundappa	944449	38	M	8.3.13	9.3.13	16.4.13	right	2 day	open II, mullers C2	9 hole LCP	-	-	0	-	90-100	10	110	120	130	excellent
28)	Errappa	947057	45	M	17.3.13	18.3.13	3.4.13	right	1 day	open IIIA,mullers C3	11 hole LCP	+	-	0	-	80-90	10	100	110	120	good
29)	Harish	947416	25	M	19.3.13	19.3.13	3.4.13	right	1 day	open IIIA,mullers C2	9 hole LCP	-	-	0	-	90-100	10	110	110	120	excellent
30)	Suresh	948229	35	M	20.4.13	20.4.13	14.5.13	right	1 day	open I, muller C2	7 hole LCP	-	-	1 cm	-	60-70	5	80	90	90	average