"FUNCTIONAL OUTCOME OF FRACTURE SHAFT OF FEMUR TREATED BY INTRAMEDULLARY INTERLOCKING NAILING"

By

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Dissertation submitted to

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In partial fulfillment

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MASTER OF SURGERY

IN

ORTHOPAEDICS

Under The Guidance of

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2014

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"FUNCTIONAL OUTCOME OF FRACTURE SHAFT OF FEMUR TREATED BY INTRAMEDULLARY INTERLOCKING NAILING"** is a bonafide and genuine research work carried out by me under the guidance of DR. O.B. PATTANASHETTY, Professor and H.O.D, Department of Orthopaedics, Shri. B.M. Patil Medical College, Hospital and Research centre, Bijapur.

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DR. MAPARI YOGESH

LIST OF ABBREVIATIONS

AIIS	Anterior inferior iliac spine
ASIS	Anterior superior iliac spine
AP	Antero-posterior
LAT	Lateral
EX-FIX	External fixator
IMIL	Intramedullary interlocking
CRIF	Closed reduction and internal fixation
ORIF	Open reduction and internal fixation
LLD	Limb length discrepancy
R.O.M	Range of motion
Pre op	Pre operative
Post op	Post operative
RTA	Road traffic accident
FWB	Full weight bearing
PWB	Partial weight bearing
NWB	Non weight bearing
PTS	Patients
TBW	Tension-Band Wiring
CC-Screw	Cannulated Cancellous Screw

ABSTRACT

BACKGROUND AND OBJECTIVE:

Femur is the longest bone of the body and one of the principal load bearing bones in lower extremity. Fracture of the shaft of femur is major cause of morbidity and mortality in patients. Fractures of the shaft of femur are the result of high energy trauma, which may be associated with multisystem injury and considerable soft tissue injury.

Urgent prompt reduction and rigid stable internal fixation is today's accepted mode of treatment, which will reduce the risk of pathophysiological complications as well as help to prevent permanent impairment of knee function by early mobilization. Intramedullary nailing of diaphyseal femur fractures provides a stable fixation construct with high union rates and low complication rates. Reaming of femoral canal allows insertion of femur nails with larger diameter which gives mechanical purchase, provides stability and also enhances fracture healing due to deposition of marrow elements at fracture site. The method that is closely approaching this perfection is intramedullary interlocking nailing of femoral shaft fractures.

The objective of this study was to confirm the results of intramedullary interlocking nailing in femoral shaft fractures with regards to the rate of union and complications.

METHODS:

The study was conducted between the period of 1st October 2012 to 31st march 2014 in Shri. B.M. Patil medical college, hospital and research centre, Bijapur. 30 patients with diagnosis of fracture shaft of femur were treated with intramedullary interlocking nailing. All closed Gustilo-Anderson type 1 and 2 femoral shaft fractures in adults aged 20 years and above of either sex were included in the study. All the patients were followed up. With each follow up, clinical and radiological examinations were performed at 6 weeks, 12 weeks, 24 weeks and thereafter once in three months.

RESULTS:

- The study included 30 patients, 20 male and 10 female aged from 21-60 years with the mean age of 31.63 years. The average time for fracture union in our series was 20.27 weeks. In the present study, malalignment of femur was observed in 3 patients. We had excellent knee range of movement in our cases. In all, there was shortening in 2 patients. One patient developed superficial infection that resolved with antibiotics. Delayed union was seen in 2 patients. Fracture united at 32 weeks in both the cases.
- Our study yielded excellent to good results in 90% of the cases.

CONCLUSION:

We conclude that Intramedullary interlocking nailing is a very effective and successful method of definitive primary treatment in most types of fractures of the shaft of the femur. Interlocking nail provides strong fixation, rotational stability, and early return to functional status, as the rate of healing is good with this method.

KEY WORDS: Femoral shaft fractures, reaming, intramedullary interlocking nailing

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INTRODUCTION

Fractures of the shaft of the femur are among the most common fractures encountered in orthopaedic practice. Because the femur is the largest bone of the body and one of the principal load-bearing bones in the lower extremity, fractures can cause prolonged morbidity and extensive disability unless treatment is appropriate. Fractures of the femoral shaft often are the result of high-energy trauma and may be associated with multiple system injuries. The type and location of the fracture, the degree of comminution, the age of the patient, the patient's social and economic demands, and other factors may influence the method of treatment. The art and science of fracture management has tremendously advanced over the years. From the use of external splints in the Hippocratic age, to the recent sophisticated instrumentation, treatment of fracture has made an impact in the surgical field. Locked intramedullary nailing currently is considered to be the treatment of choice for most femoral shaft fractures.

