"RADIOLOGICAL AND FUNCTIONAL OUTCOME OF DUAL PLATING IN COMMINUTED INTRA-ARTICULAR DISTAL FEMUR FRACTURES"

By

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In partial fulfilment of the requirements for the degree of

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Under the guidance of

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ABSTRACT

INTRODUCTION

Distal femur fractures, constituting 3-6% of femur fractures and 4% of all fractures, present significant challenges to orthopedic surgeons due to their complexity and potential for severe impairment. These fractures exhibit a bimodal age distribution, predominantly affecting young individuals (~20 years) and older women (~70 years). Fractures can be classified into extra-articular, intra-articular unicondylar, and intra-articular bicondylar categories, with the AO/OTA classification system being widely used. Despite advances in surgical techniques and implants, intra-articular multifragmentary fractures, particularly AO type C2 and C3, remain difficult to treat effectively.

AIM

To evaluate the radiological and functional outcomes of dual plating in the treatment of comminuted intra-articular distal femur fractures (AO type C3).

METHODS

A prospective study was conducted at BLDE (Deemed to be University) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, from August 2022 to November 2024. The study included 32 patients (17 males, 15 females) with comminuted distal femur intra-articular fractures. Patients were followed for a minimum of 6 months and a maximum of 12 months. Inclusion criteria were patients aged 18 and above with closed fractures who consented to treatment. Exclusion criteria included patients below 18, compound fractures, polytrauma, segmental fractures, and those medically unfit for surgery. The Neer score was used to assess outcomes.

RESULTS

Of the 32 patients, 56.3% sustained left-sided injuries and 43.8% right-sided injuries. The majority of injuries were due to road traffic accidents (75%), with the remainder from trivial falls (18.8%) and falls from height (6.3%). The modified swashbuckler approach was used in 78.1% of cases, while a dual incision approach was used in 21.9%. The mean Neer score improved from 51.69 at 6 weeks to 79.41 at 12 months, indicating a good to excellent outcome. Patients treated with the modified swashbuckler approach showed better functional outcomes.

CONCLUSION

Dual plating for comminuted intra-articular distal femur fractures (type C3) demonstrated favourable radiological and functional outcomes, with the modified swashbuckler approach yielding superior results. This study supports the efficacy of dual plating in enhancing fracture stabilization and promoting early mobilization. Further research with larger sample sizes and longer follow-up periods is recommended to validate these findings.

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LIST OF ABBREVIATION:

AO/OTA - Arbeitsgemeinschaft für Osteosynthesefragen/Orthopedic Trauma Association

DFLP – Distal femoral locking plate

DCS – Dynamic condylar screws

CBP – Condylar blade plate

LCP – Locking compression plate

L.I.S.S – Less Invasive Stabilization Systems

MIPO – Minimally invasive percutaneous plate osteosynthesis

ROM – Range of motion

TKA – Total knee arthroplasty

ORIF – Open reduction internal fixation

ITB – Iliotibial band

CPM – Continuous passive motion

VAC – Vaccum assisted closure

IMT – Induced membrane technique

PMMA – Poly methyl methacrylate

RTA – Road traffic accident

OT – Operation theatre

MAP – Medial assisted plating

1.) INTRODUCTION

Distal femur fractures are extremely complicated injuries that provide difficulties for orthopedic surgeons. There is a chance that these serious wounds will result in severe impairment. Three to six percent of femur fractures and four percent of all fractures are distal femoral fractures. [1] It has a bimodal age distribution with a characteristic occurrence in young people (about 20 years old, sports, traffic accidents) and older ladies (around 70 years old, fall at home, osteoporosis). [47] An extra-articular, intra-articular unicondylar or intra-articular bicondylar fracture of the distal femur can be broadly categorized, with sub-classifications for specific patterns and levels of comminution. The fracture categorization system developed by AO/OTA is the most widely utilized. From cautious, non-surgical care to more aggressive, operational therapy, the management of distal femur fractures has changed throughout time.

Despite recent advancements in methods and implants, treatment of intra-articular multifragmentary distal femoral fractures is still difficult. [47] The aim is to ensure the femoral shaft is angled in a valgus position between 7° and 11°; maintaining this alignment is essential for the limb's functionality. Post-Traumatic Arthritis may develop in knee fractures that heal with more than 15° of valgus or any amount of varus. [2] So, these severe injuries have the potential to produce significant disability. Fracture shortening with extension and varus deformities of the distal articular surface are typical. [47]

The goals of surgical fixation for these fractures include rigid internal fixation to initiate early mobilization, anatomical articular reduction, and preservation of the blood supply. [47] Since then, a number of tools have been presented for the treatment of distal femur fractures, including Angle blade plates, Dynamic condylar screws, Intra-medullary nails, and Distal Femoral Locking Plates (DFLP).

For AO type A and type B fractures, DFLP has produced positive outcomes; however, for type C fractures, especially in C2 and C3, the results are less encouraging. [47] Metaphyseal comminution occurs in C2 fractures, while intra-articular and metaphyseal comminution occurs in type C3 fractures. [47] When type C2 and C3 fractures occur, varus collapse and non-union are caused by metaphyseal comminution, low bone quality, and insufficient fixation.

[47] The failure likelihood decreases when a medial plate is added to the lateral locked plate configuration. According to reports, in cases of comminuted supracondylar femur fractures, low periprosthetic fractures, and nonunions, a union of patients who underwent complex intraarticular fractures (C2, C3) dual plating stabilizes the distal femur's columns and offers a stronger fixation. [19]

So, we are carrying out this study to evaluate the radiological and functional outcome of type C_3 fracture treated with dual plating for the distal femur. [47]

2.) AIM AND OBJECTIVE OF THE STUDY

To study the functional and radiological results of dual plating for the treatment of comminuted distal femur intra-articular fractures

3.) REVIEW OF LITERATURE

“The past is our foundation for future development.” History is very important for any surgeon. Technology must be incorporated into a surgeon's practice, but it works best when a surgeon is well-versed in the background of his specialty.

Ancient Indians have practiced the treatment of fractures since times immemorial. The earliest treatment of distal femoral fracture was the same as of shaft femur fracture. The goal was the maintenance of the leg in extension with a splint but with stiffness of the knee and deformity.

- 1945 - Funsten and Lee observed that the femur's middle or proximal third fractures take longer to heal than distal third femur fractures.
- 1948 – Unmasky repaired the distal femoral fractures using a reverse Blount plate.
- 1951 - Delmore, West, and Schriber proposed that the primary cause of knee stiffness following trauma is fibrosis or arthro-fibrosis.
- 1953 - Laing P.G. examined the blood flow and found that genicular veins and soft tissue attachments provided a substantial blood supply, with no large vessels entering the distal femur.
- 1963 - Sir John Charnley recommended non-operative management for distal femur fractures.
- 1965 - Muller in his study, for supracondylar and intercondylar femur fractures recommended use of L shaped condylar plates.
- 1970 - In their first assessment, the AO group examined 112 patients who had supra-condylar fractures and were treated using the principles of precise anatomic reduction, solid fixation, and early mobilization. Of these patients, 73.5% had satisfactory or excellent outcomes.

- 1971 - The blade plate for osteoporotic supracondylar femur fractures was altered by Brown and Darcy.
- 1972 - Olerud's study demonstrates that 93% of fractures treated with condylar buttress plates resulted in favorable outcomes; nevertheless, the operation was technically complex and had a significant implant failure rate. In particular, the failure rate was high in osteoporotic bone.
- 1973 - Connoly suggested closed reduction and cast brace ambulation for femur fracture in his study.
- 1974 - Schatzker announced better outcomes with surgical techniques.
- 1974 - Neer used straight plates and screws for distal femur fractures and also classified supracondylar and intercondylar femur fractures and believed that conservative care was preferable to internal fixation.
- 1977 - P. Benum conducted research on the use of bone cement in addition to internal fixing for supracondylar fractures in 14 female osteoporotic patients. The application of bone cement did not seem to prevent the process of healing. However, the application of bone cement did not appear to significantly influence the development of periosteal bone. It was difficult to assess the exact extent of the fracture healing radiologically as some parts of the fracture space were hidden. In fact, no cases of refracture indicate that firm osseous healing occurred.
- 1979 - Schatzker J - concluded that the results of blade plate fixation were better.
- 1980 - P Della Torre, P Aglietti, and M Altissimi, 48 supracondylar distal femur with rigid fixation. It confirms that supracondylar femoral fractures are severe lesions that are difficult to operate. 70% with excellent outcome, 20% with fair outcome and 6% with poor outcome. There were 100% successful outcomes for extra-articular simple or comminuted supracondylar fractures, while the

percentages for simple intercondylar fractures (87.5%) and intercondylar and comminuted supracondylar fractures (42.8%) declined considerably. In conclusion, we think that surgery is the best course of action for treating these fractures, notwithstanding the technical challenges involved. [48]

- 1984 - Retrograde intramedullary nailing was described by Swiontkowsi et al. in the medial femoral condyle, which is aligned with the coronal plane's femoral shaft center.
- 1984 - AO/ASIF The medial femoral condyle served as the entry point for the application of universal tibial and femoral nails.
- 1986 According to Regazonni, Ruedi, and Allgower, the primary disadvantage of the condylar screw implant was that it was known to cause varus collapse of the distal fragment and that it was more difficult to perform the procedure again because a large quantity of bone was removed during the condylar lag screw fixation. Supracondylar fractures of the femur were treated with the Dynamic condylar screw implant system.
- 1989 - Siliski et al. studied 52 femur cases with supra- and intercondylar fractures that were solely managed surgically and showed excellent to good outcomes in C1 (91%) and C2-C3. (77%).
- 1990- Distal femur fracture according to Muller classification (AO classification)
- 1991 – Interlocked intramedullary nailing was utilized by Mark S. Bulter et al. to treat distal femur fractures and ipsilateral femoral shaft fractures.
- 1991- The Supracondylar nail (retrograde interlocking nailing) was largely employed by Green S., Seligson D., Henry S., and Trager S.
- 1991- Double plating was utilized by Sanders, R. Swiontkowski to treat comminuted, unstable distal femur fractures.

- 2000 - In treating a supracondylar femur fracture in 11 preserved bodies, Meyer, Robert W. Nicholas and colleagues compared quantitatively the axial and torsional stiffness of a retrograde intramedullary nail and a fixed angle screw side plate. They discovered that the intramedullary nail's axial stiffness was 14% less, and the side plate's torsional stiffness was 17% less. The hardware was able to project into the articular space due to the distal axial failure of the intramedullary nail. Additionally, the side plate failed distally, causing the condylar screw to be displaced into a varus angulation. [49]
- 2000 - As the new AO plate standard, LCP was accepted.
- 2001 - Zlowodzki, Stannard J., Kregor P.J. M. shared preliminary findings about distal femoral characteristics using L.I.S.S. [26]
- 2001 - Marti et al. compared The biomechanical properties of the LISS plate compared to DCS and CBP. LISS allowed for higher elastic deformation compared to other systems since it was positioned between rigid fixation and intramedullary nailing.
- 2002 - 35 patients with 36 displaced distal femoral fractures (AO-Type C2 and AO-Type C3) were investigated by B. H. Ziran, R. H. Rohde, and A. R. Wharton. These patients had anterior approach treatment, double plating, bone grafting using allograft, and demineralized bone matrix. [7] In addition to increasing structural stability in the form of a 90–90 construct, the ability to supplement a lateral plate with an anterior plate allows for double plating via the anterior approach, which also minimizes any accidental stripping of the medial side and allows for excellent visualization and controlled access to the distal femur. [7] By 16 weeks, 24 out of 36 fractures had healed. Thus, the anterolateral approach was used to achieve the near-anatomical reduction with double plating, thereby

reducing medial side stripping and improving controlled access to the distal femur. The problem associated with this approach is indirect reduction is far too difficult. [7]

- 2003 - The invention of the locking compression plate was discovered by Frigg R.
- 2003 - Researchers Sommer C, Gautier, Muller M, Helfet Dl, and Wagner presented the locking compression plate's clinical outcomes.
- 2004 - Philip J. Kregor et al. had done a retrospective study on 103 patients with LISS and found excellent results in 93% of patients.
- 2005 - Sean E. Work and Daniel N. investigated the relationship between fractures in the coronal plane and supracondylar and intercondylar distal femurs.
- 2006 - In certain cases, Heather A. Vallier reported that the LCP condylar plate fixation failed in the distal portion of the femur.
- 2008 – Crist BD and Della Rocca GJs study showed that advancements in plating and nailing have enhanced distal femoral fracture treatment. Minimally invasive procedures offer biological benefits, reducing delayed union, infection, and bone graft requirements. Nonetheless, MIPO may lead to a higher mal-union rate and require technical skill. Prognosis appears more influenced by fracture type than implant choice.
- 2009 - G. Nabi et al. published comparative results between Bridge plate osteosynthesis using dynamic condylar screw (DCS) and retrograde intramedullary supracondylar nail and found 78% excellent results in the DCS group, whereas in nailing, it was only 60%.
- 2012 - Heather A. Vallier, had done a retrospective study on 37 patients with distal femur fractures with DFLP and found 35% complication rates.

- 2012 - Twelve patients with closed C3-type injuries were examined by Ayman El-Sayed Khalil and Mostafa Ahmed Ayoub for complex C3-type unstable distal femoral fractures; eight of the patients were male and had a mean age of 33.5 years. The mean follow-up was 13.7 months, with 8 instances undergoing surgery in the first week following injury and 4 cases in the second. [32] Anatomical reconstruction of C3-type complex distal femoral fractures was made possible by a highly invasive technique that used this modified Olerud extensile approach, with a lower predicted complication rate and a satisfactory clinical outcome. This technique provided an excellent reconstruction of the suprapatellar pouch area. It might be regarded as a backup plan for handling these challenging ailments. [32]
- 2014 - Shiblee S. Siddiqui et al. on 16 patients with distal femur fractures (AO type B) using locking plates and open reduction and internal fixation led to the recommendation that this type of surgery be used in cases of AO type B since it has a favorable prognosis, allows for early mobilization, and has few side effects. [50]
- 2014 - M Ehlinger et al., 92 patients with AO types A, B, and C were examined; locking plates made of titanium and stainless steel were used for elastic, stiff, and unusual fixation. The study's findings were modest, highlighting the seriousness of the fractures. The hardware and fixation method had no bearing on the radiological or clinical results.
- 2016 - 25 skeletally mature patients with post-traumatic distal femur fractures were included in a study by J.S. Virk et al. With a mean duration of a radiological union of 19 weeks, all patients accomplished the union by adhering to the principles of fracture reduction. The Neer score of 20 patients was rated as excellent to satisfactory, and the mean range of motion (ROM) was 109 degrees.

Nine of the cases in this study required further procedures; three also needed the initial insertion of antimicrobial cement beads and all required bone grafting. Throughout the trial, three patients experienced problems in the form of infection in two cases and mal-union in one case. This study found that, since the distal femur locking plate is the primary implant of choice for distal femur fractures of all kinds, positive outcomes can be achieved with this device alone. When fracture fixation is carried out according to all fundamental fracture fixing principles and makes use of a locking plate's mechanical qualities, the best results are anticipated.

- 2016 - In order to better understand the short-term clinical and radiological outcomes—specifically, the early complications and healing rate—Vishwanath C et al. studied fifty patients who had distal femur fractures (type A, B, or C) and were receiving DFLP and bone grafting when needed. [57] Patients' ages ranged from 22 to 74 years, with a mean of 44. The sample consisted of fifty patients, with 32 males and 18 females. The causes of fractures were motor vehicle accidents in 33 patients and falls in 17 patients. The operative time ranged from 60 minutes to 180 minutes. Patients were followed up from 01 to 24 months. [57] Functional outcome was rated as per Neer's rating score. They got excellent results in 19 cases, good in 20, fair in 08 and poor in 03 patients. They concluded that the DFLP is a good implant to use for fractures of the distal femur. However, accurate positioning and fixation are required to produce satisfactory results. [57] Their early results were encouraging, but long-term studies were needed to prove definitively acceptable outcomes so that the technique can become an integral part of the armory of an orthopedic trauma surgeon. [57]

- 2016 - The locking compression plates with the option of locked screws increased the rigidity of fixation in intra-articular fractures, according to research by Drs. Sarabjeet Kohli, Shaival Chauhan, and Nilesh Vishwakarma on comminuted distal femur fractures in 27 patients. Nevertheless, this is a technically challenging procedure. [42] The device helps with early mobilization even in cases with comminuted fractures, where alternative fixation methods often cause the mobilization process to be delayed due to instability. This is made possible by its triangular reconstruction principle. [42] They came to the conclusion that this fixation technique is particularly appropriate for fractures for which less invasive methods such as retrograde nailing and LISS would not be able to achieve articular surface congruency. [42]
- 2017 - A study by Poole et al. detailed the results of fixation with contemporary implants in the context of an early return to function strategy. [51] In 122 patients, a total of 127 fractures were found. There were 92 patients (75%) with a mean age of 72.8 years (16–101). [51] Sixty-seven percent of the cases were run by consultants, while the remaining cases were operated under direct consultant supervision. 107 patients (84%) could quickly support their entire weight. [51] Clinical and radiological union was observed in 81/85 (95%), and only 4 (3%) of the 127 fractures needed to be operated on again due to surgical failure. [51] The mortality rates after 30 days, 3 months, and 12 months were 6 (5%), 17 (15%), and 25 (22%), in that order. [51] They came to the conclusion that, similar to the group experiencing proximal femoral fractures, the incidence of distal femur fractures increases exponentially with age. [51] In these older patients, allowing immediate unrestricted weight-bearing following DFLP fixation did not result in

fixation failure. The unionization rate was high and the re-operation rate was low. [51]

- 2017 – According to a study by Ely, Jacob, and Yohai Steinberg, the failure rates of locked plating for treating distal femur fractures were comparatively low. It was frequently discovered that single lateral plating had a comparatively greater failure rate. Two patients received treatment for a non-union, and eight patients had stable implant fractures that were periprosthetic. With the exception of one patient who required bone grafting due to delayed union, two patients who experienced superficial wound infections, and one patient who needed medial plate removal following union owing to a deep infection, all fractures healed within 12 weeks. The findings suggest that the dual-plating method should be taken into account when treating distal femur fractures, especially in individuals with low periprosthetic fracture rates, comminuted fractures, and poor bone quality.
- 2017 - The operational outcomes of complex AO type C3 distal femur fractures fixed with a lateral locking plate using a modified swashbuckler technique were documented by Anuj et al. [52] They have used a modified swashbuckler technique to prospectively examine a series of 12 patients with complex AO type C3 distal femur fractures in order to ascertain the clinical and radiological prognosis following fixation with a single locked plate. [52] Depending on the fracture pattern, the extra-articular component was treated with either compression plating or bridge plating. [52] The Knee Society Score was used to calculate the clinical outcome after a year. [52] All fractures joined at a mean of 14.3 ± 4.7 weeks (range 6–26 weeks). Significant side effects like non-union, deep infection, and implant failure were absent. After three months, one of the patients had further bone

grafting. [52] The knee's range of motion was 120° ± 14.8°, with a range of 105° to 150°. At one year, the KSS showed that seven patients had exceptional, three had good, and two had a fair outcome. Three individuals had radiological indications of secondary osteoarthritis of the knee joint at a mean follow-up of 17.6 months. They came to the conclusion that most patients had satisfactory to outstanding outcomes at one year following difficult C3 type distal femur fractures that were treated with a single lateral locking plate utilizing a modified swashbuckler technique. [52]

- 2018 - The findings of a comparison study between the lateral technique and the Swashbuckler approach for distal femur fractures were published by R Ahire et al. Their study used the Swashbuckler and Lateral methods to prospectively analyze and compare a consecutive series of 60 patients with AO type B and C distal femur fractures in order to ascertain the clinic-radiological outcome following DFLP fixation. [53] The Neer's Score was utilized to determine the results of the routine follow-up, which lasted for a year. At a mean of 14.64 weeks (range: 12–20 weeks), all fractures joined. [53] The lateral approach group in their study had a longer mean operation duration (99.6 minutes) than the swashbuckler group. They came to the conclusion that, particularly in complex AO type C3 fractures, the operative results of distal femur fractures treated using a swashbuckler method are encouraging and on par with the standard lateral approach, with the majority of patients experiencing good to exceptional outcomes at one year. [53]
- 2018- A prospective case series of distal femoral fractures was published by Mohamed Imam and Ahmed Tories. [9] For the stabilization of C3-type distal femoral fractures, the procedure comprised an extended medial parapatellar anterior approach, a low-contact-locked medial plate, and a lateral distal femoral

locked plate with bone graft. According to the results, 70% of patients had well to excellent outcomes with no varus or valgus deformity, and during the course of the 12- to 14-month follow-up, range of motion was attained to 900 to 1200. [9] The anterior approach to dual plating fixation offers a number of benefits, including accurate exposure, ease of manipulation, anatomical reduction, and durable fixation. [9]

- 2018 – Bozkurt and Fettingolu, in retrospective evaluation, were made of 22 patients surgically treated with dual locking, low contact titanium plate, and screw for Type III periprosthetic fracture based on TKA. At 5 months, pain-free weight-bearing was established, and at 19–21 weeks, radiological union. The need for revision resulted from the non-union in 2. At the last follow-up exam, the mechanical axis revealed a corrective decrease in the mean knee valgus angle of 4.9° ± 1.5°, which was statistically significant but stayed within physiological bounds. Good clinical and radiological outcomes were attained when dual locking plates were used to treat periprosthetic femoral fractures resulting from TKA with osteoporosis. These plates offered the benefits of firm fixation as well as early and efficient rehabilitation.
- 2023 - Mukund Pai Manjeswar and Amit Kale studied 50 patients with distal femur fractures treated with dual plating in a prospective case series and concluded that outcomes were better for fractures of the distal femur when treated with dual fixation, probably due to superior fixation and earlier postoperative mobilization. [33]

4.) ANATOMY

BONE

The medial and lateral condyles of the distal femur are what give rise to the knee joint through their articulation with the patella and tibia. At the end of the femur are rounded regions called medial and lateral condyles. While the front surface articulates with the patella, the posterior and inferior surfaces articulate with the menisci over the tibia plateau of the knee.

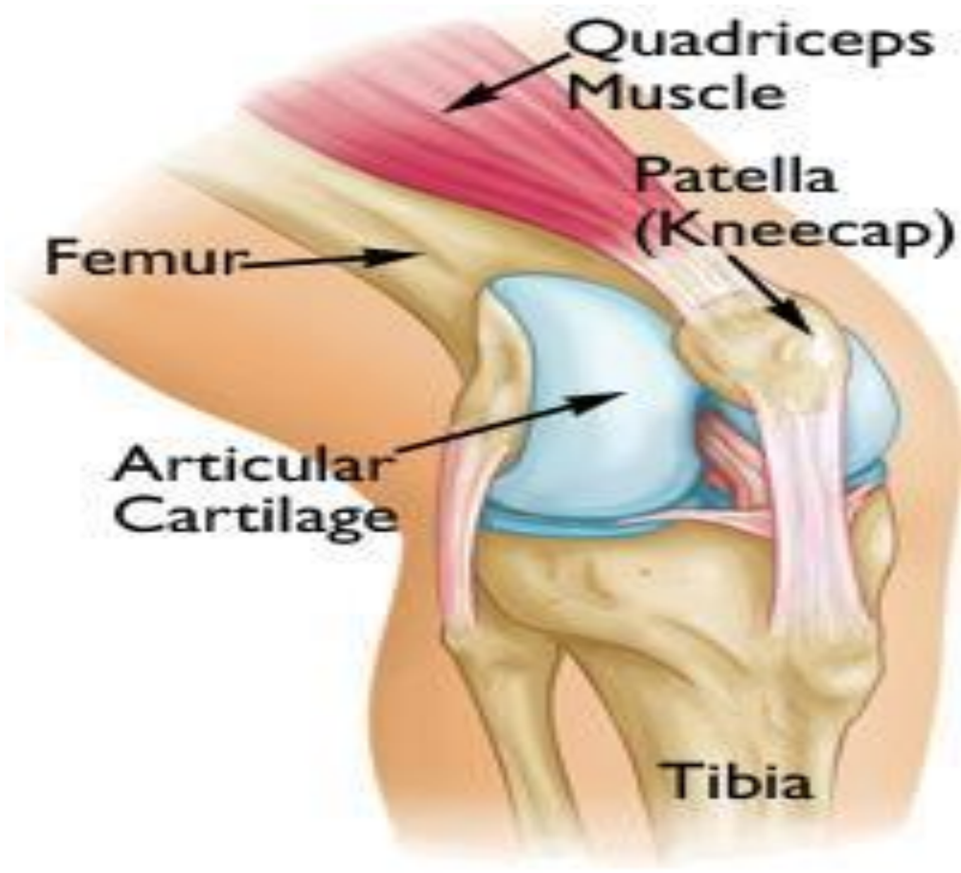


Fig 4.1 Knee joint

The medial condyle is longer and extends more distally than the lateral femoral condyle. The medial collateral ligament attaches to the convex outer aspect of the medial condyle through an epicondyle. The adductor magnus is inserted into the medial condyle, where the adductor tubercle is located on the proximal medial surface. The rear of the medial condyle gives rise to the gastrocnemius' medial head. Compared to the medial condyle, the lateral condyle is larger and stouter.

The lateral condyle is located more anteriorly in the coronal plane than the medial condyle. It prevents the lateral displacement of the patella. The fibular collateral ligament is attached to the most prominent part of its lateral surface, the lateral epicondyle.

The distal femur is trapezoidal in shape in axial view, with the greatest dimension located posteriorly and narrowest anteriorly. There is a 5–11° valgus deviation in the distal femur's anatomical axis, which is produced between the diaphyseal axis and the distal joint line. The medial wall inclines 25 degrees, and the lateral wall inclines 10 degrees.

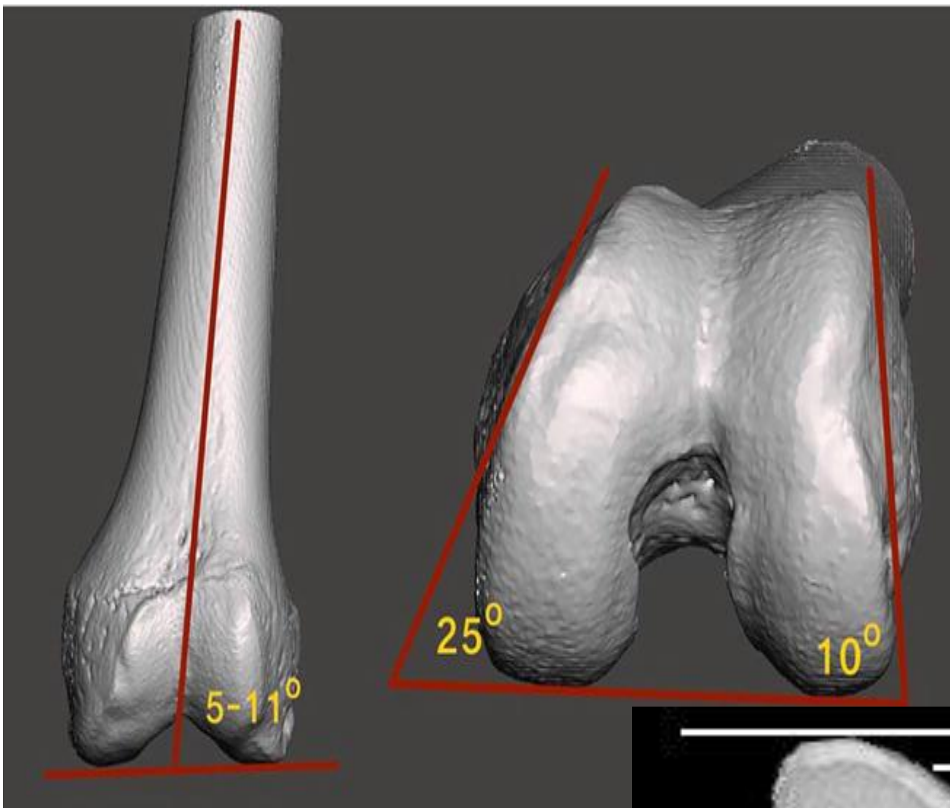


Fig 4.2 The anatomical axis of the femur is aligned at 5-11^0 with the distal joint line, in the transverse plane distal femur is trapezoidal in shape

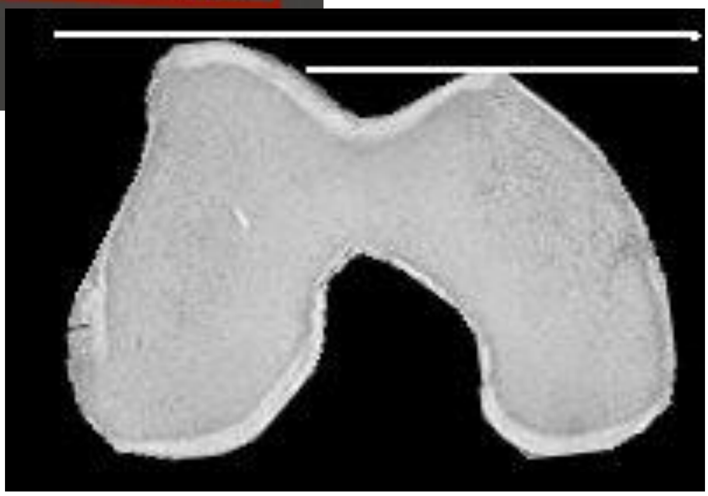


Fig 4.3 in the coronal plane lateral condyle is more anterior than the medial

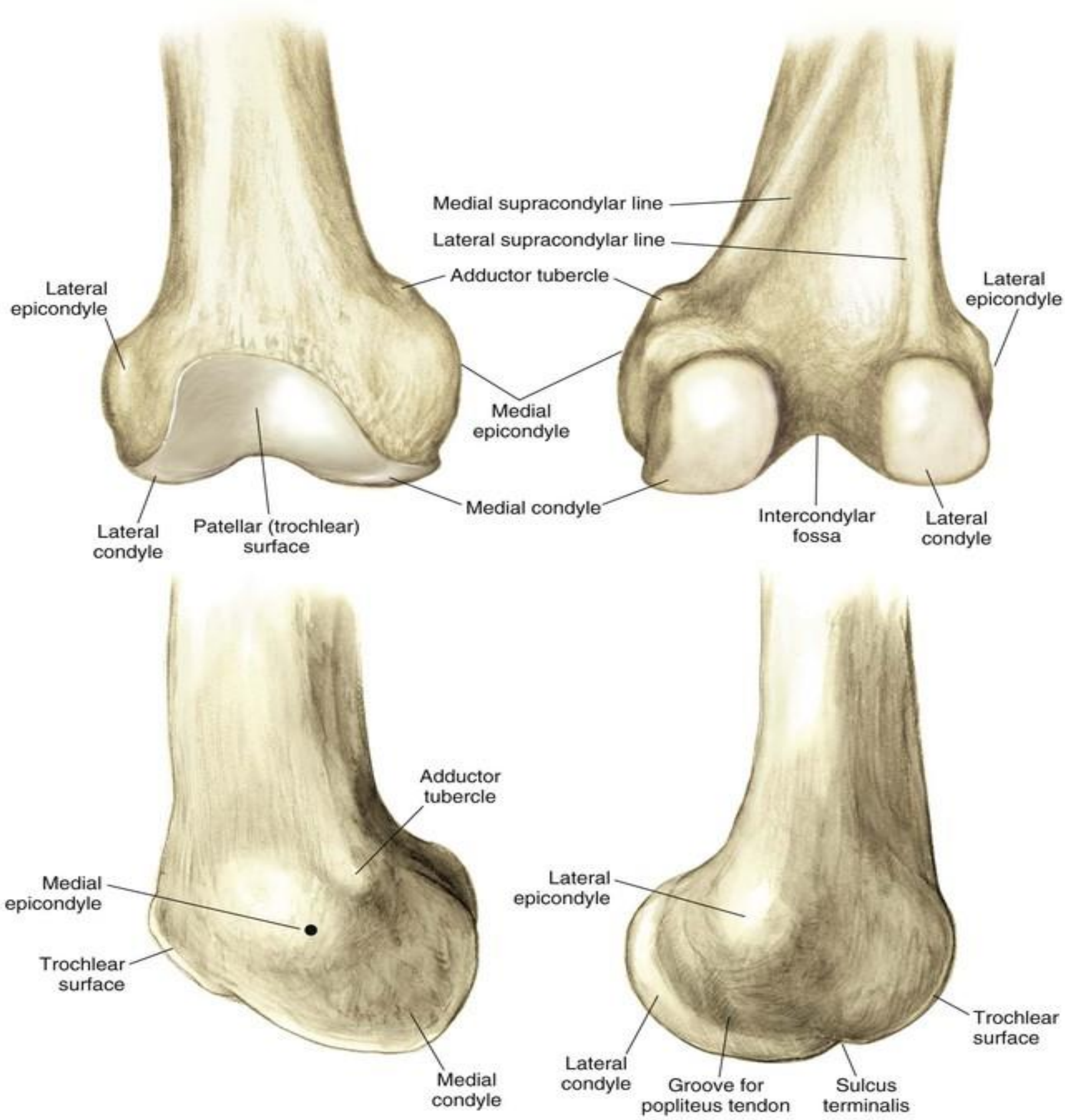


Fig 4.4 Anterior, posterior, medial and lateral view of the distal femur

The anatomical axis, or the angle formed between the femur shaft and the knee joint, has an average valgus angulation of 9 degrees. The anterior two-thirds of the condyle and the femur shaft are aligned in the sagittal plane. Both mediolaterally and anteroposteriorly, the tibial articular surface is convex. The intercondylar fossa is a depression that sits between the two condyles on the posterior aspect of the femur. It has two faces on which the internal knee ligaments can attach.

The medial wall of the intercondylar fossa contains the facet where the posterior cruciate ligament attaches. The location of the posterior cruciate ligament of the knee is a big, rounded, flat face.

A smaller facet than the one on the medial wall of the intercondylar fossa is located on the lateral wall and serves as the attachment point for the anterior cruciate ligament. It is the location of the knee's anterior cruciate ligament attachment.

MUSCLE ATTACHMENTS OF FEMUR

- Pectineus muscle inserts into the pectineal line. [54]
- Adductor longus and adductor brevis muscles inserts into the femur's medial ridge of linea aspera. [54]
- Adductor magnus muscle inserts into the medial ridge of linea aspera and the adductor tubercle of the femur. [54]
- Vastus lateralis muscle arises from the greater trochanter and lateral ridge of linea aspera. [54]
- Vastus intermedius muscle arises from the front and lateral surface of the femur.
- Vastus medialis muscle arises from the distal part of an intertrochanteric line and medial ridge of linea aspera of the femur. [54]
- The short head of biceps femoris arises from the lateral ridge of linea aspera.
- Popliteus muscle arises from under the lateral epicondyle of the femur.
- Articularis genu muscle arises from the lower 1/4 of the anterior femur deep to the vastus intermedius. Gastrocnemius muscle arises from behind the adductor tubercle, over the lateral epicondyle and the popliteal notch. Plantaris muscle arises from over the lateral condyle of the femur. [54]

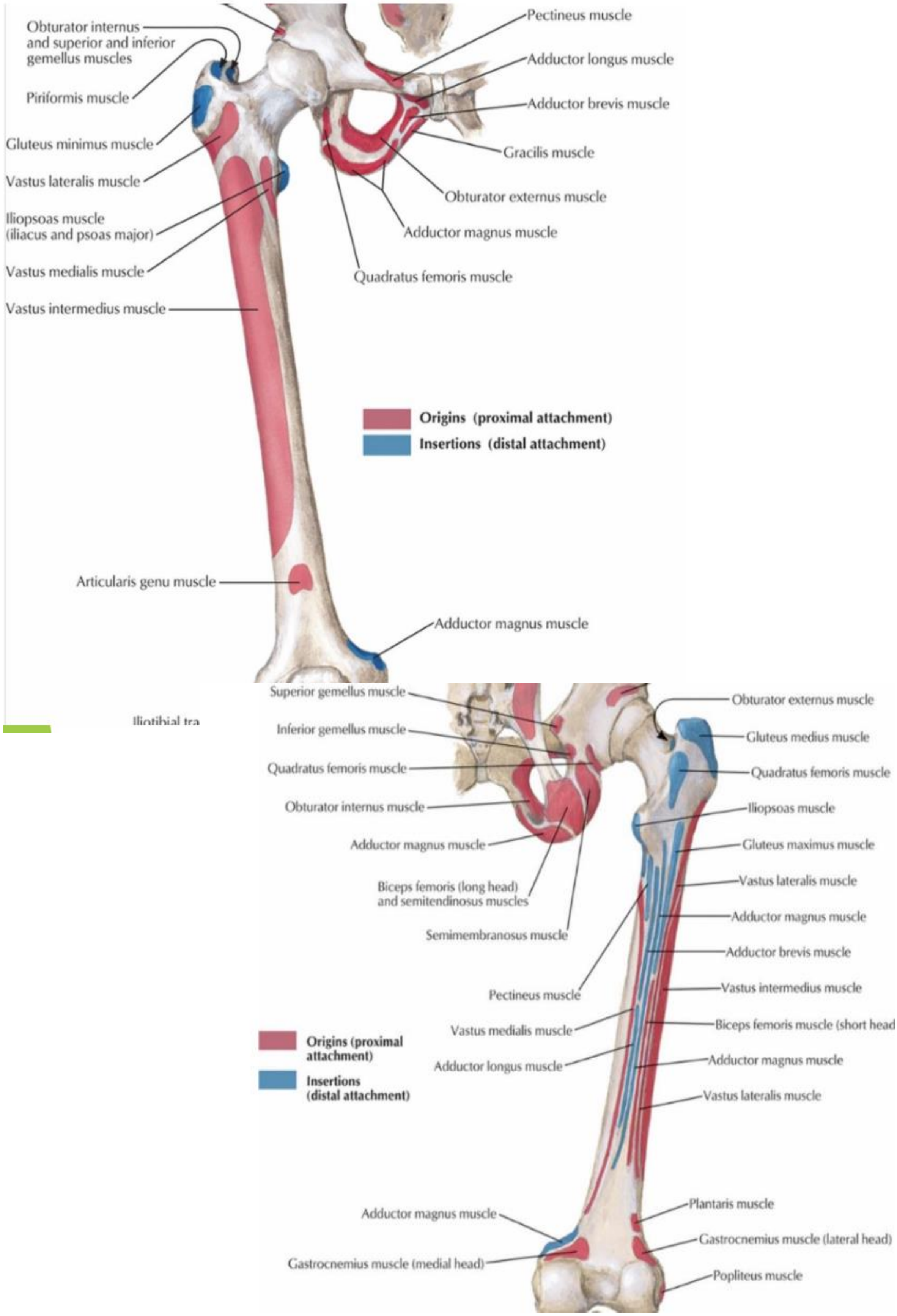


Fig 4.5 Muscular attachments on distal femur

DYNAMIC FORCES AROUND THE DISTAL FEMUR

The thigh muscles are split into 3 compartments: anterior, medial and posterior.

1.) Strong muscles of the thigh

The quadriceps femoris, sartorius, and pectineus are located in the anterior compartment. The iliopsoas also passes through the anterior compartment. [54]

The femoral nerve (L2-L4) supplies the anterior compartment. [54]

2.) Muscles of Posterior Compartment

Muscles in the posterior compartment include the hamstrings group, Semitendinosus, biceps Femoris and Semimembranosus. [54]

Muscles are innervated by sciatic nerve(L4-S3).

3.) Muscles of the Medial Compartment

Muscles of the medial compartment include the hip adductors- gracilis, adductor brevis, adductor longus, adductor magnus and obturator externus. [54]

The obturator nerve innervates muscles.

LIGAMENTOUS ATTACHMENTS

The femur and tibia are more conformably shaped by the lateral and medial meniscus formation. The plateau rises into the intercondylar prominence between the condylar surface. The proximal borders of the femoral condyles and the intercondylar area are where the knee joint capsule is joined posteriorly. The capsule is fastened proximally to the popliteus tendon groove.

Above the patella is a deficiency in the anterior connection of the capsular bone.

The tibial collateral ligament is a flat, triangular band situated beneath the upper portion of the tibia's medial surface and superiorly inserted above the medial femoral condyle.

Attached proximally to the lateral epicondyle is the fibular collateral ligament resembles a cord and is situated above the popliteus tendon and below the lateral head of the gastrocnemius. It is attached distally to the fibula's head.

Anterior and posterior (2 pairs) cruciate ligaments are very strong ligaments connecting the tibia to the femur. They are extra synovial and intracapsular. [54]

Between the attachments of the anterior horns of the medial and lateral menisci, on the anterior portion of the tibial plateau, is where the anterior cruciate ligament is attached.

It attaches to the postero-medial side of the lateral femoral condyle and ascends postero-laterally.

A smooth impression on the posterior surface of the tibial intercondylar region is where the stronger and shorter posterior cruciate ligament is joined. It ascends anteromedially and is attached to the anterolateral aspect of the medial femoral condyle.

The medial meniscus is almost semicircle and is broader posteriorly. Its anterior horn is attached to the intercondylar area in front of the anterior cruciate ligament, while the posterior horn is similarly attached in front of the posterior cruciate ligament.

The lateral meniscus is about four-fifths of a circle. The posterior horn is attached in front of the posterior horn of the medial meniscus, and the anterior horn is attached to the front of the tibia's intercondylar eminence.

The retrograde supracondylar nailing's intra-articular entry point is located around 5 mm anterior to the posterior cruciate ligament's attachment in the intercondylar notch.

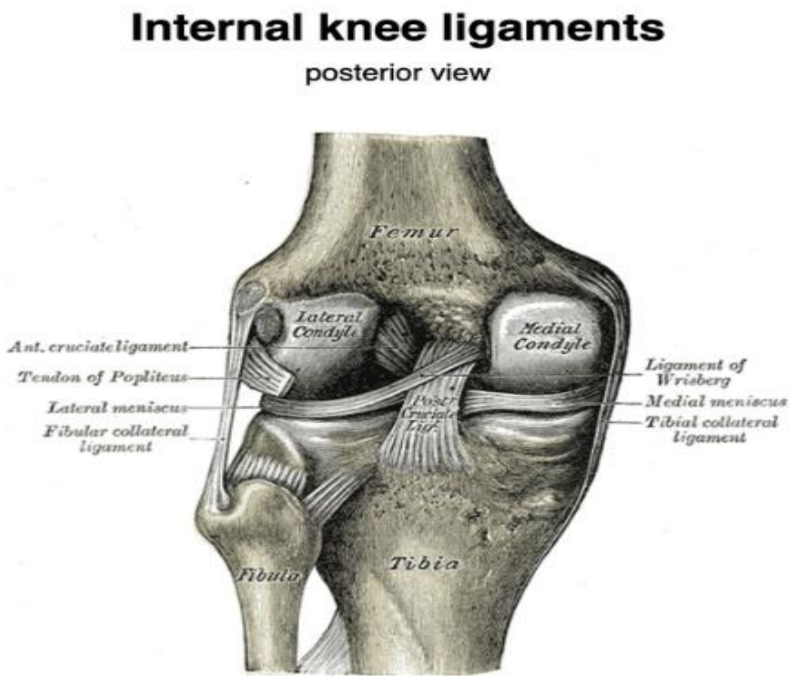


Fig 4.6 Ligaments around the knee joint and their attachments

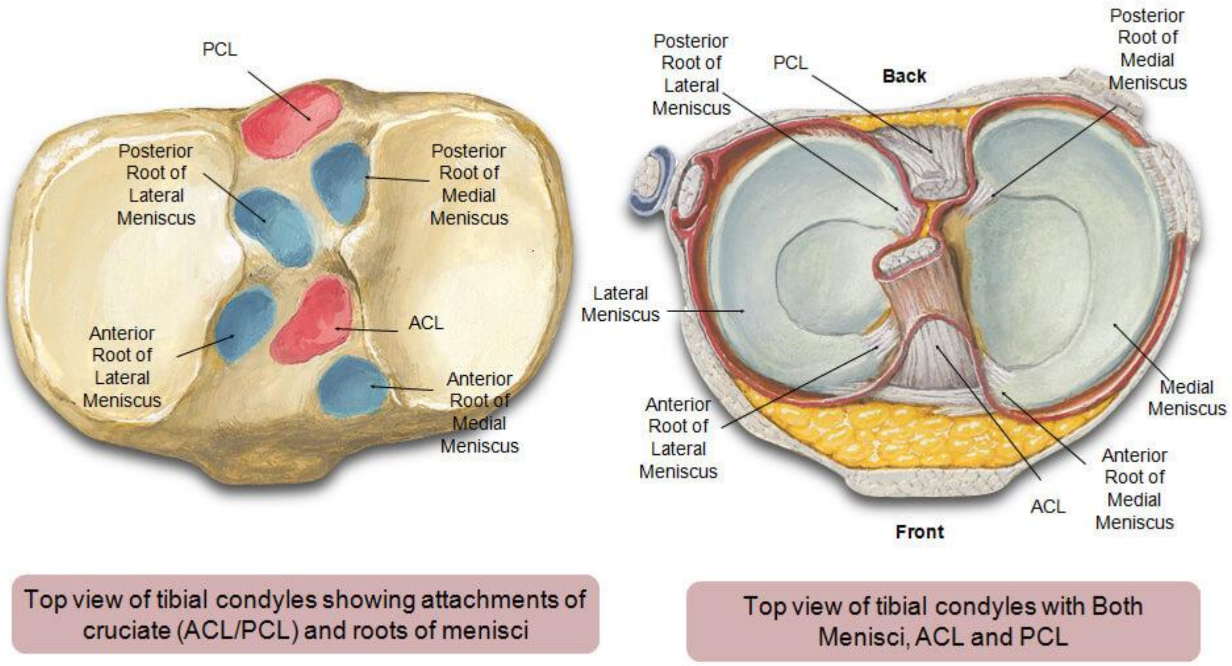


Fig 4.7

BLOOD SUPPLY

The popliteal artery's five genicular collaterals are the main contributors. Because it devitalizes the skin, subcutaneous dissection should not be performed on the anterior approach to the knee, superficial to the face layer.

The second perforating tributary of the femur's distal end is where the nourishing artery to the bone begins. The nutritional foramen is directed superiorly on the medial aspect of the linea aspera.

The lower end has a rich blood supply through genicular vessels. The lower end ossifies from a single secondary ossification center appearing at the 9th month of intrauterine life, and it gets fused by the 20th year.

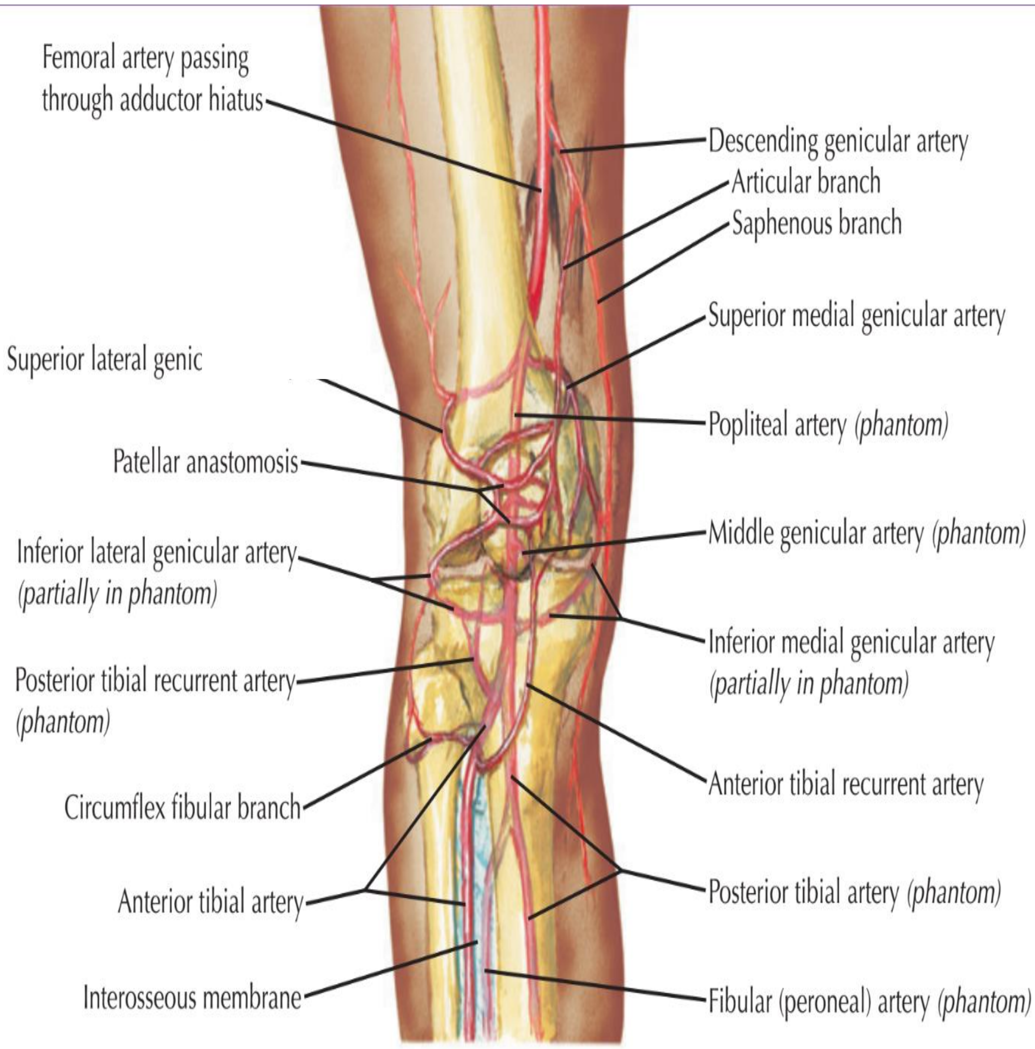


Fig 4. 8 Blood supply of distal femur

NERVE SUPPLY

The femur joint receives nerve supply from several sources: the femoral nerve branches out to the three vasti muscles from the lumbosacral plexus, while the sciatic nerve provides genicular branches through its deep tibial and common peroneal components. Additionally, the obturator nerve contributes via a branch from its posterior division.

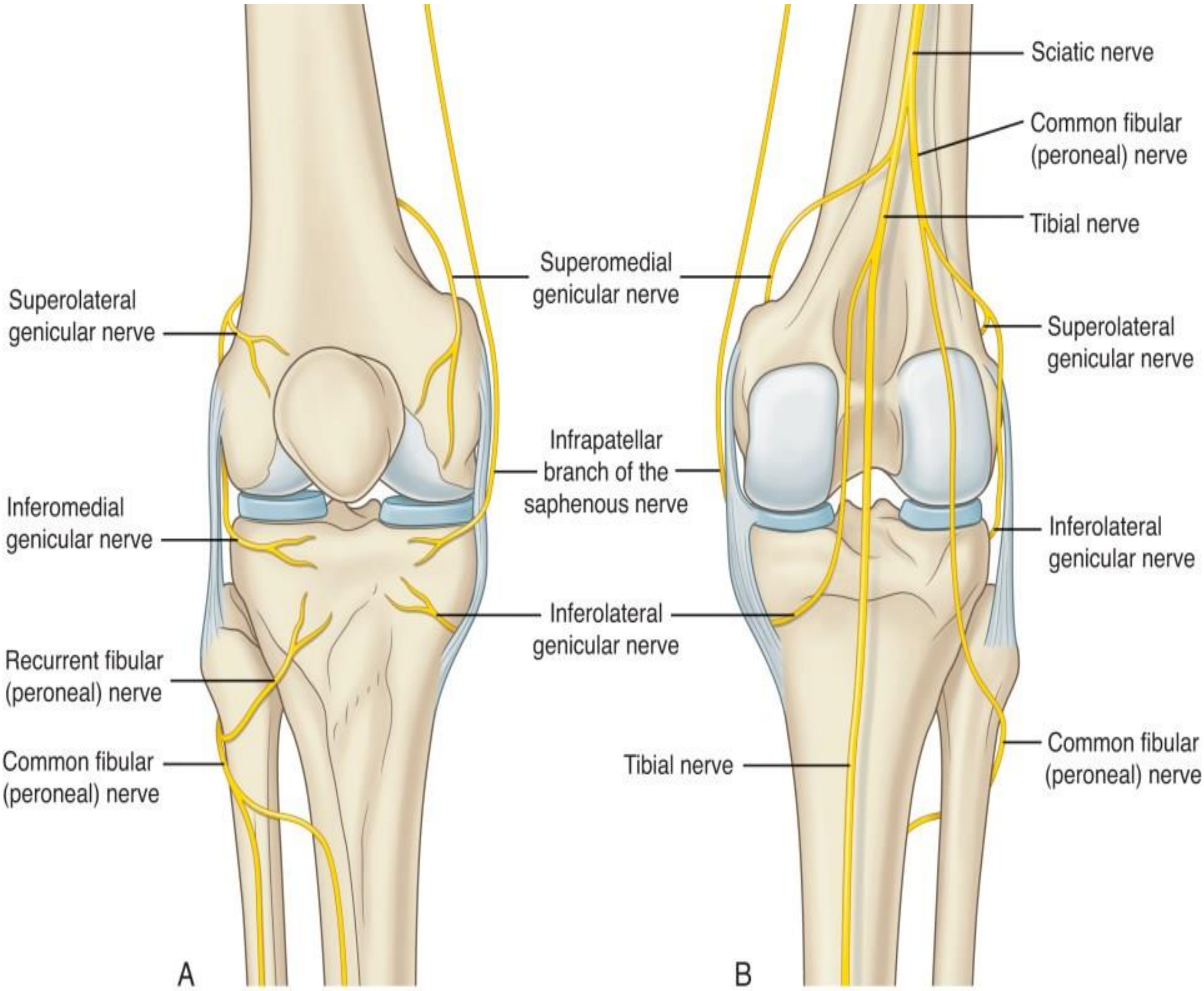


Fig 4.9 Nerve supply of distal femur

BIO-MECHANICS OF INJURY

The majority of fractures to the distal femur occur from significant valgus, varus, or rotational force combined with axial strain. This kind of force is usually the consequence of high-velocity trauma in the younger age groups, such as motor vehicle accidents and falls resulting in a bent knee. [55]

Following a fracture, the distal fragment's posterior deviation and femoral shortening with posterior angulations typically cause the abnormalities that are seen. [55]

The sources of these deforming stresses are the quadriceps femoris, gastrocnemius muscles, and posterior muscle group hamstrings. The pull of the adductor muscles may cause varus deformity. Due to the gastrocnemius muscles' distinct attachments to each condyle, rotational misalignment of the condyles (and consequent joint incongruity) is frequently seen in cases of intercondylar fractures. [55]

The axial bending loads applied to the femur in the production of a supracondylar fracture may produce additional injuries to the same extremity. [55] Both a physical examination and radiographic evaluation are necessary to determine whether the acetabulum, femoral neck, or shaft are fractured. An applied valgus or varus stress to the knee may cause a related ligament injury. Conversely, the same load may cause the tibial plateau or shaft fractures. Five to ten percent of all supracondylar fractures result in an open fracture. Patients often have some injury to the distal quadriceps muscle or tendon since the open incision most frequently occurs over the anterior thigh, close to the patella. [55]

Due to their near proximity to the fracture site, the femoral and popliteal arteries are susceptible to injury, but the likelihood of these arteries suffering an associated injury is minimal. When a concomitant posterior dislocation of the knee occurs, the popliteal artery is more frequently injured. [55]

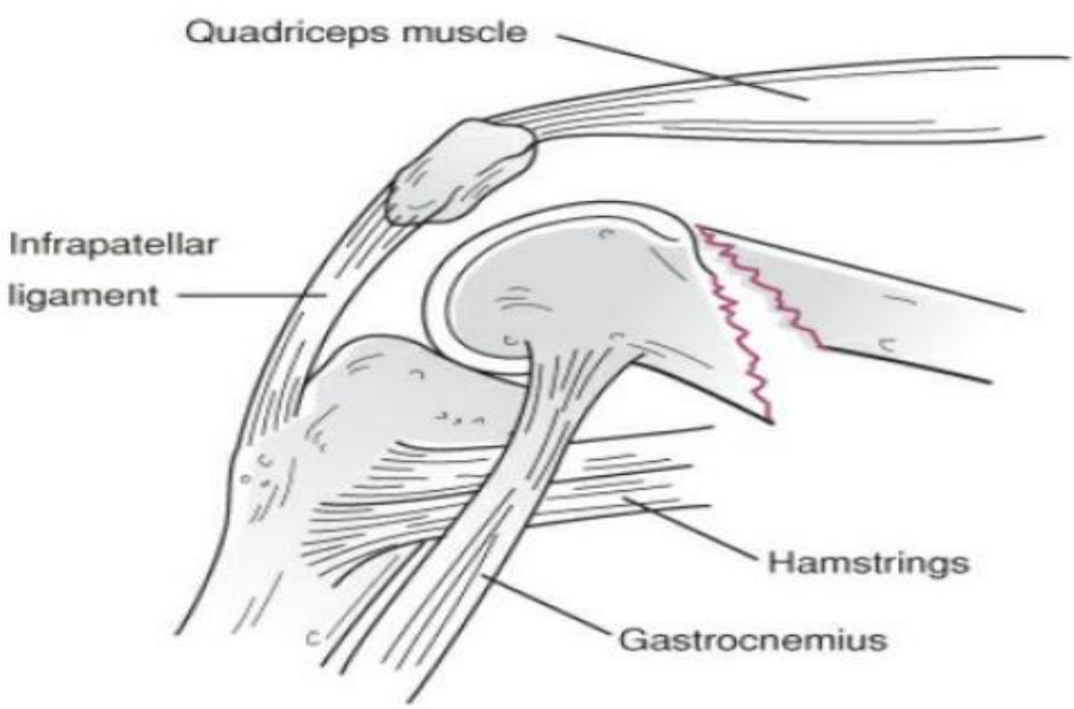


Fig 4.10 Forces acting on the fracture fragments

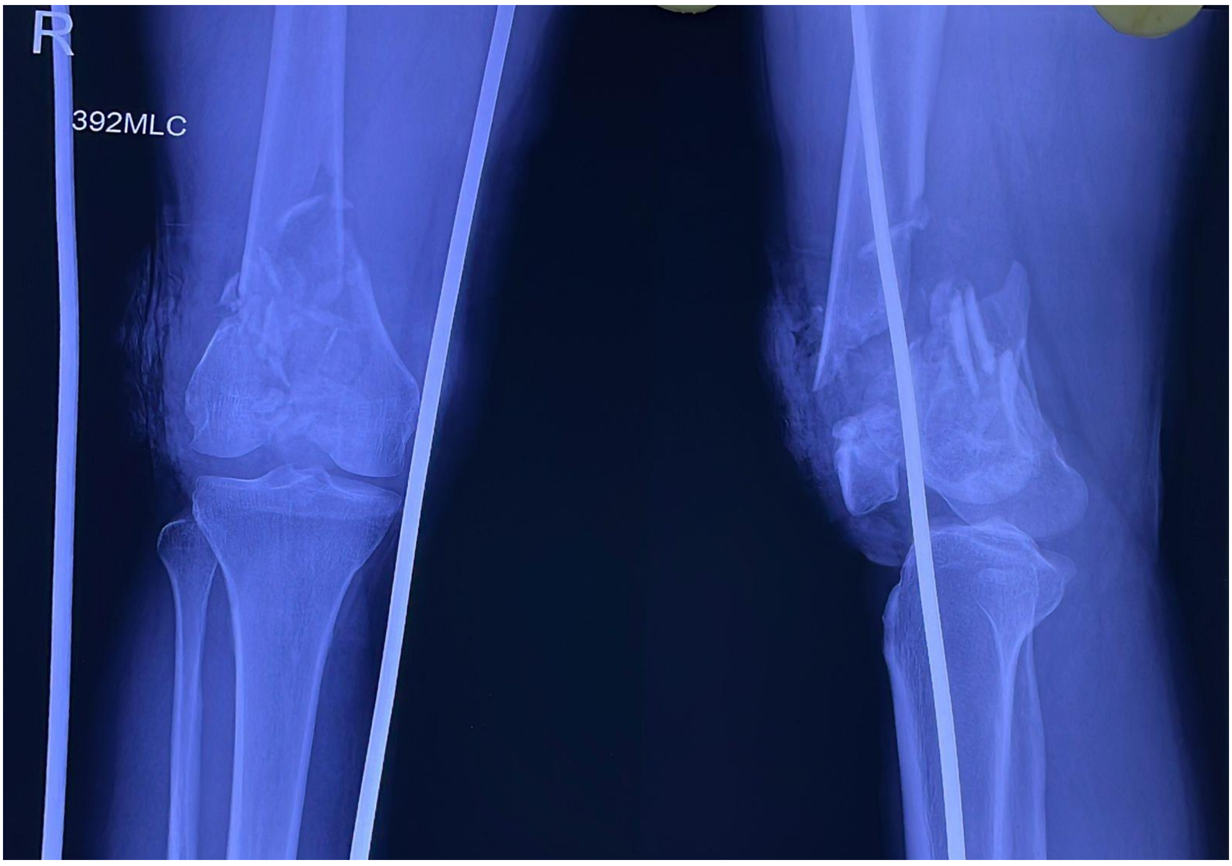


Fig 4.11 X-ray showing such deformity pattern

CLASSIFICATION

Classification for distal femur fractures should

1. Distinguish possible injuries to this area, including extra-articular, intra-articular and isolated condylar lesions.

2. Allow different surgeons consistently & reliably to grade a fracture pattern into one of the classification patterns.

3. Assist in deciding the method of treatment.

4. Correlate with findings of outcome analysis.

Many classification systems have been used, like Neer's, Schatzker and Tile, Seinsheimer and Muller et al. The most widely accepted and used is that of Muller et al.

I. NEER CLASSIFICATION [56]

1. Minimal displacement

2. Displacement of condyles Medial-Lateral

3. Concomitant supracondylar and shaft fractures.

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

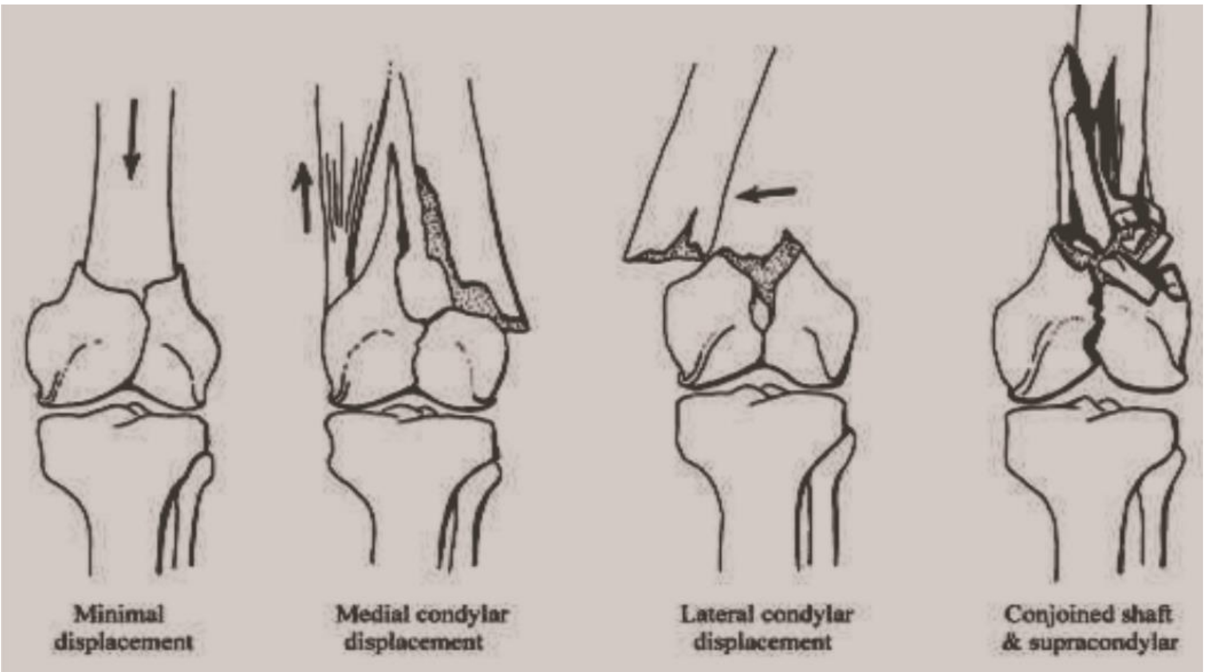


Fig 4.12 Neer's classification of distal femur

II. SEINSHIEMER CLASSIFICATION: [56]

1) Non-displaced fracture Any fracture with less than 2 mm of displacement of fractured fragments.

2) Fractures involving only the distal metaphysis without extension into the inter-condylar region.

a) Two Part fracture

b) Comminuted fractures

3) Fractures involving the intercondylar notch in which one or both condyles are separate fragments.

a) The medial condyle is a separate fragment; the lateral condyle remains attached to the femoral shaft.

b) The lateral condyle is a separate fragment; the medial condyle is intact.

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

4) Fractures extending through the articular surface of the femoral condyles

a) Fracture through the medial condyle (two parts are comminuted)

b) Fracture through the lateral condyle (two parts are comminuted)

This classification is exhaustive and is no longer used.

III. AO /ASIF CLASSIFICATION-MULLER CLASSIFICATION: [56]

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

AO Classification based on Muller et al. is as follows: [56]

A Extra-articular fracture

A1 Extra-articular fracture, simple.

A2 Extra-articular fracture metaphyseal wedge.

A3 Extra-articular fracture metaphyseal complex.

B Partial-articular fracture

B1 Partial articular fracture, lateral condyle, sagittal

B2 Partial articular fracture, medial condyle sagittal

B3 Partial articular fracture, frontal

C Complete articular fracture

C1 Complete articular fracture, articular simple, metaphyseal simple

C2 Complete articular fracture, articular simple, metaphyseal multifragmentary.

C3 Complete articular fracture multi-fragmentary.

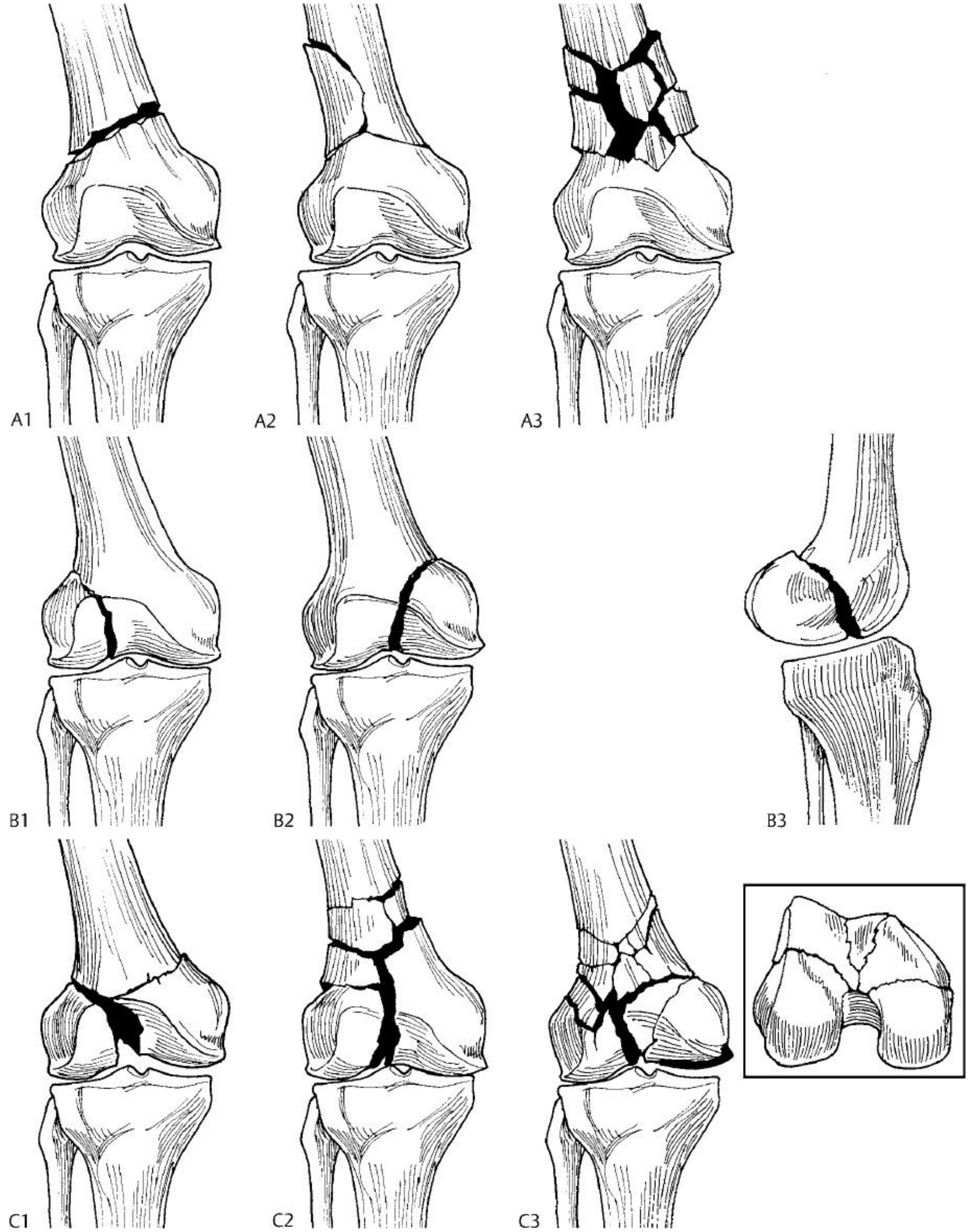


Fig 4.13 AO/OTA classification of distal femur

This classification is widely accepted, and although the classification is complex, the severity of the fracture progressively increases from one type to the next. We have followed this classification in our study. [56]

5.) FIXATION METHOD AND IMPLANTS

Due to a dearth of suitable internal fixation treatments for this type of fracture, conservative methods such as traction of the affected limb and cast bracing yielded better results in the 1960s than operative care.

In the 1980s, newer internal fixation devices started to alter the available treatment options. One of the earliest tools for treating distal femur fractures was the angle blade plate created by the AO group, which was widely accepted. A less technically difficult device called a Dynamic Condylar screw was introduced since the original device was too complex.

The Condylar Buttress plate was introduced to address the issue of fractures that could not be repaired using either the Dynamic Condylar screw or the Condylar Blade Plate.

Intramedullary nailing produced greater biological fixation; hence, it was utilized to treat distal femur fractures. Retrograde nails have been designed specifically for insertion through intercondylar notch for the treatment of supracondylar and intercondylar femoral fractures, which mostly involve Type A and B of AO/OTA.

For more robust fixation and improved support, medial buttress plating (LCP) or dual plating with an anatomical lateral locking plate (lateral buttress plate) is the optimum course of treatment for distal femur fractures with intraarticular extension and medial comminution (Type C III).

Fig 5.1 Distal femur anatomical lateral locking plates

Fig 5.2 Distal femur anatomical medial locking plates

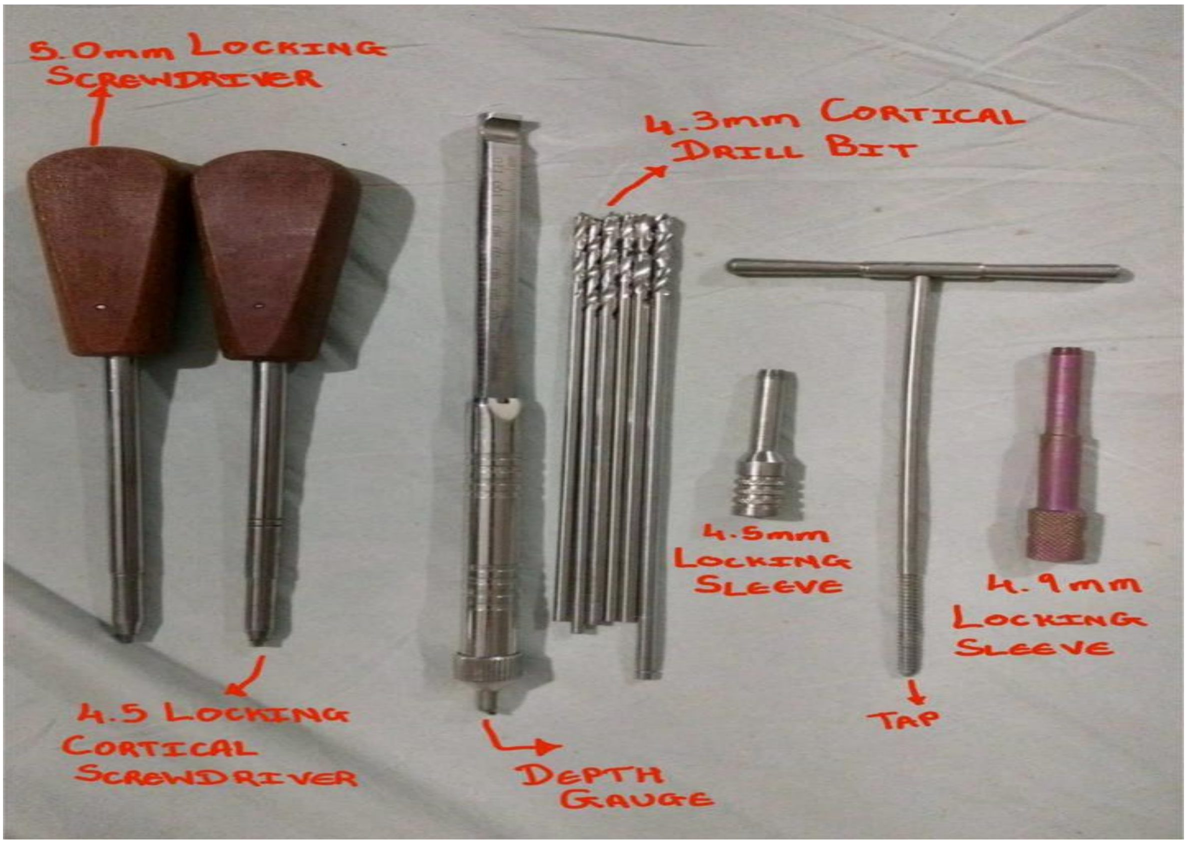


Fig 5.3

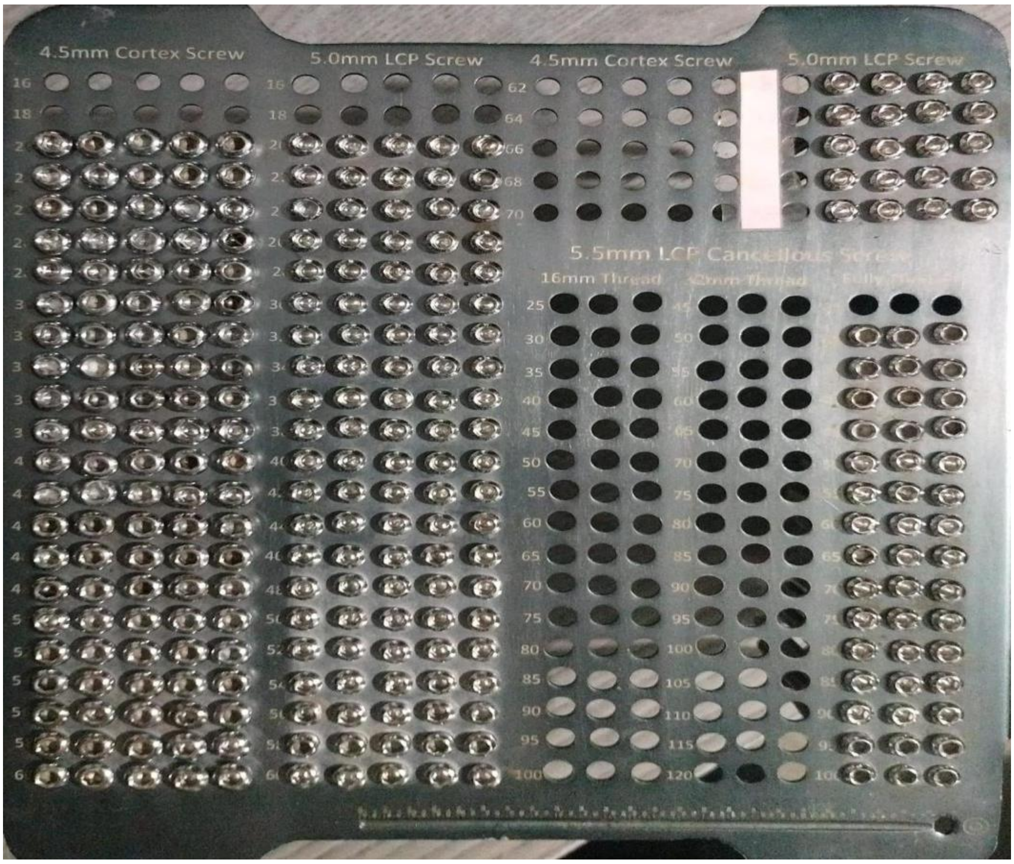


Fig 5.4 4.5mm cortical screws, 5mm locking cortical screws, and 5 mm locking cancellous screws

OPERATIVE MANAGEMENT FOR DISTAL FEMUR FRACTURE

Goals of Operative treatment of distal femur fracture:

a) Fracture alignment should be anatomical

b) Stable fixation of the fractures

c) Early Mobilization and range of motion of knee joint

d) Early functional rehabilitation of joint by physiotherapy

Since 1970, all research comparing the outcomes of conservative and surgical approaches has favored surgical stabilization of distal femur fractures. As surgical methods and implant technology have advanced over the previous 25 years, internal fixation of displaced fractures of the lower end of the femur has become increasingly accepted.

The implants that are most frequently used include locking compression plates (LCP), supracondylar nailing, dynamic condylar screws (DCS), and dynamic condylar plates (DCP). When there is 34 centimetres or less of intact femoral condylar bone present in a fracture, as well as when there is significant articular comminution, blade plates and condylar screws should not be used. The most frequently utilized implant is the Condylar Buttress Plate (CBP). Hence, dynamic condylar blades and dynamic condylar screws are best for 33 type A (AO/OTA) and particularly for types 33A2 and 33 A3.

The iliotibial sliding over the prominent edge of the implant, causing extreme irritation, is one of the knee symptoms caused by DCS shoulder, which is more evident than that of an angled blade. The condylar screw may not offer as much rotational control of the distal fragment in low supracondylar fractures as the 95° CBP.

Potential drawbacks are linked to the retrograde supracondylar nail's architecture. Knee stiffness, knee sepsis, patella femoral degeneration, and synovial metallosis are the consequences of the intraarticular part.

The locking compression plate system resembles traditional plate fixation methods in many ways, with a few notable changes. These include locking screws that offer a fixed-angle design and improved adhesion in osteoporotic bones.

The advantages of locking compression plates over other implants are:

1. The screws do not rely on plate-to-bone compression
2. Improved fixation for Type C3 fractures is possible with multiple screw fixation in the distal femoral condyle.
3. There is no need for intra-operative contouring because the anatomically shaped distal end is contoured to match the distal femur.
4. In addition to a locking mechanism, combi-holes feature extra dynamic compression holes that offer alternatives for axial compression.
5. By keeping the proximal fragment and plate apart until the locking screw is inserted, which preserves alignment, lateralization of the proximal femur is avoided.

The medial cortical buttress is functionally lost in distal femur fractures with substantial metaphyseal comminution, osteopenic bone, and high-energy fractures. The likelihood of the medial column recovering in these circumstances is reduced. A medial plate increases stability and lowers the likelihood of implant failure. It is found that additional medial plating with bone grafting is needed for a non-union distal femur with medial bone loss of more than 2 cm.

6.) APPROACHES TO DISTAL FEMUR

Numerous surgical approaches are available to expose the distal femur. Such as:

A. Lateral (Most Commonly used)
B. Anterolateral approach (Swashbuckler approach)
C. Minimally invasive plate osteosynthesis(MIPO)
D. Anterior midline approach; Lateral and Medial para-patellar arthrotomy
E. Medial sub-vastus approach
F. Y-shaped skin incision by Olerud.

A. LATERAL APPROACH

Indication: ORIF with plating for Type A fracture

Simple distal femur articular fractures can be visualized, reduced, and fixed with the lateral approach. [58] The lateral method uses a lateral arthrotomy for joint visualization and an atraumatic elevation of the vastus lateralis from the lateral face of the distal femur. [58] The same method can be used to apply lateral plates and reduce arthritis. [58]

The skin incision bends proximally along the lateral femoral condyle after starting at the mid-lateral line of the femoral shaft at Gerdy's tubercle. [58] The fracture's most proximal extent determines the skin incision's proximal beginning location. [58] Depending on whether an arthrotomy is required, a distal extension of the skin incision may be required. If joint visualization is needed, the incision is made up to the level of Gerdy's tubercle (dashed line). You can stop the skin incision 1-2 cm distal to the joint line if an arthrotomy is not required. [58]

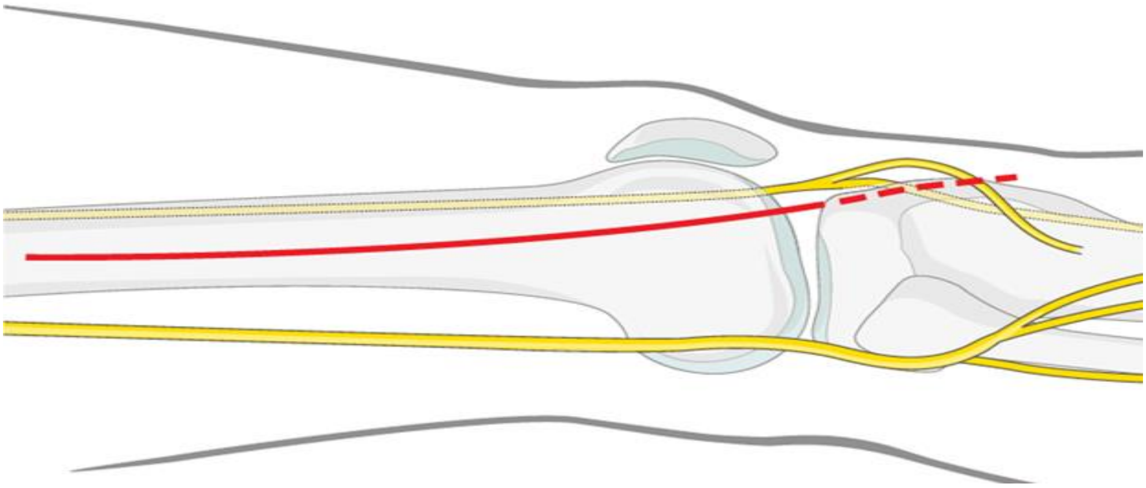


Fig 6.1 Bony landmarks for Lateral approach to the distal femur

Line up the skin incision with the iliotibial band's (tract) incision. The fibers distally slope anteriorly in the direction of Gerdy's tubercle. The iliotibial band should be separated into a single, accurate incision to enable flawless closure. [58]

In the distal 8–10 cm of the femur, very few vastus lateralis muscle fibers are located beneath the iliotibial band. Working from distal to proximal, cut the muscle fascia enveloping the vastus lateralis anteriorly to the lateral intermuscular septum and elevate the muscle fibers off the septum. [58] This is most easily achieved by using a huge elevator. Pull the vastus lateralis backward and to the side.

It is necessary to ligate several profunda femoris artery and vein perforating vessels. Excessive bleeding will occur if this isn't done.

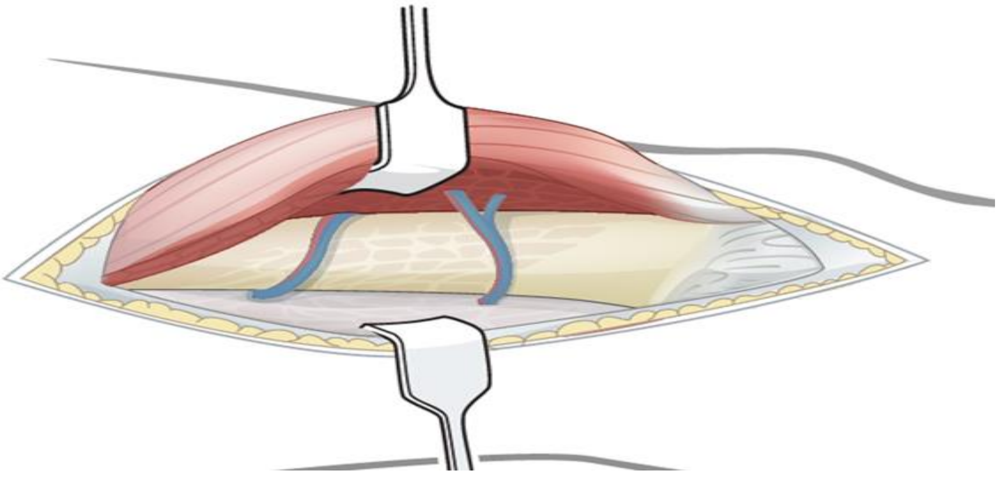


Fig 6.2 Perforating arteries and veins of profunda femoris visualized by retracting vastus lateralis

Distally, incise the joint capsule over the anterior third of the lateral femoral condyle.

This joint arthrotomy can be carried distally as far as the lateral meniscus. [58]

B. ANTEROLATERAL APPROACH (SWASHBUCKLER)

Indication: ORIF for type 33 C2 and C3 fractures.

The lateral aspect of the tibial tuberosity is where the skin incision is performed first. It began at the base of the patella and traveled a small distance, perhaps five fingerbreadths, to reach the anterolateral side of the thigh, which is along the posterior depression of the vastus lateralis. The incision is given along the anterolateral aspect of the femur as proximal as needed.

Initially, a deep incision was made all the way to the quadriceps fascia, exposing the fibers of the quadriceps muscle. The iliotibial band was then laterally retracted and the vastus lateralis muscle was separated sharply from it. The anterior and posterior compartments of the thigh are divided by the lateral intermuscular septum, which is normally directly related to the iliotibial band distally at the level of the patella. The septum was divided from the vastus lateralis using a blunt dissection, and the surgeon used this to expose and visualize the anterolateral aspect of the femoral shaft as needed. The distal femur was exposed, and the quadriceps muscle was moved medially using Hohmann retractors after the vastus lateralis had been separated from the lateral intermuscular septum. The lateral portion of the quadriceps extension, the lateral patellar retinaculum, the lateral superior genicular artery, and the underlying intermuscular septum between the vastus lateralis and rectus femoris are all visible when the iliotibial band (ITB) is retracted, and the deep fascia is severed.

Prior to its ligation and union with the anastomotic lateral circle, the superior lateral geniculate artery was located.

Three sequential steps are performed to improve access to the distal femur.

1. Intermuscular septum is incised. The lateral edge of the distal section of the vastus intermedius is incised to reveal the underlying bone upon reaching the underlying layer.

2. Sharp dissection is performed in the lateral patellar and quadriceps extension regions.

3. The distal femur and the articular surface are fully revealed by turning the patella over to the inside after incision of the knee joint capsule and lateral patellar retinaculum.

Using this point, full exposure was achieved.

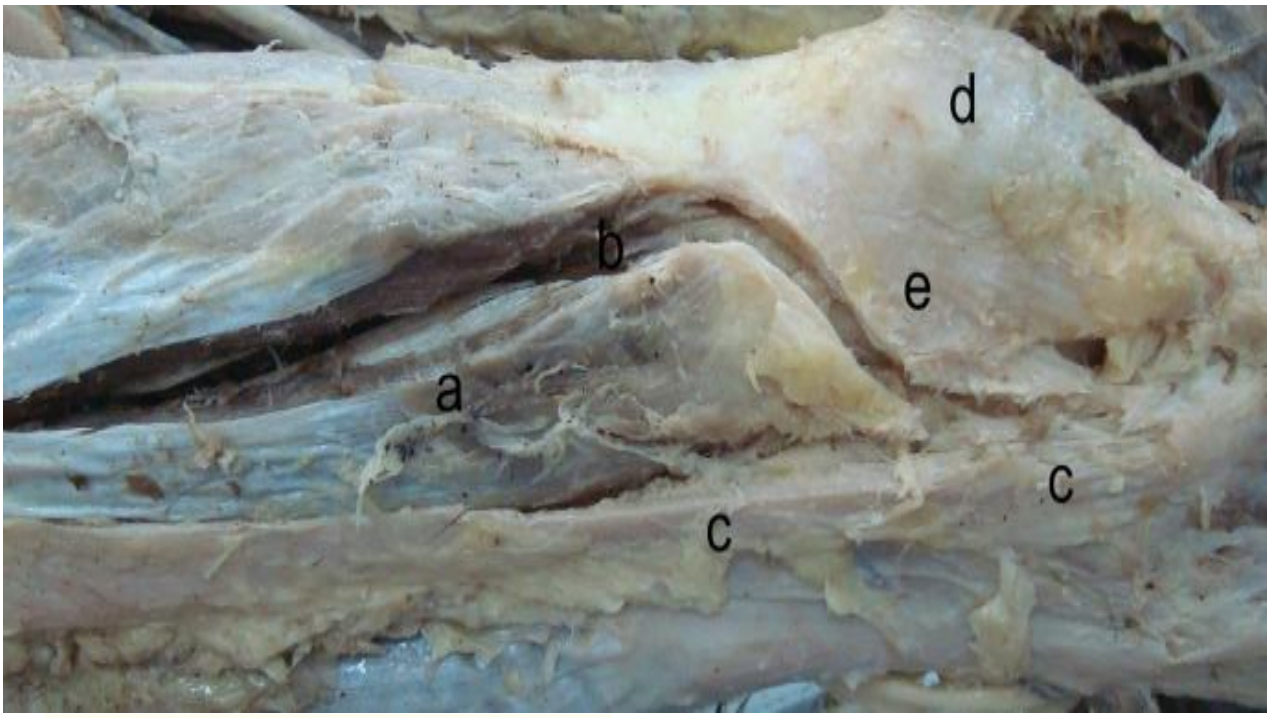


Fig 6.3 Structures in swashbuckler approach

(a) Vastus lateralis

(b) Incision line along the intermuscular septum

(c) Iliotibial band

(d) Patella

(e) Lateral patellar retinaculum.

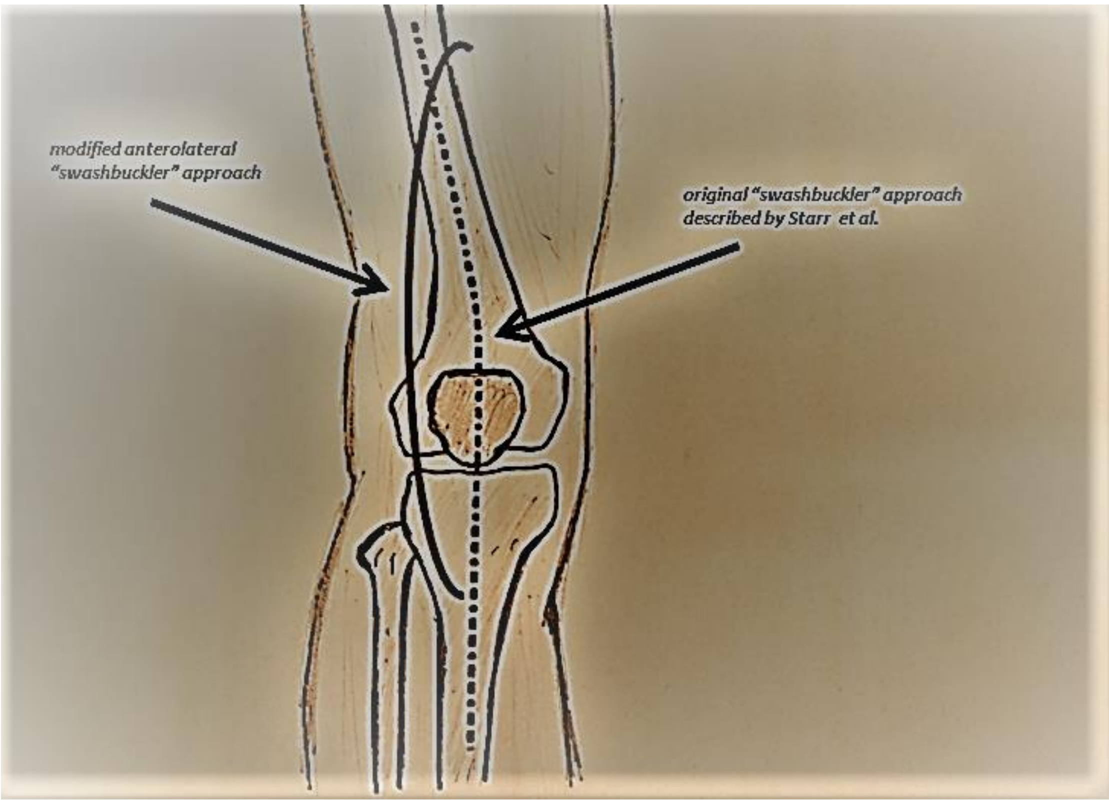


Fig 6.4 Difference between modified swashbuckler and swashbuckler approach

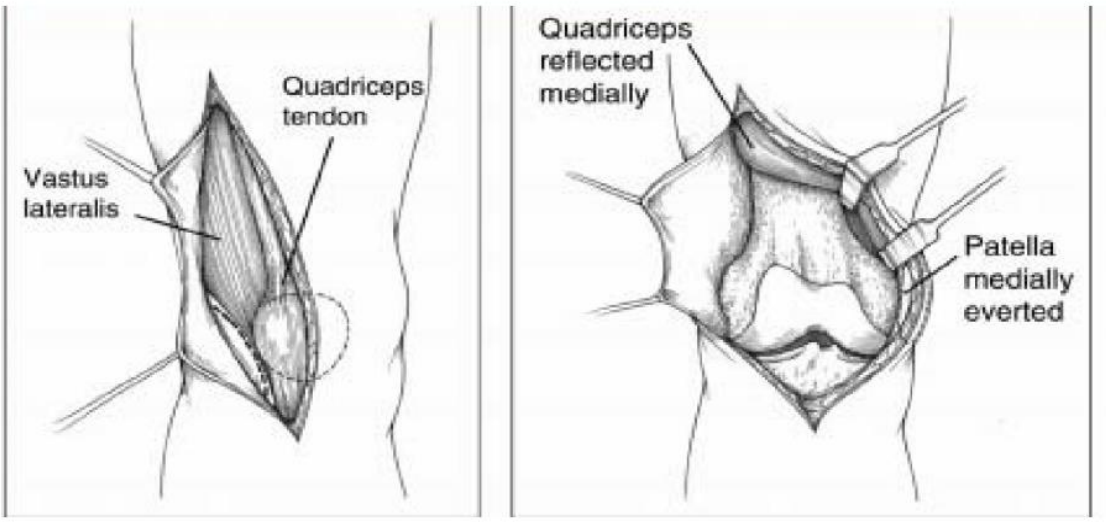


Fig 6.5 Swashbuckler approach

Maintaining patellar vascularization on both sides of the anastomotic ring is believed to depend critically on the integrity of the transverse infrapatellar and lateral descending arteries. It was usually necessary to ligate the lateral inferior geniculate artery, which passes through the surgical incision at the height of the lateral meniscus.

The anterior tibial recurrent artery, which often passes through the surgical field at the tibial tuberosity's height, tries to preserve the peripatellar anastomotic ring's superior vascularization. Since there are no attachments of the vastus intermedius muscle to the femoral anterior cortex, it could be removed if a larger view of the medial side of the distal femur is needed. Bending the knee a few degrees in tandem with a medial sliding of the extensor apparatus was the final step to maximize the exposure of the medial condyle and prevent needless tension at the fracture site. Since it is not necessary to expose the adductor magnus and biceps femoris brevis muscles any further, they typically remain intact at the posterior part of the femur. To shift the patella medially, a retractor is typically helpful.

Before skin suture, the retinaculum is closed with absorbable sutures to avoid damaging the patellar network’s lateral circulatory anastomosis.

C. MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS(MIPO)

Indication: ORIF type 33 A3, C1 and C3 fractures.

Two windows are utilized for the minimally invasive approach to the distal femur. The distal window makes the articular surface of the distal femur visible and functions as a lateral Para patellar access to the knee. As part of the lateral approach to the femoral shaft, the proximal window offers access to the shaft.

Position: Supine.

Incision: Longitudinal incision of about 6- 8 cms over the anterior half of the lateral femoral condyle, extending upward from the joint line. A second proximal longitudinal incision should be made across the lateral part of the femur shaft.

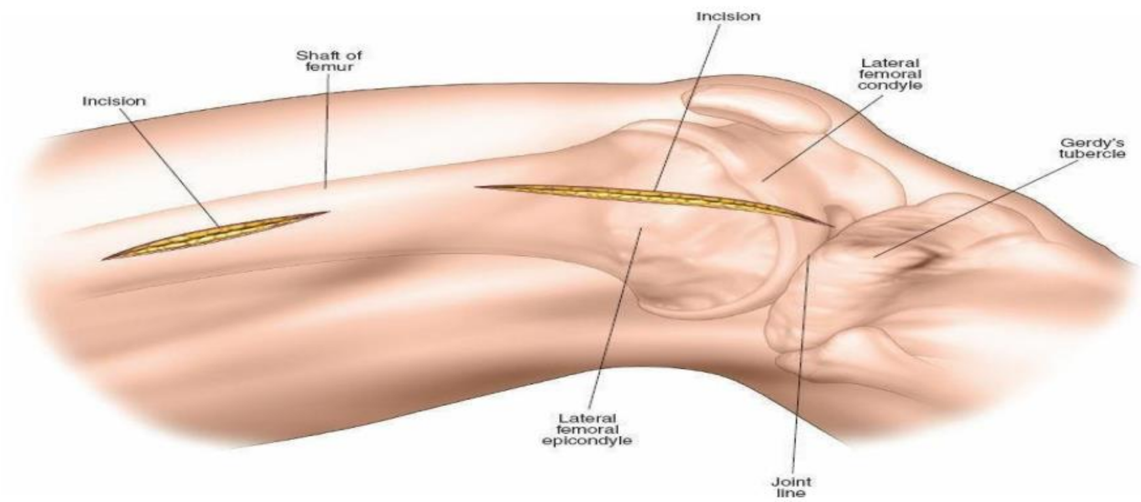


Fig 6.6 Skin incision – MIPO technique

Superficial dissection begins from the distal end of the incision. Make an incision in the subcutaneous tissue along the skin's incision line. Divide the lateral retinaculum to visualize the joint capsule. Create a plane between the lateral intramuscular septum posteriorly and the vastus lateralis anteriorly at the proximal end of the distal window. At this location, the operating field is crossed by numerous branches of the superior lateral genicular artery, each of which has related veins that require cauterization or ligation.

Cut the subcutaneous fat at the skin incision line close to the muscle's surface, and then longitudinally divide the deep fascia covering the vastus lateralis.

Deep Surgical Dissection: The whole distal end of the femur is visible when the knee joint capsule and synovium are divided distally and longitudinally. Using the proper retractor, retract the patella and bend and extend the knee to view every part of the joint. The periosteum on the lateral aspect of the femoral shaft can be directly accessed by splitting the vastus lateralis muscle in a line of fibers. Lastly, use a blunt dissector or the surgical implant to create an epi-periosteal plane between the two windows on the lateral aspect of the femur.

Risks: Veins and the superior genicular artery must be visualized and ligated. These veins are frequently seen and intimately attached to the periosteum. There will be a sizable hematoma following surgery if these vessels are not managed.

D. ANTERIOR MIDLINE APPROACH

The lateral and medial Para patellar approach gives an excellent view of the articular surface of the distal femur. The patella may dislocate medially or laterally due to a longitudinal division of the extensor mechanism and quadriceps tendon. The Para patellar technique is most frequently employed when treating an intraarticular distal femur fracture. The method employed depends on how the fracture is ground up. The para-patellar method is most commonly used when treating an intraarticular distal femur fracture.

The method employed depends on how the fracture is ground up.

Two Types:

a.) Lateral para-patellar arthrotomy

b.) Medial para-patellar arthrotomy

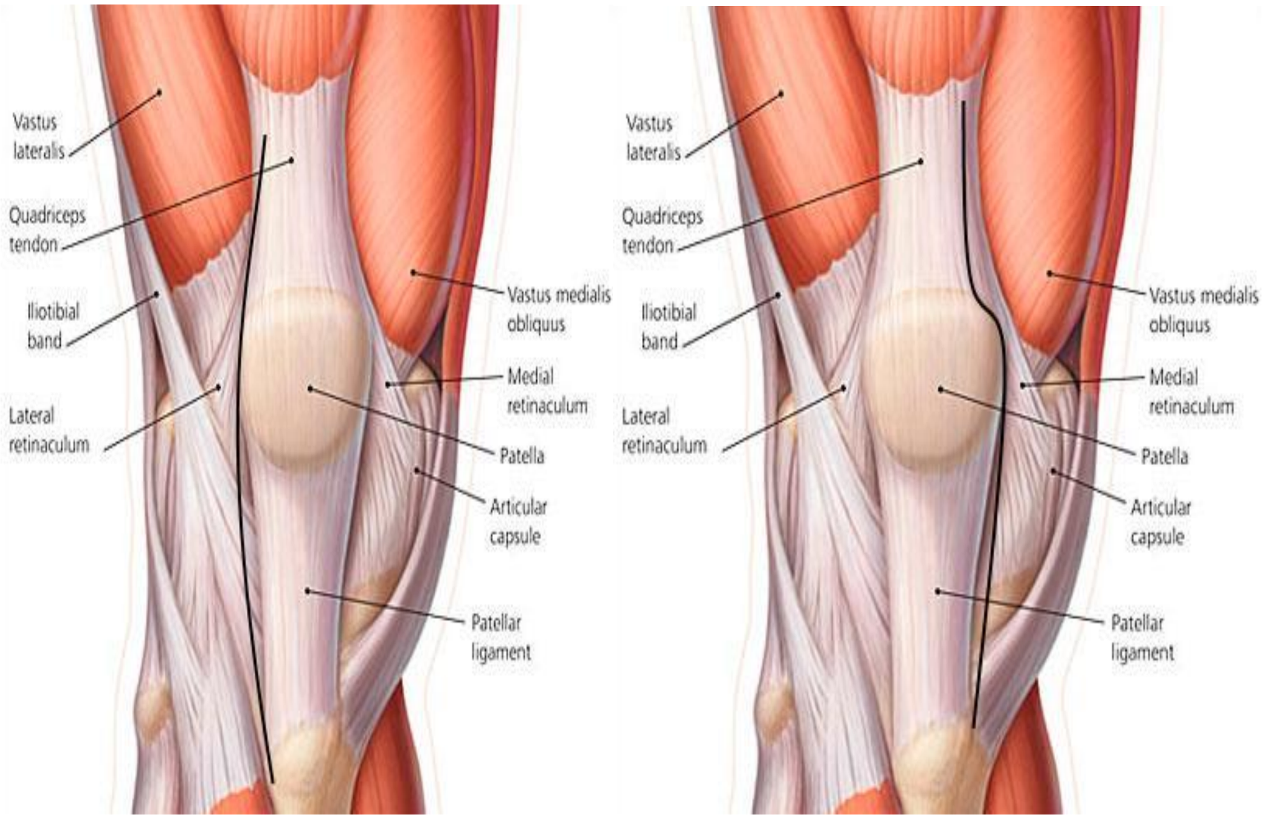


Fig. 6.7 Lateral and Medial Para patellar approach

a.) Lateral Para patellar Approach

Both the patella and the tibial tubercle are clearly visible, and the incision can be made exactly midline or, better yet, slightly lateral to the midline. Making the incision too short is a common mistake that can eventually prevent medial patellar dislocation. Usually, the incision measures 15 to 18 centimetres.

The extensor retinaculum is unharmed over the front of the patella. Cut through the quadriceps tendon and the lateral Para patellar retinaculum in a longitudinal incision that is full thickness.

It curves to the lateral aspect of the patella after starting somewhat lateral to the midline (40% lateral; 60% medial).

On the lateral aspect of the patella, it ought to leave an 8–10 mm Para patellar retinaculum cuff.

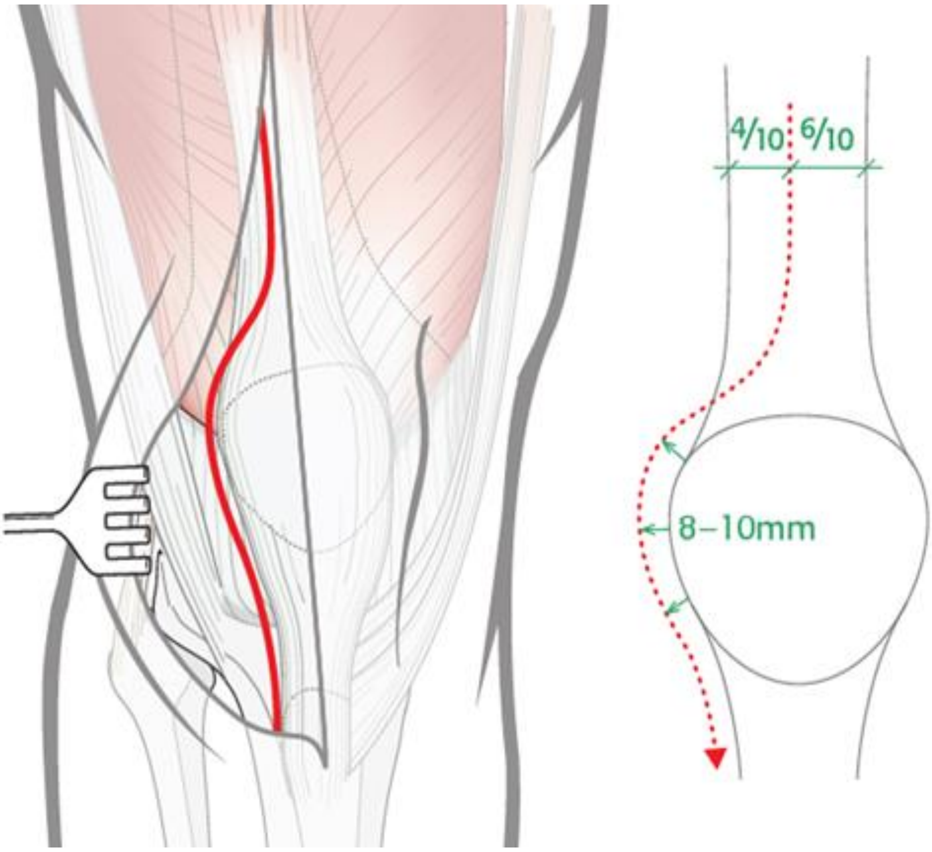


Fig. 6.8 Skin Incision for Lateral Para patellar approach

The vastus lateralis and tensor fascia lata form the inter-nervous plane. From the lateral intermuscular septum, raise the vastus lateralis muscle until it reaches the femur shaft.

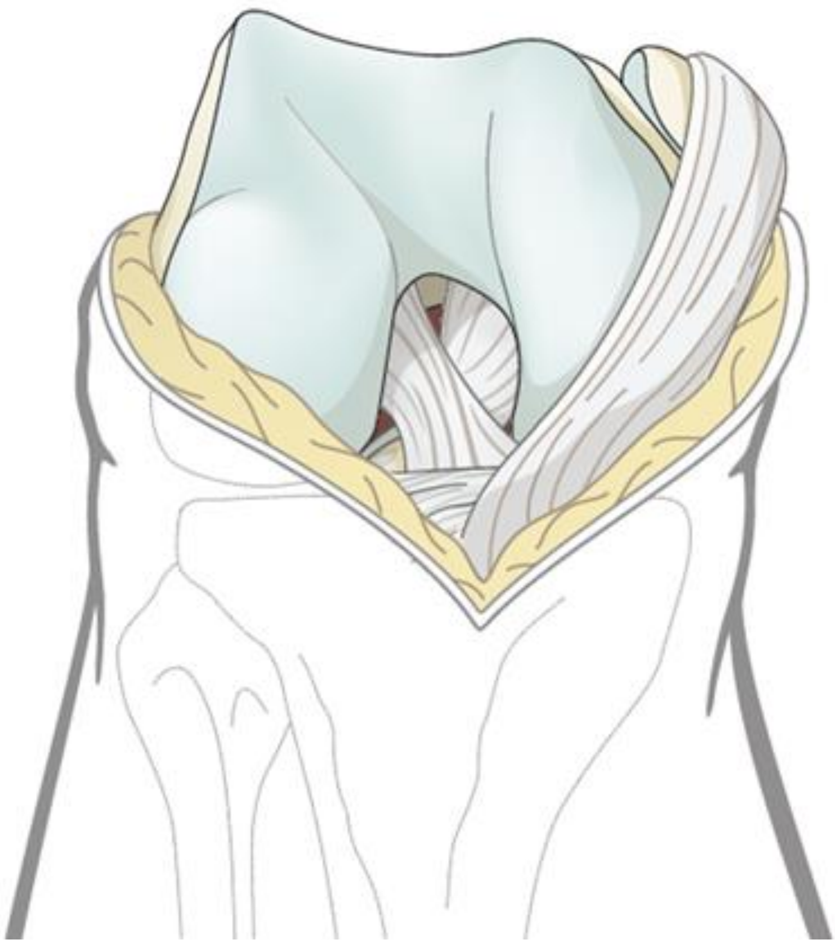


Fig 6.9 Knee is flexed to expose the distal femur articular surface

Extend the knee fully, evert the patella medially, and retract the vastus lateralis medially. While Flexing the knee joint precaution should be taken so that, the patellar tendon is not avulsed.

b.) Medial Para-Patellar Approach

The distal femur's medial side is where the saphenous nerve is located.

The medial and inferior portions of the patella are home to the saphenous nerve's infrapatellar branches. Although there will be some modest sensory disruption below and around the scar following surgery, major injury to the saphenous nerve can be prevented. Postsurgical saphenous nerve neuroma development can happen occasionally. However, it's rarely a big deal. Preserving the lengthy saphenous vein is important. The medial side of the knee joint has no arteries that are surgically significant.

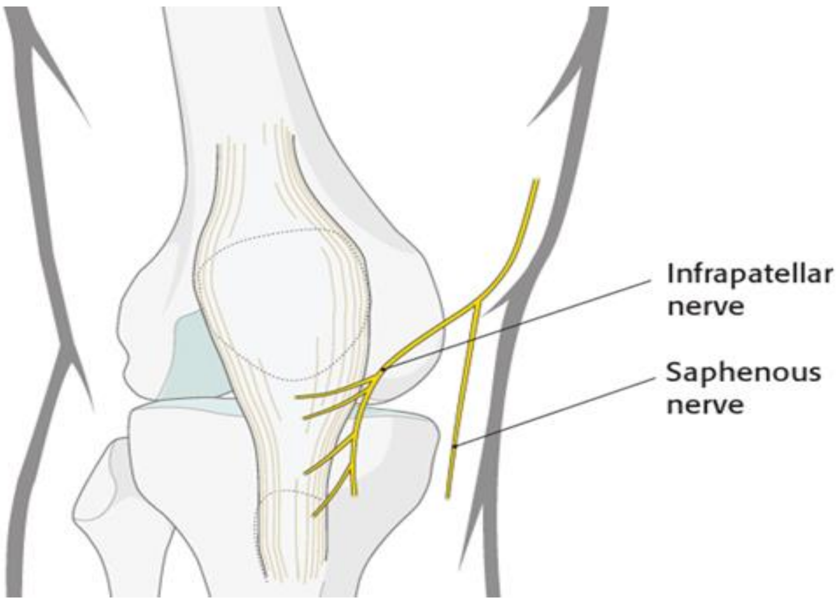


Fig. 6.10 Infrapatellar nerve and saphenous nerve lie on the posteromedial aspect of the patella and are exposed during this approach

An incision of about 10 to 15 centimetres in length is made medially along the anterior portion of the knee. Leaving a cuff of capsular tissue medial to aid in closure, the incision is made along the medial border of the patella and medial patellar tendon. The vastus medialis and rectus femoris form the false inter-nervous plane. The femoral nerve supplies both muscles relatively close to each other.

Evert the patella laterally, retract the vastus medialis laterally, and fully extend the knee.

An injury with a high velocity typically causes a medial metaphyseal spike to herniate through a vastus medialis rent.

The incisions made during the arthrotomy featured such rents.

In order to see articular comminution, the patella is retracted laterally. This allows for the treatment of proximal fracture extension, coronal split fractures, and intercondylar fractures.

E. MEDIAL SUB-VASTUS APPROACH:

Since almost all anatomically tailored plates have been made for the lateral portion of the distal femur, the medial approach is less frequently utilized.

If necessary, the medial approach provides sufficient exposure to the distal femur.

An incision is made in the skin along the adductor magnus tendon.

The line of the adductor tendon is marked proximally, and the adductor tubercle is delineated.

A straight incision is made along the adductor magnus tendon's posterior border.

The saphenous vein is not cut; the incision is made just anterior to the Sartorius along the medial portion of the distal femur.

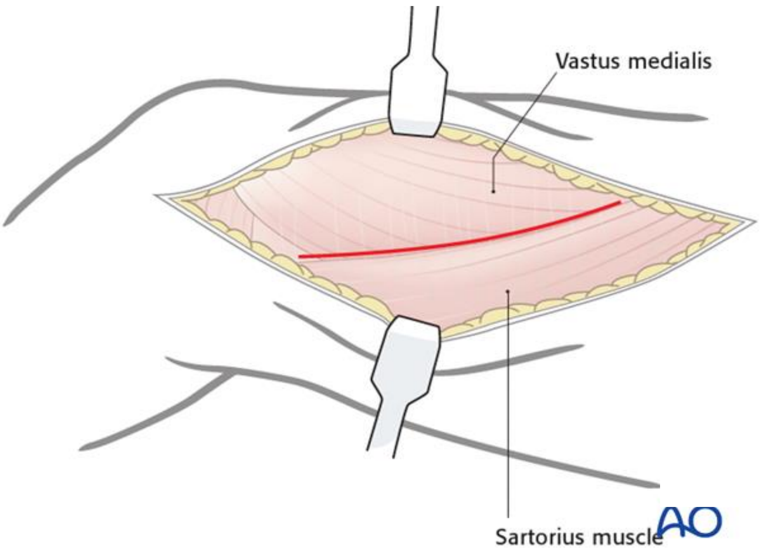


Fig. 6.11 Fascia is incised in line with skin incision to expose vastus medialis

To reveal the vastus medialis, the fascia is cut in accordance with the skin incision. After that, an incision is made at the medial intermuscular septum in the vastus medialis fascia. Determine the farthest part of the wound's posterior boundary of the vastus medialis. Develop the plane between this muscle and the Sartorius by elevating the medialis anteriorly from the femur and advancing proximally. The proximal boundary of Hunter's Canal, which houses the femoral vessels, is formed by Sartorius. In order to avoid damaging the vessels during proximal dissection, caution should be exercised.

The medial approach involves cutting the muscle off the fascia (medial intermuscular septum) in a distal to proximal manner and ligating any perforating arteries that are found. The distal femur's medial side is visible when the muscle retracts anteriorly.

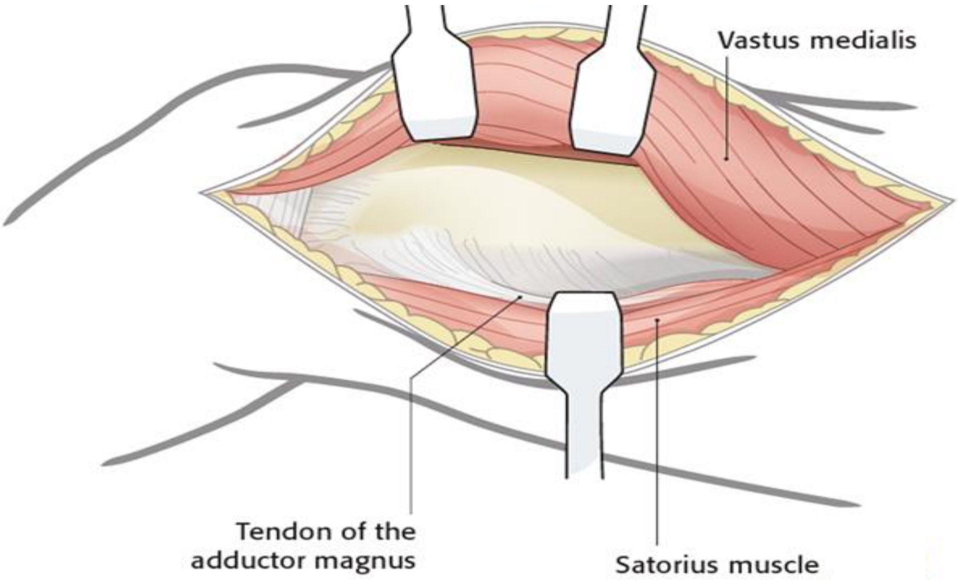


Fig. 6.12 Vastus medialis is retracted anteriorly and Sartorius posteriorly and femur shaft is exposed

To aid the dissection, flex the knee to allow the anterior border of the Sartorius to be retracted posteriorly. This will allow the exposure of the tendon of the adductor magnus. The adductor magnus tendon inserts into the adductor tubercle anteriorly. The femoral artery remains posterior and proximal to the dissection. This approach may be useful for isolated medial condylar fractures for comminuted distal femur fractures and for corrective distal femur osteotomies.

F. Y-SHAPED SKIN INCISION BY OLERUD

Indication: Any distal femur fracture with minimal extension too proximally.

The patient was placed on his back throughout the procedure, and a pillow was placed beneath his knee to allow for 90 degrees of knee flexion.

In the extensive approach, as prescribed by Olerud,

The five most important steps needed to be followed:

In the first step, a V-shaped skin incision was made to replace the Y-shaped incision with its apex located just 1 cm below the tibial tuberosity.

Second, to enable fixation with two 6.5mm cancellous screws with washers at the conclusion of the treatment, two predrilled holes are made in the tibial tuberosity.

Third, an electric saw is used to start the tibial tuberosity osteotomy, and a sharp osteotome is used to finish it. The marking is done using electrocautery.

Fourth, on the surface of the reflected extensor mechanism, the suprapatellar pouch is maintained to the greatest extent feasible.

Fifth, to improve fixation, tension band wire is placed through a transverse tunnel distal to the osteotomy site and across the head of the proximal screw.

The distal femur is exposed and the quadriceps group of muscles is retracted during a tibial osteotomy.

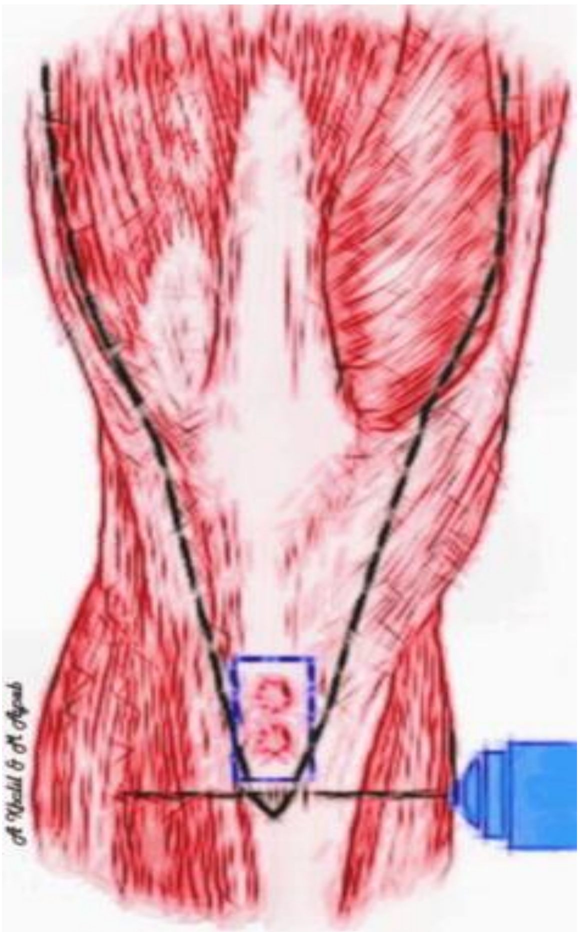


Fig 6.13 V-shaped skin incision, tibial tuberosity osteotomy with two screws in predrilled holes, and transverse tunnel for tension band wiring

Fig 6.14 The comminuted distal end of the femur after finishing the approach with upward reflection of the whole extensor mechanism, including the osteotomized tibial tuberosity

Since the anterior Para patellar approach offers more vision and ease of fixation to the articular component and the medial and lateral surfaces, the extensile approach with TT osteotomy is generally not recommended. [47]

Only when there is severe fibrosis in the distal portion of the femur as a result of multiple surgeries and the patella cannot be moved or everted is TT osteotomy recommended. [47]

7.) POST OPERATIVE REHABILITATION PROTOCOL

Postoperatively wounds were evaluated on the 3rd and 10th day if otherwise clean.
Per pain tolerance, assisted quadriceps exercises were initiated on the 3rd postoperative day.
Weight-bearing was started according to the union status of individual patients.

After surgery, early knee motion is started. Motion is initiated on the first or second postoperative day in conscious patients receiving physical therapy.
A continuous passive motion (CPM) machine is ordered for patients who are reluctant to move their knee, as well as for patients who are intubated or in the intensive care unit.
Active aided range of motion and early isometric muscle-strengthening activities are recommended. Weakness of the quadriceps muscle was assessed by comparing the opposite normal limb. Quadriceps strength was assessed on the 10th postoperative day and at every follow-up.

Depending on each patient's union state, weight-bearing was initiated. When a patient's internal fixation is steady,
Partial weight bearing (i.e., up to 20 pounds of body weight with crutches or a walker) is permitted in patients with A-type fractures after 3 to 6 weeks, although progressive weight bearing is typically postponed in patients with less stable fixation until healing (callus) shows up on an x-ray.
Weight bearing should be postponed for 10 to 12 weeks, or until the articular injury heals, in the case of an intraarticular injury (B or C type). Most patients should be able to bear a significant amount of weight by 12 weeks; however, many still need an assist device.

8.) POSTOPERATIVE COMPLICATION

Thanks to advancements in implant technology, surgical outcomes for distal femur comminuted intraarticular fractures have improved.

However, the new methods also present their own problems.

Complications of operative treatment:

a) Infection.

b) Mal-union.

c) Non-union.

d) Knee stiffness.

e) Post-traumatic arthritis.

f) Vascular Injuries.

g) Pulmonary complications

a) INFECTION

The significant risk of infection is one of the main disadvantages of fixating a distal femur fracture. Debridement and vigorous irrigation are recommended if wound drainage appears after surgery.

Aggressive irrigation and debridement are indicated if a deep infection develops postoperatively and can be temporarily treated with a wound VAC or antibiotic beads.

Because stable fractures are easier to handle than unstable fractures, leaving the implant in place is preferable rather than removing it in cases with florid infections. On the other hand, if the implant is loose, it needs to be taken out, and the fracture needs to be secured externally using an external fixator.

The length of the antibiotic treatment must be in line with the wound's clinical appearance, the infection level determined in the lab, and the results of the bacteriologic tests. For three to six weeks, intravenous antibiotics should be administered as needed.
Replanting hardware after sepsis should only be done when infection symptoms have subsided and with extreme caution. To avoid non-union, the fracture needs to be closely monitored, and bone grafting can be required. There is still debate on the use of the Ilizarov external fixator and beads impregnated with antibiotics.

b) MALUNION

More than a 5 to 10-degree malalignment is likely to have an impact on gait and knee mechanics. Elevated valgus or varus can cause the joint to become overloaded, which can then result in arthrosis in the lateral or medial compartment, respectively.
Flexion, extension, rotational deformity, or shortening may affect gait and produce pain during normal activities. Issues with fixation failure, varus collapse, and malalignment for unstable injuries were frequently encountered while using Lateral locking plates and screws. Button reported on four patients whose internal fixation with a locking plate failed due to proximal screw pull-out. To guarantee the best screw purchase, high-quality lateral radiographs must show that the plate is centered on the bone.
In the comparatively osteopenic distal or condylar segment, numerous investigations have demonstrated better fixation employing locked plates or retrograde nails.
Alignment has become increasingly difficult with minimally invasive reduction and fixation techniques since indirect reduction methods do not permit direct examination of the fracture. To guarantee proper alignment, the operating room requires vigilant attention to detail.

c) NON – UNION

In the past, in 29% to 38% of cases of distal femur fractures, open anatomic reduction and rigid internal fixation with conventional plates were linked to delayed or non-union. These complications most likely result from further stress to the surrounding soft tissues during the extensive dissection needed to perform the procedure.

By employing more biological strategies and upgraded implants, significantly better outcomes have been documented in cases of comparable injuries.

Bolhofner found better outcomes when employing 95-degree fixed-angle devices for internal fixation and indirect fracture reduction to treat distal femur fractures.

After receiving LISS treatment for their mechanically unstable distal femur fractures, the patients' union rates without the need for bone grafting were 100%.

Studies on complications following internal fixation with LISS have revealed comparatively decreased incidence of "biologic problems" like infection, non-union, and the requirement for a bone graft.

According to two recent studies that detailed the outcomes of locking plate treatment for distal femur fractures, host issues such D.M. and steroid medication may be risk factors for non-union.

Due to its close proximity to the knee joint, history of surgery, and disuse osteopenia, treatment for distal femur non-union may be challenging.

Revision osteosynthesis and bone grafting should be used to treat aseptic non-union in patients with a sufficient bone stock. Fibular struts, which are osteoinductive and osteoconductive and offer some degree of instant stability, are employed. They can be autogenous or come from a bone bank.

Treatment for non-union resulting from a bone defect involves the use of the Masquelet procedure. The induced membrane technique (IMT) is another name for the Masquelet technique, which was first described by Masquelet in 2000.

Reconstruction of bigger diaphyseal deformities is done with it. This is a two-step process. A thorough debridement of the site and fracture stabilization are carried out in the initial step of the operation.

A poly-methyl methacrylate (PMMA) spacer is inserted into the bone deficiency as the following procedure. The spacer’s objective is to stimulate the development and maturation of a biological membrane around the bone deficiency. It is believed to function as a foreign body.

In the second stage, which occurs ideally after 4–8 weeks, an autologous cancellous bone graft is inserted in lieu of the spacer, which was removed by a longitudinal incision to protect the biological barrier.

The induced membrane resembles the periosteum and is crucial to the process. It has growth factors and osteogenic cells, and it is highly vascularized. When autologous bone graft is present, it limits resorption while simultaneously creating a closed environment promoting bone regeneration.

Additionally, it serves as a physical barrier that keeps soft tissue from leaking in and offers some mechanical stability.

The best method for using this methodology is still up for debate, despite numerous improvements and alterations having been documented.

The non-union site’s stable internal fixation typically results in hypertrophic non-union. The 95-degree condylar blade plate is still a great tool for treating non-union and malunion.

Using bone morphogenetic protein, extra autologous bone, or atrophic non-union or bone loss is necessary. In rare cases, the short osteopenic condylar segment's screw fixation may be improved by using methyl methacrylate or resorbable tricalcium phosphate cement.
An objective technique was used by Rajasekaran et al. to set dual plates. If the medial void measured more than 2 centimetres following the realignment of the lower leg at the fracture site, the recommendation was for medial plating using bone grafting. [4]

d) KNEE STIFFNESS

The following conditions increase the likelihood of knee stiffness: severe osteoarthritis (Kellgren-Lawrence grade >4), open fracture, comminuted intra-articular fracture, extensor mechanism damage, temporary external fixation, and cast immobilization (>3 weeks).
Loss of knee mobility is a frequent consequence of distal femur fractures. This undesirable conclusion is almost always the result of either surgical exposure for fixation, injury to the quadriceps mechanism and joint surface from the initial trauma, or both.
Quadriceps scarring with or without knee or patellofemoral joint arthrofibrosis is thought to restrict knee movement. The consequences of immobilization following internal fixation or fracture are amplified significantly.
When the knee is immobilized for longer than three weeks, it usually becomes somewhat permanently stiff.
A distal femur fracture has the best chance of healing if it is treated with careful soft tissue handling, early stable internal fixation of the fracture, and rapid mobilization of the knee joint.
Four weeks after surgery, the majority of patients should have 90 degrees of knee flexion.
The most effective treatment for patients who are unable to regain knee motion within the

first month is a rigorous range-of-motion exercise regimen overseen by a physical therapist and an orthopedic physician.

In younger individuals, further treatment is warranted if knee flexion is not restored to a minimum of 90 degrees within 8 to 10 weeks after surgery.

One method to restore functional knee motion is to combine arthroscopic lysis of adhesions with mild knee manipulation. Avoid using force when manipulating the knee; quick mobilization of the knee is necessary to preserve knee motion.

Quadriceps plasty is a late reconstructive treatment that may be appropriate for patients who have experienced considerable loss of motion following an injury.

e) POST-TRAUMATIC ARTHRITIS

It is uncertain how frequently distal femur comminuted intraarticular fractures result in post-traumatic arthritis. Early-onset arthritis is most likely caused by the incongruity of the joint surfaces.

The damage frequently impairs the joint’s ability to function normally in many people who have fractures involving weight-bearing joints.

Unfortunately, a large number of patients with degenerative arthritis of the knee following a fracture are young adults, making them unsuitable candidates for knee replacement surgery.

A suitable corrective osteotomy may be necessary if the arthritis is restricted to the medial or lateral compartment.

Patients with severe, incapacitating tri- or bi-compartmental arthritis may benefit from total knee replacement.

Surgery planning is greatly influenced by variables like age, knee range of motion, flexion contractures present or absent, and infections.

f) VASCULAR INJURIES

Although the precise frequency of vascular damage associated with distal femur comminuted intraarticular fracture is unknown, it is thought to be between two and three percent. Initial damage to the arteries and veins might be induced by direct laceration or contusion by fracture fragments, or indirectly by stretching.

Vascular damage rates following skeletal external fixation are unclear, although numerous case reports showing this potentially fatal consequence can be found in the literature. According to some descriptions, vessel damage develops as a result of erosion, indirect compression and impingement, and direct or partial laceration.

Following the implantation of an external fixation frame in 121 lower extremity fracture cases, Paul et al. documented four iatrogenic vascular injuries, representing a 3.3% incidence. Following the insertion of an external fixator pin, ischemia, a pulsatile mass, loss of distal pulse, and bleeding from the insertion site were indicators of vascular damage.

It is critical to do a clinical examination for symptoms of ischemia, including an assessment of pulses and motor and sensory function.

g) PULMONARY COMPLICATIONS

In patients with numerous injuries, the frequency of pulmonary problems increased with delayed fracture stabilization.

A substantial incidence of fat embolism (22%), however, was seen in patients receiving conservative treatment or late stabilization of fractures in polytrauma patients.

9.) METHODOLOGY

We conducted a "Prospective study" in BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, from August 2022 to November 2024. In our study, 32 patients were involved, of whom 17(53.1%) were male and 15(46.9%) were female. 18 patients (56.3%) sustained a left-side injury, whereas 14 patients (43.8%) sustained a right-sided injury. A minimum of 6 months and a maximum of 12 months of follow-up were achieved. All middle-aged or old-aged patients who presented to the orthopedic emergency at the BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, with comminuted distal femur intraarticular fracture.

INCLUSION CRITERIA

1. Patient aged 18 years and above
2. Closed fracture
3. Patients willing for treatment and giving informed and written consent.

EXCLUSION CRITERIA

1. Patients aged below 18 years
2. Compound fractures
3. Polytrauma
4. Segmental fracture
5. Patients medically unfit for surgery.

SAMPLING:

Sample size

With anticipated Mean±SD of time of complete radiological union in the distal femoral fracture patients 6.0±3.5 [9], the study would require a sample size of 32 patients with a 95% level of confidence and a precision of 1.4 using Statulator software

Formula used $n = \frac{z^2 S^2}{d^2}$

Where Z= Z statistic at α level of significance

d^2= Absolute error

P= Proportion rate

q= 100-p

Statistical Analysis

- The data obtained will be entered in a Microsoft Excel sheet, and statistical analysis will be performed using statistical package for the social sciences (Verson 20).
- Results will be presented as Mean ±SD, Median and Inter quartile ranges, frequency, percentages and diagrams.

PRE-OPERATIVE WORK-UP:

Patients with Comminuted intraarticular distal femur fractures have been clinically and radiologically confirmed were admitted to the Orthopaedics Department at the BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, in Vijayapura. Routine tests such as complete blood count, Blood sugar, CXR & Electro Cardiography were checked, and a pre-anesthetic examination was done.

Patient 1

A 39-year-old male patient came to casualty with a history of RTA (Slip and fall) with no head injury or internal injuries. The patient complained of right knee pain with visible deformity and no external wound; after the x-ray, the patient was diagnosed with a right distal femur intraarticular fracture and planned for operative management with dual plating because of medial cortex comminution.

Fig 9.1 Pre-operative x-ray

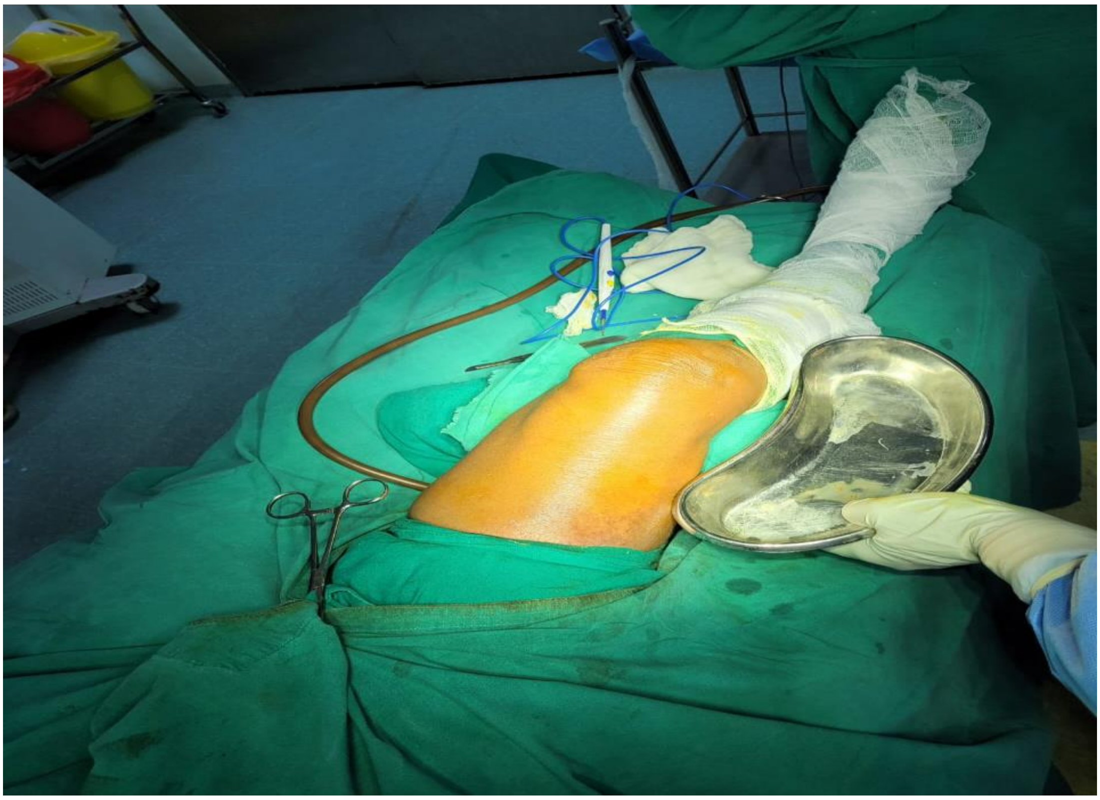


Fig 9.2 On table patient draping and positioning

OPERATIVE MANAGEMENT

The patient was shifted to the OT table under aseptic precaution, and spinal anesthesia was given. The patient was positioned in a supine position with the knee in 20 to 30 degrees of flexion using an OT drape.

Central midline incision and lateral para patellar approach was used, and superficial dissection was done. Note the patella and the tibial tubercle. The incision should ideally be made somewhat lateral to the midline but can be made directly midline. The incision is typically between 15 and 18 centimeters long.

It begins slightly lateral to midline and curves to the lateral aspect of the patella. It should leave an 8–10 mm Para patellar retinaculum cuff on the patella’s lateral aspect.

The quadriceps tendon split about 10 centimeters above the patella’s superior pole, minimizing the chance of avulsion of the patellar tendon during dislocation of the patella.

Cut the lateral Para patellar retinaculum through to full thickness, creating an inter-nervous plane between the vastus lateralis and the tensor fascia lata. Up until it reaches the femur shaft, the vastus lateralis muscle is elevated from the lateral intermuscular septum.

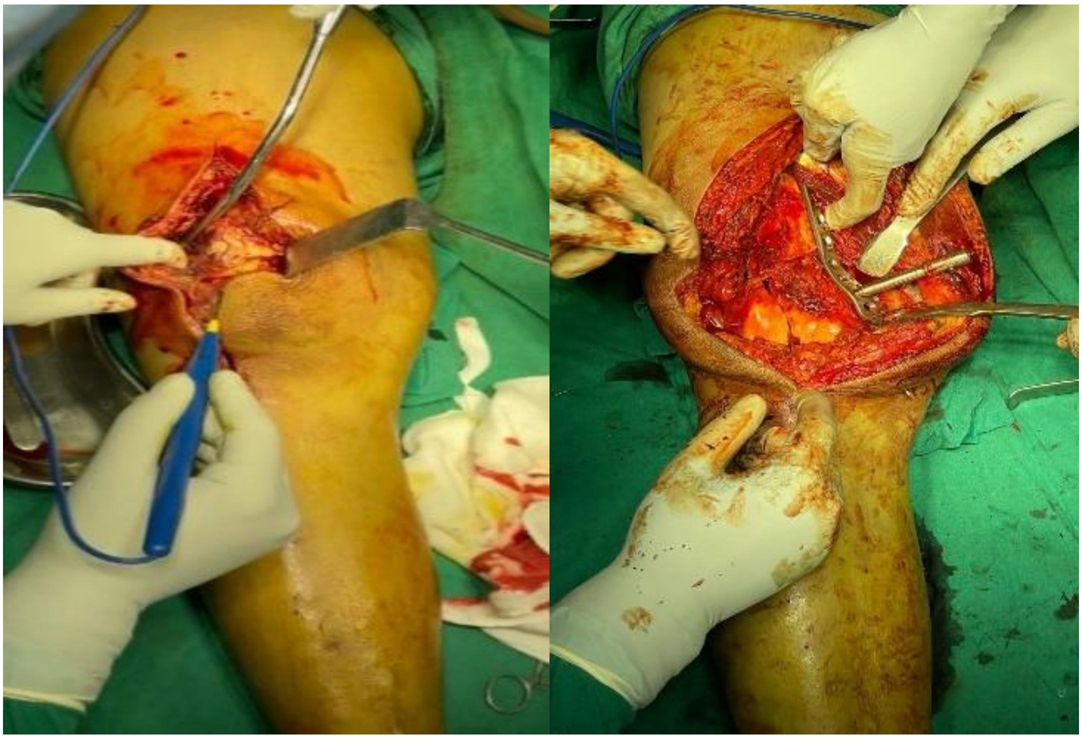


Fig 9.3 Intra operative exposure of distal femur

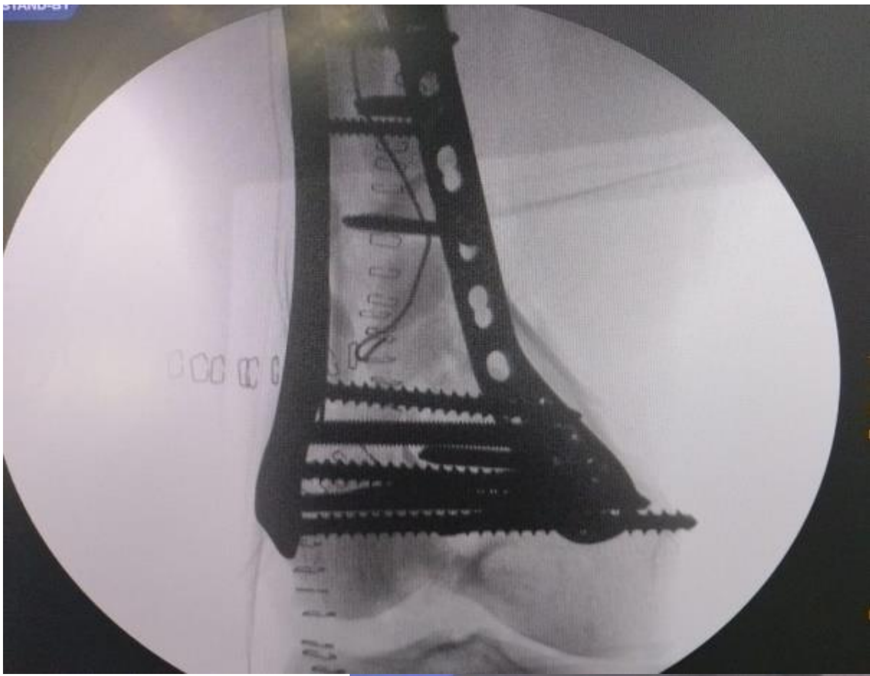


Fig 9.4 Intra-operative fluoroscopy images of distal femur dual plating

The leg was fully extended, the patella was everted to the medial aspect of the knee, and the knee was flexed up to 20 to 30 degrees. The articular surface of the distal femur was completely exposed, and articular alignment was obtained and fixed with 3 mm k wire. The proximal femur shaft fracture and distal femur fragment were reduced in place, and a medial anatomic plate was placed and fixed 2 cortical and 2 locking cancellous screws distally. A lateral locking plate was used and fixed with proximal and distal screws. Fracture fixation and plate were fixed with appropriate screws, and stable fracture fixation was achieved.

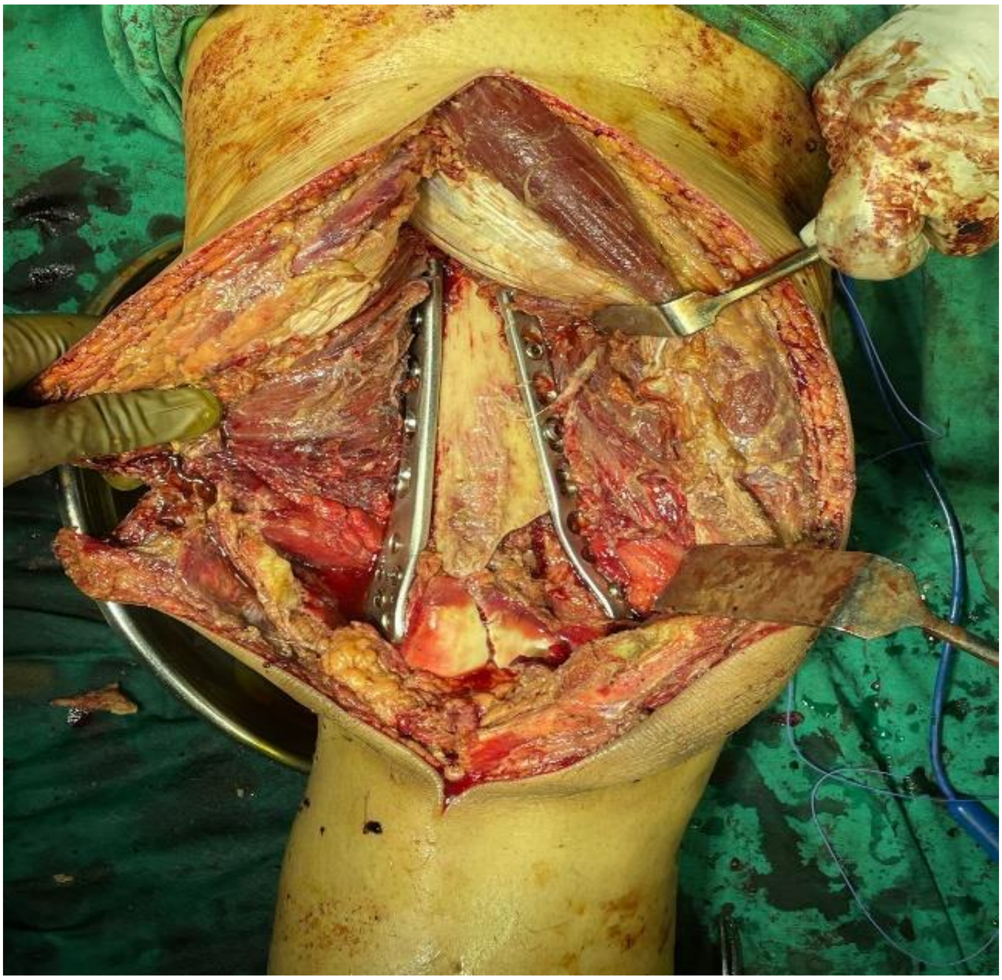


Fig 9.5 Final intra-operative images of distal femur fracture fixed with dual plating

Fig 9.6 Post – op day 2 of 0-90^0 of passive range of motion started

Post-operatively patient was started on static and dynamic quadriceps exercises and ankle flexion exercises. After 2 clean dressings, on postoperative day 5 patient was started on Passive Knee range of motion up to 90 degrees.

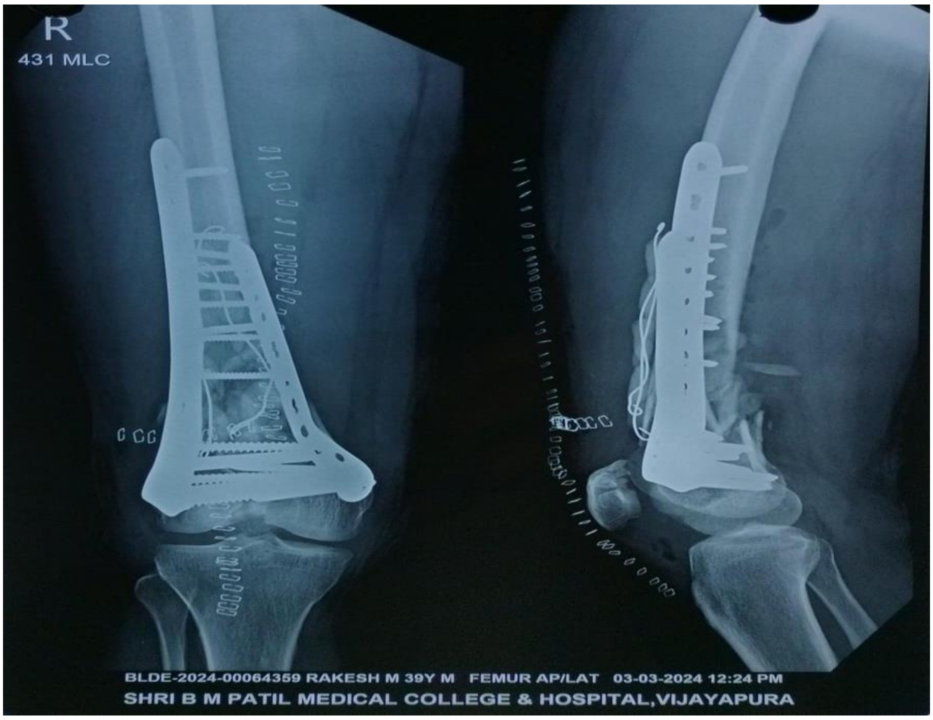


Fig 9.7 Post-op day 1 check X-ray

The patient was discharged on postoperative day 12 after suture removal.

The patient was followed up for postoperative every month for the following 3 months and was started on partial weight bearing after 6 weeks and full weight bearing by the 11^{th} week. The patient was followed up every alternate month from 3 months up to 12 months.

Post-operative X-rays were obtained and Neer score was measured.

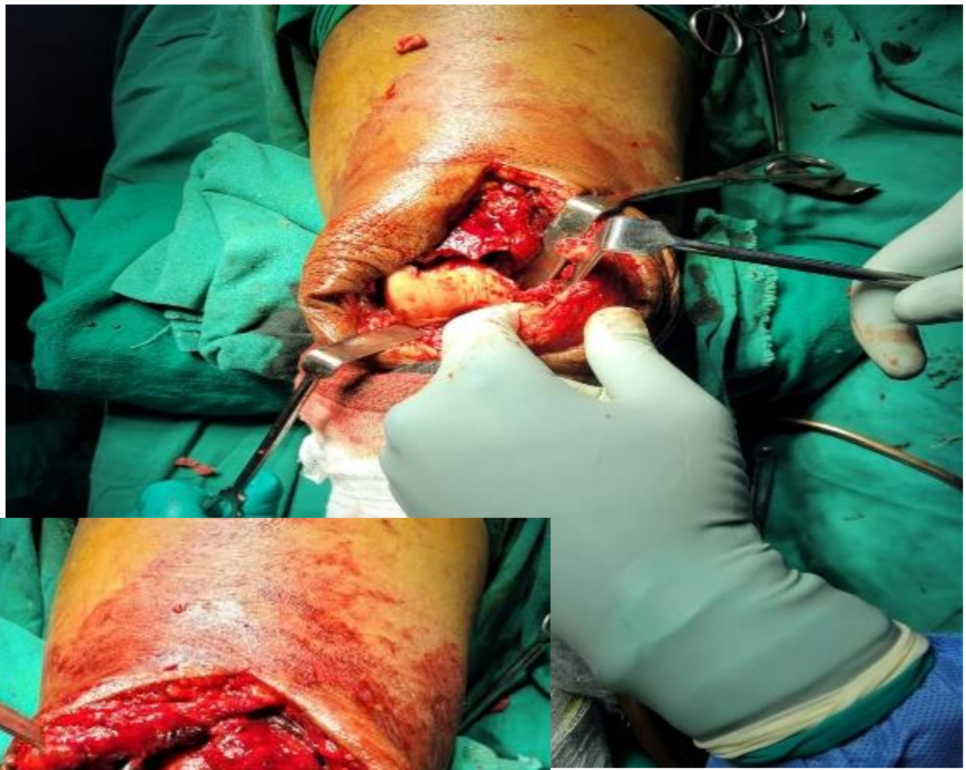
Patient 2

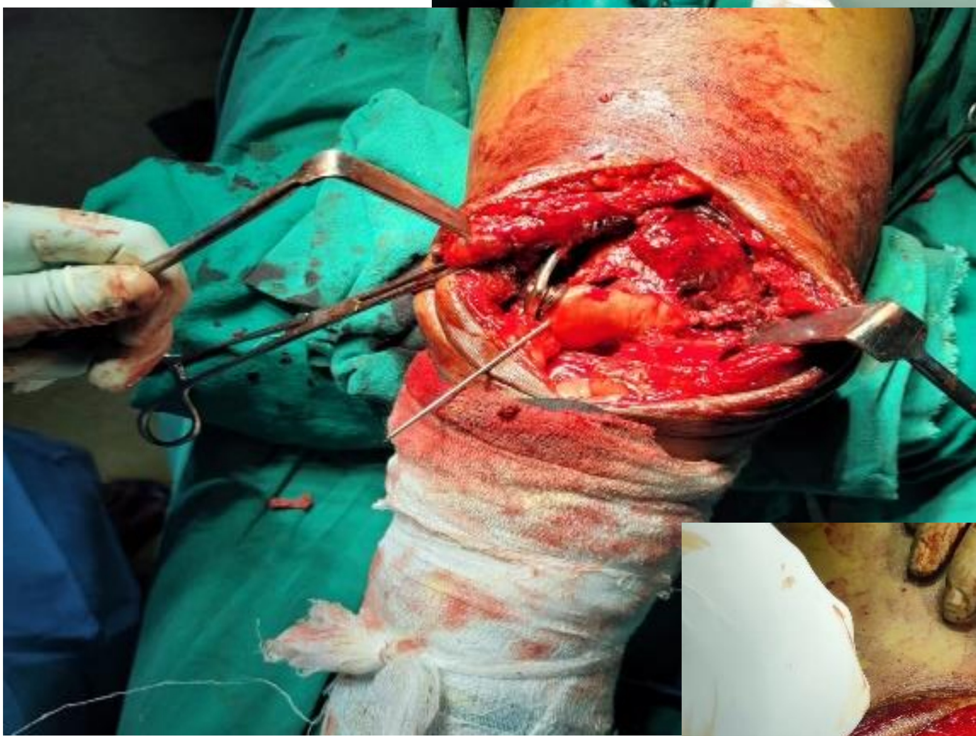
A 48-year-old female came to a casualty with a history of RTA (bike-to-bike collision) with a complaint of pain over the left knee with no other long bone injury or internal bleeding. The patient was advised to X-ray and was diagnosed with a left distal femur intraarticular comminuted fracture. The patient was advised for the operative procedure and dual plating was done using anterior midline incision and lateral Para patellar approach.

Fig 9.8 Pre-Operative X ray

Following the entire approach, debridement, and assembly of the fracture fragment, initial Kirschner wires (K-wires) were smoothly inserted from all sides surrounding the exposed distal end of the femur.

The use of lateral locking distal femur plate, contoured medial plate, and countersunk cannulated cancellous screws—including those for Hoffa fractures—were the first steps in the definitive fixing process. Ultimately, all bony deficiencies were filled with autogenous iliac bone grafting with satisfactory impaction, particularly in the anterior and medial sides, and the incision was carefully closed.





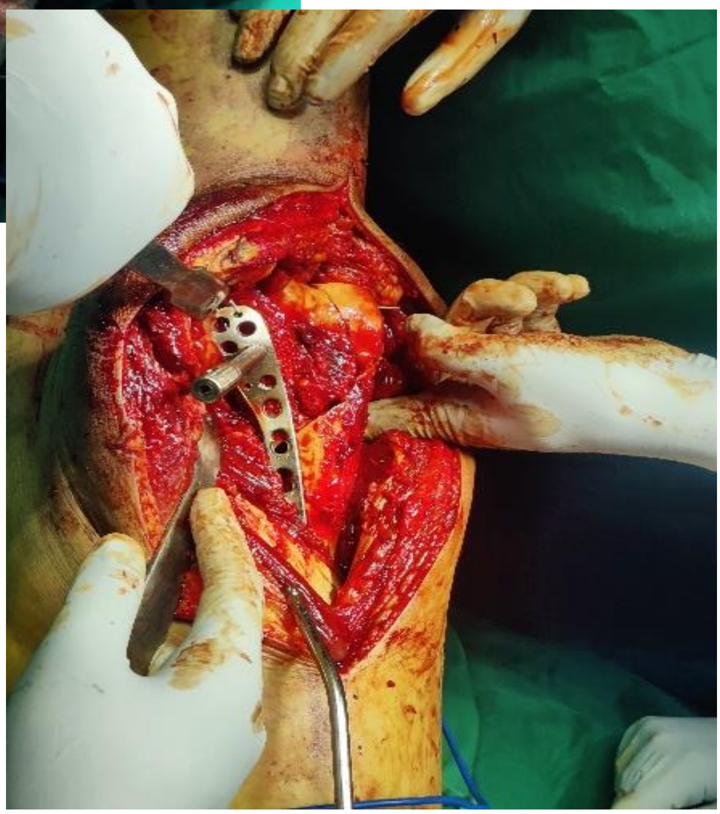


Fig 9.9 Intra-operative images of distal femur intraarticular comminuted fracture fixed with dual plating

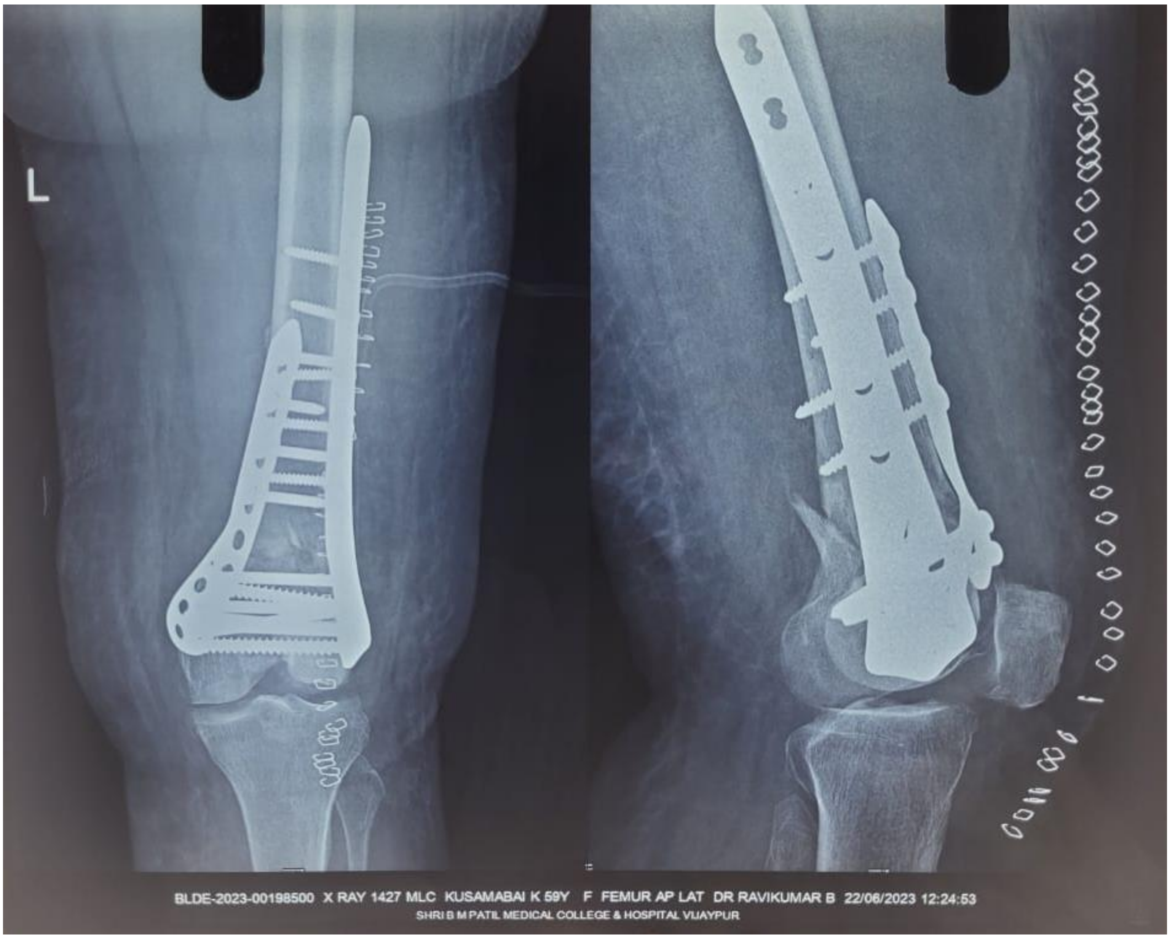


Fig 9.10 Post-operative X-ray

. Fig 9.11 12 months' Post-Operative range of motion Flexion: 110^0 and complete extension

The patient was started on routine as per the above-mentioned protocol, and partial weight bearing was started by 6 weeks and full weight bearing by the 13th week.

The patient has achieved a full range of motion from complete extension to flexion up to 110 degrees with a well-healed fracture over 12 months' postoperative x-ray.

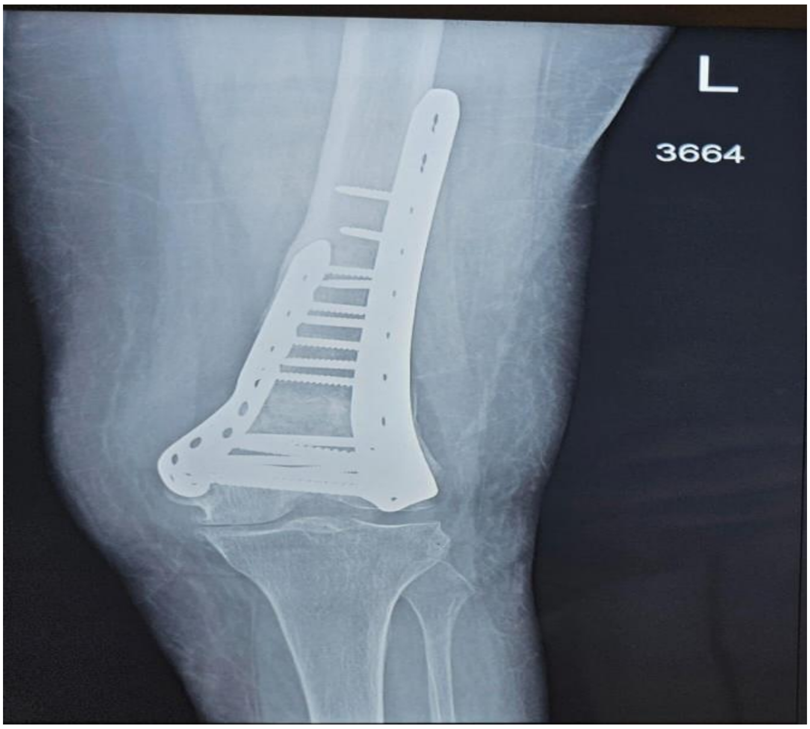


Fig 9.12 Post-operative x-ray after 1 year

10.) RESULTS

32 patients were included in the prospective study. All middle-aged or old-aged patients who presented to the orthopedic emergency at the BLDE (DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Hospital & Research Centre, Vijayapura, with comminuted distal femur intraarticular fracture.

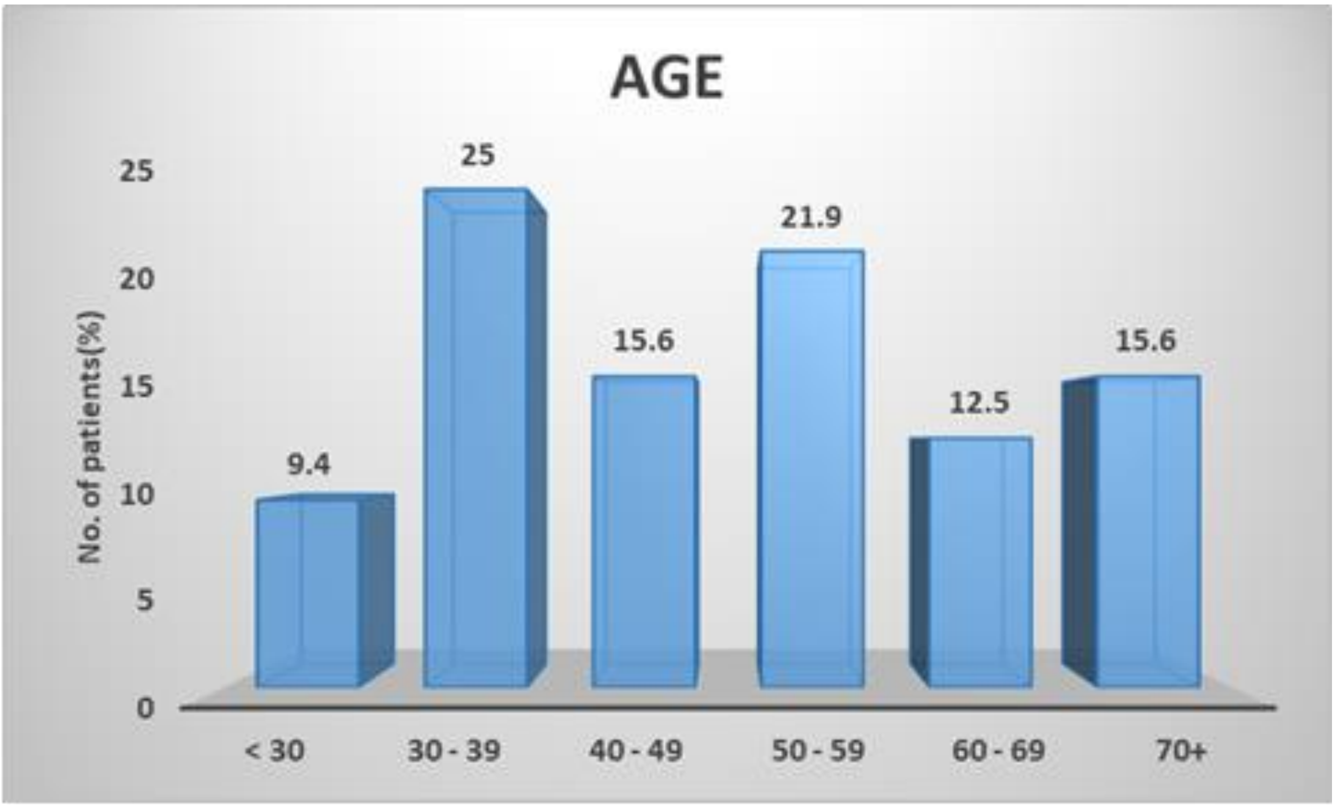
AGE DISTRIBUTION:

Age	No. of patients	Percentage
< 30	3	9.4
30 - 39	8	25.0
40 - 49	5	15.6
50 - 59	7	21.9
60 - 69	4	12.5
70+	5	15.6
Total	32	100.0

Table 10.1 Age Distribution

Total 32 patients diagnosed with comminuted intraarticular distal femur fracture were included in the study. 16 patients were above the age 50 years and 16 patients were below the age of 50 years.

Fig 10.1 Age distribution



Sex Distribution:

Gender	No. of patients	Percentage
Female	15	46.9
Male	17	53.1
Total	32	100.0

Table 10.2 Sex Distribution

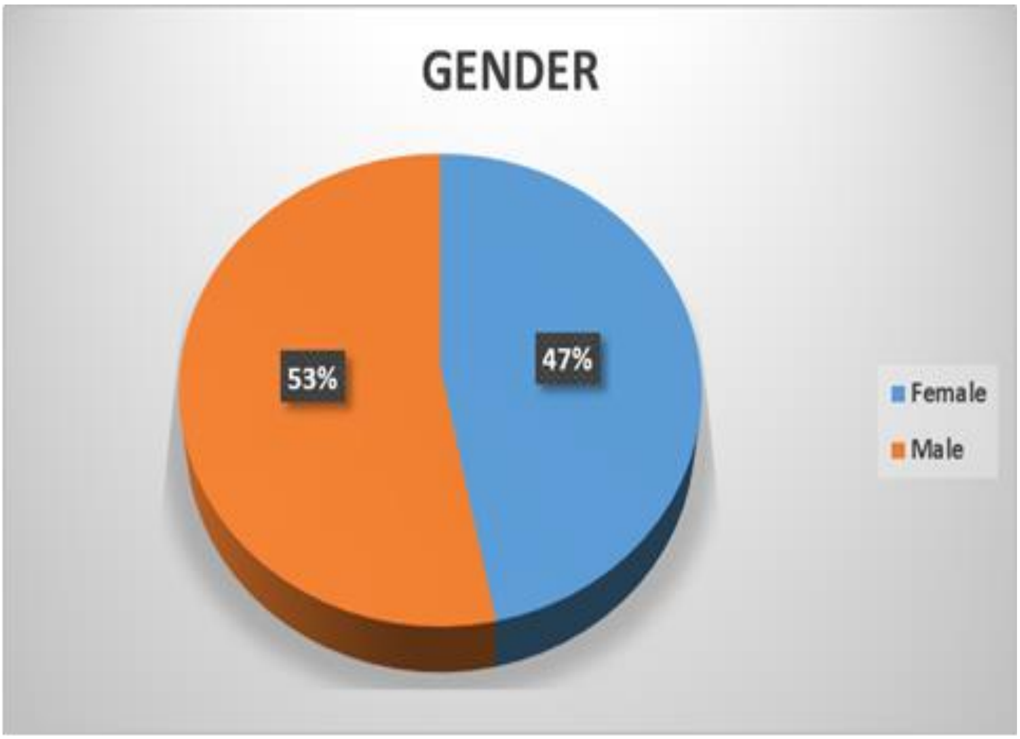


Fig 10.2 Sex distribution

Males sustained this injury noticeably more than females. 17(53%) of 32 operated for Comminuted intraarticular distal femur fracture in our study were males, and 15(47%)

females were diagnosed with distal femur comminuted intraarticular femur fracture in our study.

Side involvement:

Out of the 32 patients involved in the study, 18(56.3%) patients have suffered from left-sided injury of the distal femur, and 14(43.8%) patients have suffered from right-sided injury.

SIDE OF LEG INJURED	Frequency	Percentage
LEFT	18	56.3
RIGHT	14	43.8
Total	32	100.0

Table 10.3 Side involvement

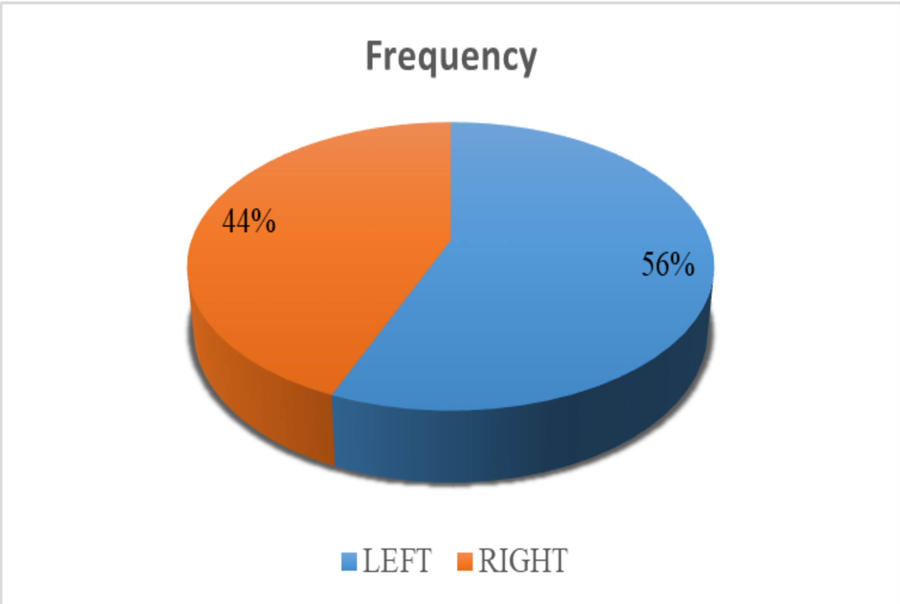


Fig 10.3 Side involvement

Mode of Injury:

Out of 32 patients who suffered from distal femur comminuted intraarticular femur fracture, 24 patients had a history of road traffic accidents (RTA), and 6 were elderly patients who were diagnosed with distal femur fracture after a history of trivial falls and 2 were fall from a height.

MODE OF INJURY	Frequency	Percent
Fall from height	2	6.3
RTA	24	75.0
Trivial Fall	6	18.8
Total	32	100.0

Table 10.4 Mode of Injury

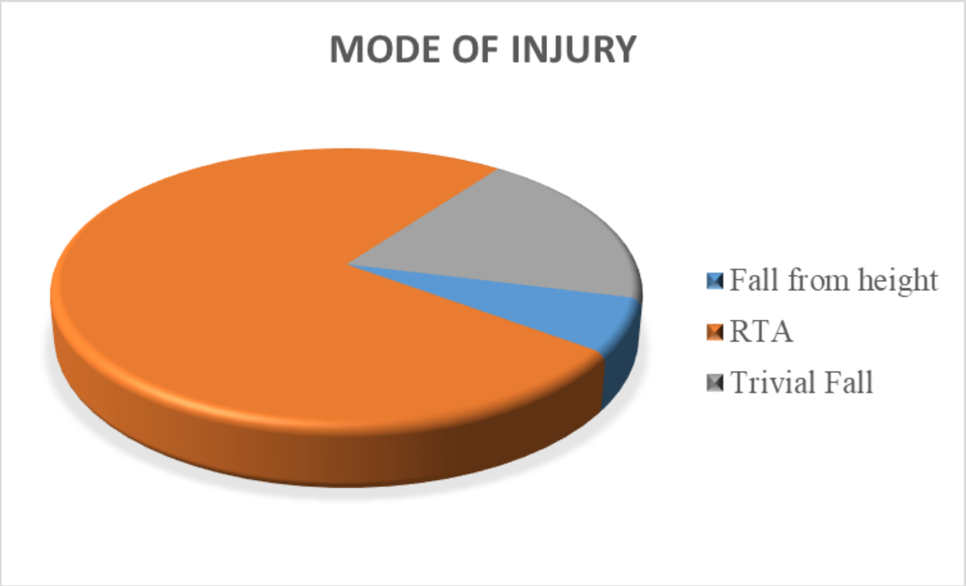


Fig 10.4 Mode of injury

Approach to Distal Femur:

Out of a total of 32 patients diagnosed with comminuted intraarticular distal femur fracture, 25(78.1%) patients were operated on with the modified swashbuckler approach, and 7 were operated on using dual incision, which includes the lateral swashbuckler approach and medial sub vastus approach.

Approach to Distal femur	Frequency	Percentage
Dual Incision	7	21.9
Modified Swashbuckler	25	78.1
Total	32	100.0

Table 10.5 Approach to distal femur

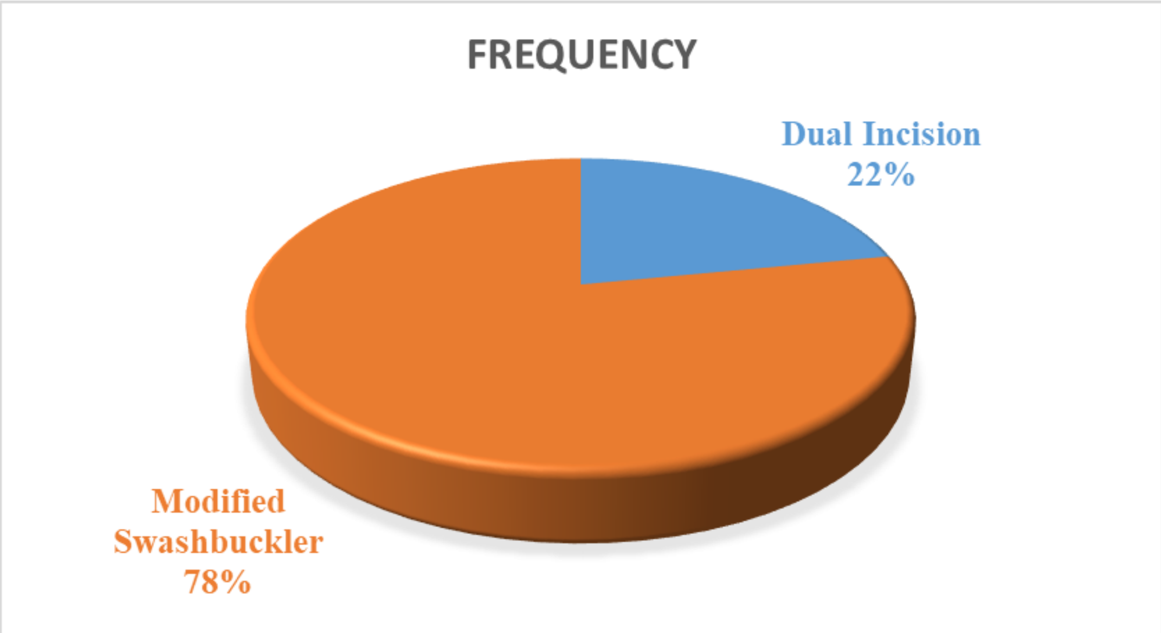


Fig 10.5 Approach to distal femur

During the follow-up, 32 patients were assessed clinically, radiological and functionally using Neer's criteria.

During the first 6 weeks of follow-up, patients had a mean Neer score of 51.69, suggestive of a fair outcome. The mean Neer's score progressively increased to 66.56 at 3 months, 76.47 at 6 months and finally, at 12 months mean Neer's score was 79.41, suggestive of good to excellent outcome.

FOLLOW UP	NUMBER	NEER SCORE
6 weeks	32	51.69
3 months	32	66.56
6 months	32	76.47
12 months	32	79.41

Table 10.6 Neer score, follow-up patient for 6 weeks, 3,6 and 12 months

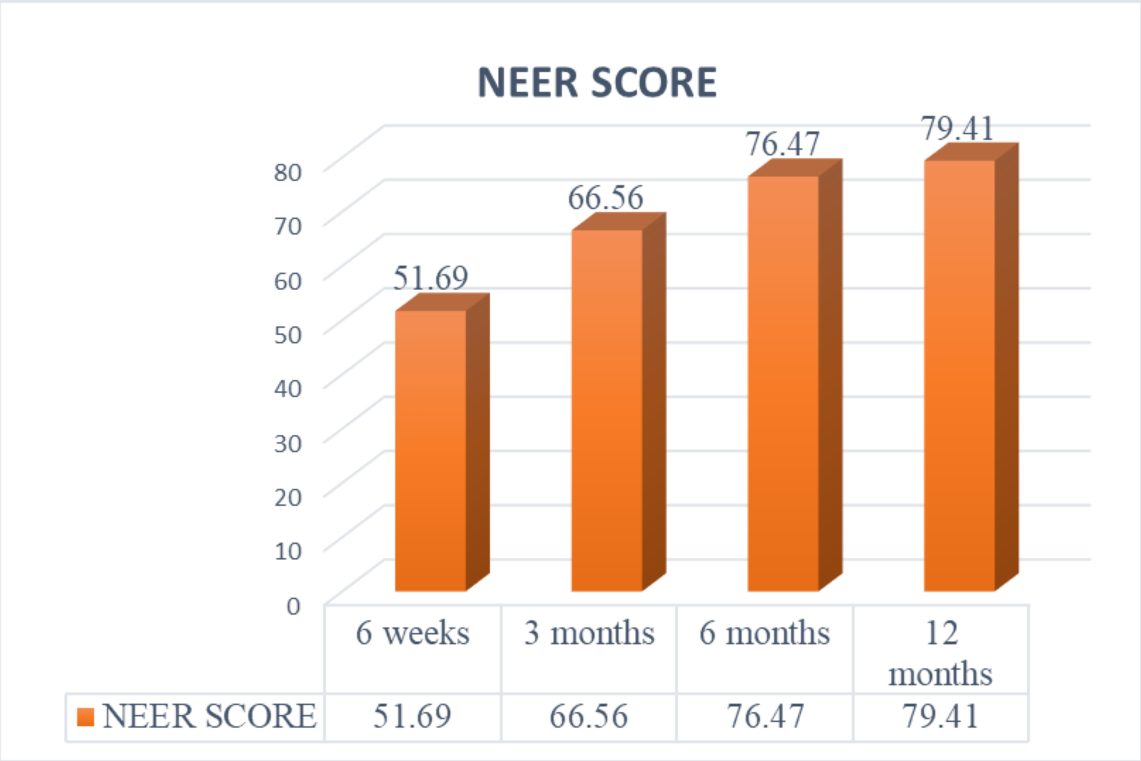


Fig 10.6 Neer score, follow-up patient for 6 weeks, 3,6 and 12 months

FOLLOW UP	APPROACH	NO.	NEER SCORE
6 weeks	Dual Incision	7	48.86
	Modified Swashbuckler	25	52.48
3 months	Dual Incision	7	66
	Modified Swashbuckler	25	66.72
6 months	Dual Incision	7	76.86
	Modified Swashbuckler	25	76.36
12 months	Dual Incision	7	78.57
	Modified Swashbuckler	25	79.64

Table 10.7 Neer score in comparison to approach

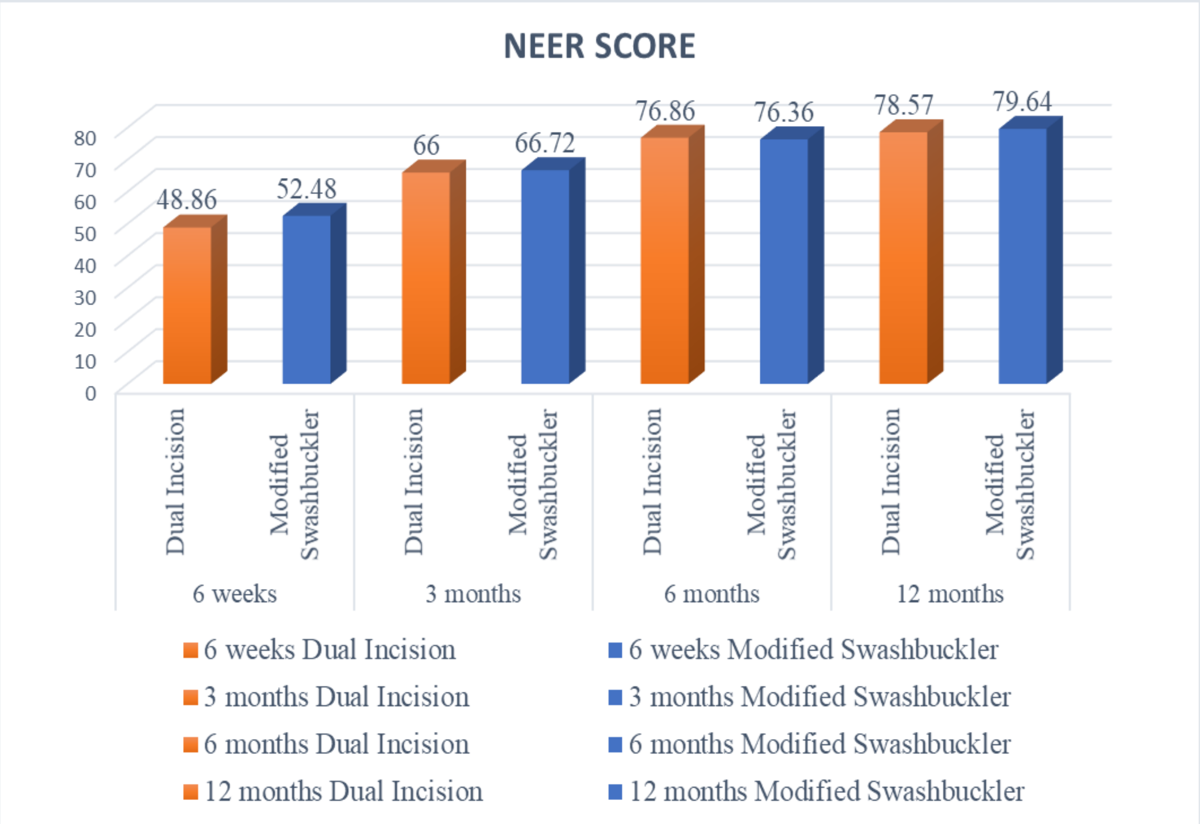


Fig 10.7 Neer score in comparison to approach

Neer's score was compared to the two approaches used for distal femur fracture.

Neer's score for all the follow-up periods showed that 21 patients operated with the modified swashbuckler approach had a better functional outcome.

FOLLOW UP	MODE OF INJURY	NUMBERS	NEER SCORE
6 weeks	Fall from height	2	52.00
	RTA	24	51.25
	Trivial Fall	6	53.33
3 months	Fall from height	2	63.00
	RTA	24	66.08
	Trivial Fall	6	69.67
6 months	Fall from height	2	74.50
	RTA	24	76.42
	Trivial Fall	6	77.33
12 months	Fall from height	2	79.00
	RTA	24	79.63
	Trivial Fall	6	78.67

Fig 10.8 Neer score in comparison to the mode of injury

All 32 patients were also compared based on the mode of injury.

24 patients had a history of road traffic accidents, and the mean Neer score at the time of 6 weeks was around 51. On further follow-up at 3 months, 6 months and 12 months, the mean Neer score progressively increased to 60, 76 and 80, respectively, suggestive of excellent outcome.

6 patients had a history of trivial falls (e.g., fall from a standing height); the mean Neer score at the time of 6 weeks was around 53. On further follow-up at 3 months, 6 months and 12 months, the mean Neer score progressively increased up to 69, 77 and 78, respectively, suggestive of good outcome.

2 patients had a history of fall from height; the mean Neer score at the time of 6 weeks was around 52. On further follow-up at 3 months, 6 months and 12 months, the mean Neer score progressively increased to 63, 74 and 79, respectively, suggestive of good outcome.

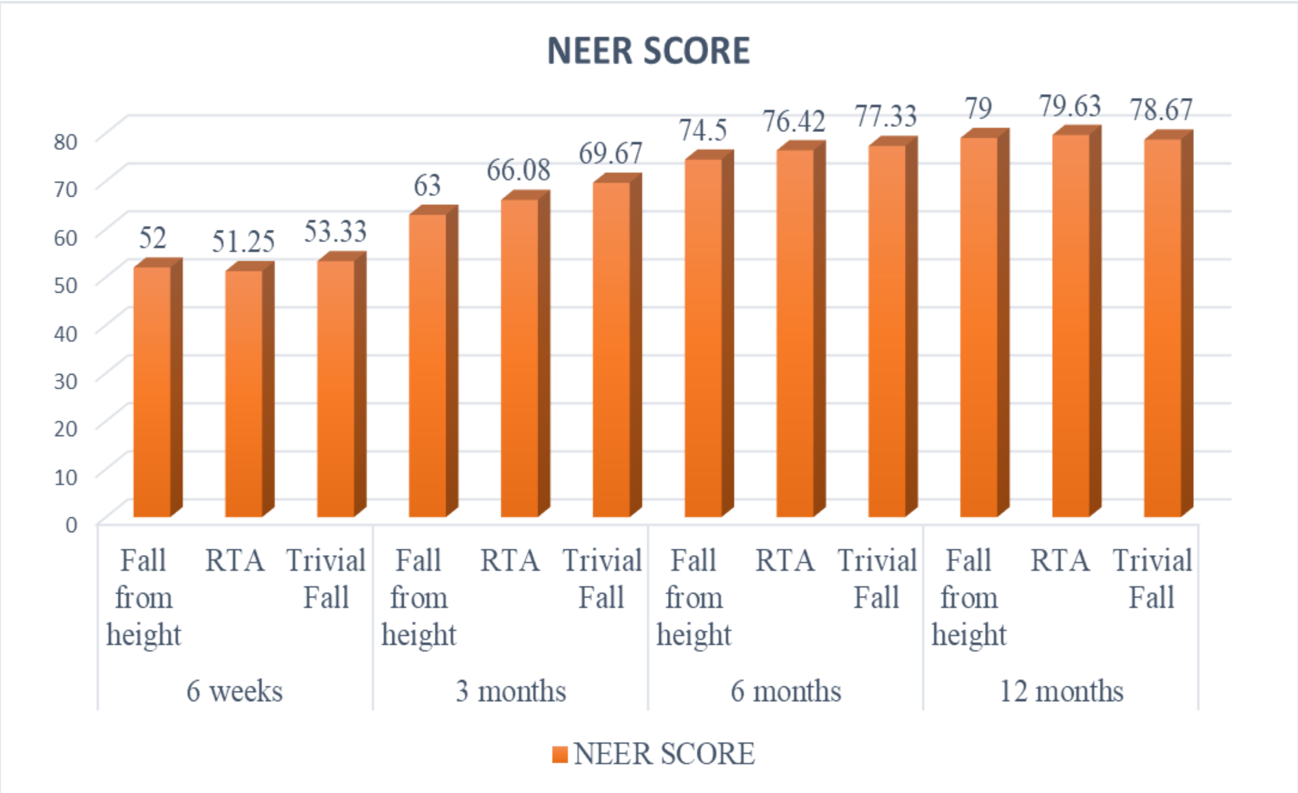


Fig 10.8 Neer score in comparison to the mode of injury

11.) DISCUSSION

Fractures of the distal femur are challenging due to the proximity to the knee joint and the effect of deforming forces, which need to be countered during reduction and fixation. Utilization of appropriate and effective reduction techniques is vital for achieving desirable clinical and functional outcomes, which would involve the preservation of vascularity and soft tissue in the vicinity of the fracture.

Due to the predominance of high-velocity injuries in distal femur fracture, comminution of the fracture is common and proves to be a major deciding factor when it comes to the implementation of an appropriate method of reduction and fixation and would also dictate the need for bone grafting depending on the bone loss present.

Dual plating, also referred to as medial assisted plating (MAP), in distal femur fractures, has been implemented in the treatment to address the above-mentioned challenges. Dual plating achieves a more rigid and anatomical fixation due to the nature of the stabilization.

The primary concerns for medial plating are unfamiliar approaches and proximity to the neurovascular bundle. It is lateral locked plating, not the addition of a medial plate, that causes the majority of vascular damage subsequent to open reduction and internal fixation of the distal femur.

According to the meta-analysis of the comparative investigations, there was no difference in the non-union rate or blood loss between the single plate and double plate fixation groups. On the other hand, double plate fixation required less time for fracture healing and required a longer surgery. [47]

A thorough examination of the research shows that the distal femur fracture has dual plating. The distal femur's A2, A3, C1, C2, and C3 fractures are classified according to AO.

Comparably, only a few studies chose the dual plate in cases of extremely low periprosthetic fracture and non-union after prior plate fixation for the aforementioned comminuted metaphyseal or articular fractures.

Very few studies show the radiological and functional outcomes of dual plating for the distal femur. There are studies comparing the treatment parameters for comminuted intraarticular distal femur fracture.

In our study, 32 patients were included, of which 25 were operated with a single modified swashbuckler approach, and 7 were operated on dual incision using medial and lateral approaches.

The modified swashbuckler approach was preferred compared to dual incision as it increases the duration of surgeries and more bleeding, and the medial approach is not preferred due to the close approximation to descending genicular branches along with arterial anastomosis to vastus medialis. If the muscular branches are not identified and cauterized, they get retracted, and it is difficult to stop the bleeding. A safe medial interval for plating has also been documented in other investigations, up to approximately 16 cm proximal to the adductor tubercle, with minimal risk to the femoral artery, nerve, and branches. [14]

According to our research, the dual incision approach group's mean surgical time was longer than the swashbuckler group's. In the swashbuckler approach group, the mean ROM was 120^0, while in the lateral group, it was 100^0. In the lateral approach group, the mean Neer score was 78.57, whereas in the swashbuckler approach group, it was 80.

This study was done to determine the clinical and functional outcome of dual plating of distal femur fractures. A total of 32 patients with fractures of the distal femur underwent fixation with dual plating during the time frame from August 2022 to August 2023. In our study, 53.1% of the patients were male, and 46.9 % were female, with 17 and 15 cases, respectively.

In the study by Rekha et al., 70% of the cases were male, with 30% being female. In the study by Bai et al., the female-male ratio was 1:1. [25], a ratio comparable to ours.

The observed average age of patients with distal femur fracture was 39, with the majority of the cases being between 21 and 40 years of age, accounting for 64% of the total cases, supporting that the majority of the cases are that of high-energy trauma in a younger population. The average age documented in the study by Kregor et al. was 49 [26], while in the study by Yeap et al., it was 44 [27].

RTA accounted for 60% of the total cases, contributing to the majority of the cases, while falls contributed to the remaining 40%. In the study by Rekha et al., 73% of the cases were due to RTA, and 27% were due to domestic falls [25]. In our study, AO type C3 was the pattern of fracture, accounting for all the cases. Hence, 68% of our cases were of AO type C fracture pattern, while Kregor et al. noted 50% of their cases were AO type C [26]. In the study by Rekha et al., 46.7% of their cases were AO type C [25].

Most of the fractures, i.e., all the cases, were closed fractures. The study by Apostolou et al. noted that 20% of their cases were open fractures, with the remaining cases (80%) being closed fractures, which is comparable to our study [28].

Although 84% of cases (n=26) did not have any postoperative complications on follow-up after three months, 8% (three cases) of cases had knee stiffness, 4% (one case) had non-union, and 4% (one case) had an infection. Schutz et al. noted 7% of cases had infection postoperatively [29], while Kregor et al. noted 5% infection in his study [26]. In the study by Garg et al, 10% of cases had superficial infections, non-union, and knee stiffness each [30].

Only 16% of cases, that is, five cases, had fixed flexion deformity, with four of them having up to 5 degrees. Sixty-eight percent of cases had knee flexion up to 120 degrees, while 24% of cases had a full range of motion, i.e., up to 130 degrees of knee flexion. Only 8% of cases had flexion less than 110 degrees, with the least being up to 100 degrees, which was still within functional limits. Our results were comparable to the study by Markmiller et al., where the average range of motion was 0-110 degrees [31]. Garg et al., in their study, had a mean range of flexion up to 124 degrees [30].

Twenty-four percent of cases had excellent outcomes per Neer's scoring systems, while 94% had good outcomes. Only 6% of cases had fair and poor outcomes. In the study by Garg et al., 50% of cases had excellent outcomes as per Neer's criteria, 30% had good outcomes, and fair and poor outcomes were 10% [30].

In this study, 78% of cases had shortening of affected limbs less than 1 cm postoperatively, while only 12% of cases had more than 1 cm shortening. In the study by Rekha et al., 10% of cases had a shortening of more than 1.5 cm [25].

84 % of cases had postoperative fracture displacement of less than 1.5 cm, which can be co-related with the better outcome of walking. 16 % of cases had a displacement of more than 1.6 cm. Park et al., in their study, reported a postoperative mean displacement of 5.6 mm [18].

12.) CONCLUSION

This research involved 32 patients who had fractures of the comminuted intraarticular femur. These patients received dual plating MAP (medial assisted plating) treatment, and the study evaluated their clinical results and functional outcomes. Our findings indicate a low occurrence of knee stiffness among patients.

According to Neer's scoring system, the majority of cases showed good to excellent results. After surgery, there was minimal displacement of fractures and shortening of limbs. Most patients regained normal walking ability postoperatively. Our study concludes that using dual fixation yields better outcomes for fractures in the distal femur, likely due to improved stabilization and earlier postoperative mobility.

This systematic review also revealed that dual plating leads to a satisfactory union in comminuted intraarticular distal femur fractures, low supracondylar periprosthetic fractures, geriatric fractures, and non-union using a modified swashbuckler or Para patellar approach depending on the type of comminution.

Limitations of this study are:

i. The sample size was small
ii. Follow-up duration was short; longer follow-up is required in order to assess such procedures.
iii. Assessment was done by subjective scores only.

FUNCTIONAL (70 POINTS)	SCORE
1	2
pain (20 points)	
no pain	20
intermittent	16
pain with fatigue	12
limits function	8
constant pain	4
walking capacity(20 points)	
same as before accident	20
mild restriction	16
restricted stair side ways	12
use crutches or other walking aids	4
joint movements (20 points)	
normal or 135 degrees	20
up to 100 degrees	16
up to 80 degrees	12
up to 60 degrees	8
up to 40 degrees	4
up to 20 degrees	0
work capacity(10 points)	
same as before accident	10
regular but with handicap	8
alter work	6
light work	4
no work	2
ANATOMICAL (30 POINTS)	
gross anatomy(15 points)	
thickening only	15
5 degree angulation or 0.5 cm shortening	12
10 degree angulation or 2 cm shortening	9
15 degree angulation or 3 cm shortening	6
healed with considerable deformity	3
non-union or chronic infection	0
roentgenogram (15 points)	
near normal	15
5 degree angulation or 0.5 cm shortening	12
10 degree angulation or 1 cm shortening	9
15 degree angulation or 2 cm displacement	6
union but with greater deformity,	
spreading of condyles and osteoarthritis	3
non-union or chronic infection	0

Fig 12.1 Neer Score

Neer clinical outcome score
EXCELLENT – more than 85 points
GOOD - 70 to 85 points
FAIR - 55 to 69 points
POOR - less than 55 points

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ANNEXURE I

SCHEME OF CASE TAKING:

CASE NO. :
FOLLOW UP NO. :
NAME :
AGE/SEX :
I P NO :
DATE OF ADMISSION :
DATE OF SURGERY :
DATE OF DISCHARGE :
OCCUPATION :
RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

Vitals
PR: RR:
BP: TEMP:
Systemic Examination:
Respiratory system -
Cardiovascular system -
Per abdomen -
Central nervous system -

Local examination:

Right/ Left Leg

Gait:

Inspection:

a) Attitude

b) Abnormal swelling

c) Shortening

d) Skin condition

e) Compound injury, if any

Palpation:

a) Swelling

b) Local tenderness

c) Bony irregularity

d) Abnormal movement

e) Crepitus/ grating of fragments

f) Absence of transmitted movements

g) Wound

Movements:	Active	Passive
Flexion		
Extension		

Intra Operative details:

Post-Operative:

- Rehabilitation protocol as per the guidelines
- Functional outcome evaluation with:
    1. Neer score

ANNEXURE II

INFORMED CONSENT FORM FOR PARTICIPATION IN DISSERTATION / RESEARCH

I, the undersigned, _______________, S/O D/O W/O ________________, aged ____years, ordinarily resident of ____________, do hereby state/declare that Dr. KAUSHAL TRIVEDI of Shri. B. M. Patil Medical College Hospital & Research Centre has examined me thoroughly on ______________ at ______________ (place), and it has been explained to me in my own language that I am suffering from ________________ disease (condition) and this disease/condition mimics the following diseases. Further, Dr. KAUSHAL TRIVEDI informed me that he/she is conducting a dissertation/research titled "RADIOLOGICAL AND FUNCTIONAL OUTCOME OF DUAL PLATING IN COMMINUTED INTRARTICULAR DISTAL FEMUR FRACTURES" under the guidance of Dr. SANTOSH S. NANDI requesting my participation in the study. Apart from routine treatment procedures, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

The doctor has also informed me that during the conduct of this procedure, adverse results might be encountered. Most of them are treatable but are not anticipated; hence there is a chance of aggravation of my condition. In rare circumstances, it may prove fatal despite the expected diagnosis and best treatment made available. Further, the Doctor has informed me that my participation in this study will help in the evaluation of the results of the study, which is a useful reference to the treatment of other similar cases in the near future. also, I may benefit from getting relief from suffering or a cure of the disease I am suffering.

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

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

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

Signature of the patient:

Signature of doctor:

Witness: 1.

2.

ANNEXURE III

75 Azadi Ka Amrit Mahotsav

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 727/2022-23 30/8/2022

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Friday, 26th August, 2022 at 3.30 p.m. in the Department of Pharmacology** scrutinizes the Synopsis of Post Graduate Student of BLDE (DU)'s Shri B.M.Patil Medical College Hospital & Research Centre from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "Radiological and Functional Outcome of Dual Plating In Comminuted Intraarticular Distal Femur Fracture".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR KAUSHAL PRADHYUMAN T

NAME OF THE GUIDE: Dr.S.S.Nandi, Dept. of Orthopedics. .

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

Smt. Bangaramma Sajjan Campus, B. M. Patil Road (Sholapur Road), Vijayapura - 586103, Karnataka, India.
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College: Phone: +918352-262770, Fax: +918352-263019, E-mail: bmpmc.principal@bldedu.ac.in

MASTERCHART

SR NO.	NAME	AGES(YEARS)	SEX	PATIENT ID	MODE OF INJURY	SIDE OF INJURY	APPROACH	NEER SCORE			
								6 weeks	3 months	6 months	12 months
1	MALLIKARJUN	29	M	19840	RTA	LEFT	Dual Incision	44	64	76	80
2	GANGAWWA	78	F	48005	Trivial Fall	LEFT	Modified Swashbuckler	52	76	78	78
3	MALLIKARJUN	56	M	111894	RTA	LEFT	Modified Swashbuckler	48	64	76	82
4	SEETA ANAND	32	F	78632	Fall from height	RIGHT	Modified Swashbuckler	52	66	74	80
5	NEELAMMA	35	F	149420	RTA	LEFT	Modified Swashbuckler	54	68	76	80
6	BHIMAWWA	52	F	181798	RTA	RIGHT	Modified Swashbuckler	52	60	75	78
7	PARVATI	58	F	230361	RTA	RIGHT	Modified Swashbuckler	50	72	78	80
8	SINGALINGAPPA	61	M	89234	Trivial Fall	LEFT	Dual Incision	48	60	76	78
9	RESHMA	35	F	304797	RTA	RIGHT	Modified Swashbuckler	50	62	74	80
10	SUSHMA	32	F	332700	RTA	LEFT	Modified Swashbuckler	54	72	78	80
11	SUDHA	33	F	365988	RTA	RIGHT	Dual Incision	46	66	76	76
12	HARINI	37	F	361737	RTA	RIGHT	Modified Swashbuckler	52	64	76	82
13	TAMMNAGOUDA	77	M	457682	Trivial Fall	LEFT	Modified Swashbuckler	62	72	78	80
14	BASSLINGAPPA	50	M	125923	RTA	LEFT	Modified Swashbuckler	52	60	75	78
15	GOURABAI	65	F	269582	RTA	RIGHT	Modified Swashbuckler	52	76	78	78
16	KUSHMABAI	43	F	436876	Trivial Fall	LEFT	Modified Swashbuckler	46	58	76	80
17	RAKESH	23	M	267866	RTA	LEFT	Dual Incision	54	66	76	78
18	SADASHIV	38	M	23455	RTA	LEFT	Modified Swashbuckler	48	62	76	83
19	BASASAB	42	M	109441	RTA	LEFT	Modified Swashbuckler	52	66	78	80
20	SHIVSHANKAR	43	M	142846	RTA	RIGHT	Modified Swashbuckler	54	68	76	82
21	SAIPAN	56	M	139341	RTA	RIGHT	Dual Incision	42	66	78	80
22	KAMALABAI	78	F	368432	Trivial Fall	RIGHT	Modified Swashbuckler	52	76	78	78
23	RACHHAPPA	64	M	376984	RTA	RIGHT	Dual Incision	48	64	78	80
24	PUNDALIK	70	M	368963	Fall from height	RIGHT	Modified Swashbuckler	52	60	75	78
25	MUTTAPPA	54	M	592047	RTA	LEFT	Modified Swashbuckler	44	58	74	80
26	YAMLAPPA	65	M	349023	Trivial Fall	LEFT	Dual Incision	60	76	78	78
27	KABIR	25	M	216047	RTA	LEFT	Modified Swashbuckler	54	66	76	80
28	SHIVBASSAPPA	48	M	395184	RTA	RIGHT	Modified Swashbuckler	62	72	78	80
29	SHRISHAIL	50	M	501286	RTA	LEFT	Modified Swashbuckler	50	64	76	80
30	SAKKARBAI	72	F	226104	RTA	LEFT	Modified Swashbuckler	52	66	76	76
31	PARVATI	35	F	167395	RTA	LEFT	Modified Swashbuckler	62	72	78	80
32	LAXMI	46	F	319652	RTA	RIGHT	Modified Swashbuckler	54	68	76	78

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