The advent of interlocking nailing has widened the spectrum of femoral shaft injuries that could be stabilized by IM technique. Use of interlocking nailing minimizes the incidence of leg length discrepancies, rotation and angulation deformities. Intramedullary nail being close to center of femur can tolerate bending and torsional loads better than plates and the locking mechanism provides less tensile and shear forces than plates. IM interlocking nail is a load sharing device causing less cortical osteopenia of stress shielding which is a feature of the load bearing plates. Regardless of the treatment method chosen, the following principles are agreed on: (1) restoration of alignment, rotation, and length; (2) preservation of the blood supply to aid union and prevent infection; and (3) rehabilitation of the extremity and the patient.

The method studied for this dissertation is ‘Functional outcome of fracture shaft of femur treated by intramedullary interlocking nailing’

AIMS AND OBJECTIVES

To confirm the results of intramedullary interlocking nailing in femoral shaft fractures with regards to the rate of union and complications.

REVIEW OF LITERATURE

Intramedullary (IM) nailing is one of the greatest advances of this century in the treatment of fractures. Most of the development has come about in the past 40 years.

- History of treatment of femoral shaft fractures dates back to ancient civilization where wooden splints wrapped with leather, bandages stiffened with gum and more recently fabrics hardened with plaster of Paris was used[1].
- Spanish conquerors in 16th century reported that Incas and Aztecs used resinous wooden pegs in the medullary canal of long bones to treat non unions[2].
- First attempted internal fixation though unsuccessful was by Lapuyand and Sirco in 1775. Methijesen a Dutch surgeon in 1852 reported the use of plaster of Paris for immobilization of fractures[3].
- Buck a U.S. Military surgeon in 1861 described skin traction for femoral shaft fractures with knees extended[3].
- Thomas Hugh O. a brace maker of U.K. in 1875 introduced his splint to immobilize tuberculosis knee, which soon became popular in the treatment of femoral shaft fractures[3].
- In 1897, Ronsohoff promoted open reduction and internal fixation for irreducible fractures. Steinmann a Berlin surgeon in 1907 described his "pin" which when introduced in distal femur and weights added, was useful in femoral shaft fractures[3]
- Hey Groves in 1918 first reported intramedullary nailing of femoral fractures in 3 cases of gunshot injuries. The nail did not span much of distal fragment.

The results were unsatisfactory as all cases were infected and he abandoned its use[4].

- Bohler an Australian surgeon in 1929 published his text on non-operative treatment of fractures. He developed his " Bohler's frame" which when combined with already established skeletal traction was used in treatment of femoral shaft fractures[5].
- Rush L.V. and Rush H.L. in 1939 described a technique, of introducing a longitudinal pin in fixation of certain fractures of femur[6].
- Kuntscher of Kiel in Germany in 1940 reported and popularized closed nailing in femoral shaft fractures. Initially it was 'u' shaped and later modified to cloverleaf shape to give stability to fracture site[7].
- Kuntscher in 1957 introduced the technique of reaming in AAOS meeting[8]. Kuntscher in 1968 proposed a new device for Intramedullary osteosynthesis in comminuted fractures. It was called the " Detensor nail". It consisted of proximal and distal locking bolt and was forerunner of interlocking nails[9]. Closed nailing came in vogue in the 1970s with the advent of the image intensifier. The technique of closed nailing was popularized by the AO-ASIF during the period 1970-75 for midshaft fractures of the femur and tibia.
- Klemm and Schellaman in 1972 introduced the interlocking nails, following initial success with this treatment of infected nonunions, they began treating comminuted fractures making appropriate changes in design and technique with experience[10].
- Grosse and Kempf in 1976 modified the nail further to include proximal cylindrical internally threaded portion and 45 deg proximal diagonal screw fixation and moved the distal transfixation holes closer to the tip of the nail[11].

- Thoresen B.O. et al: in 1985 reported their finding of treating 48 femoral shaft fractures with Groose - Kempf interlocking nailing. 30 had excellent, 8 had good, 7 had fair and two poor results. Median time to weight bearing was 30 days, median time of radiographic consolidation was 16 weeks. Complications included shortening in 7 patients (l.l to 9cms), varus, valgus or genu recurvatum in 5 patients with one delayed union. They concluded that interlocking nailing was a useful method and recommended static method be used whenever in doubt about fracture stability[12].
- Wiss .D. A. et al, in 1990 treated thirty three segmental factures (26 closed and seven open fractures) by G.K nail. Thirty two united at average of thirty two weeks with one nonunion. They concluded that closed interlocking nailing is the treatment of choice for most segmental fractures of shaft of femur[13].
- Knudsen C.J. and Crobler G. P. in 1991 described a simple method of inserting the distal screws in a locked femoral nail using 3mm K-wire and an air drill[14].
- Wu et al[15] 1991, treated fractures of the distal femur with GK-interlocking nail, pts were followed up over a period of 1 year, 5 did not unite and the rest healed after a period of 5 months (3-7 months). Nail breakage was the most serious complication, more distal the fracture, more easily the nail broke. They concluded that the addition of cast brace and protected weight bearing, a locked nail is a good fixation device for distal femoral fractures down to 4 cms above the condyles.
- Fogarty A B et al[16] 1991 treated 46 femoral fractures between June 1986 and April 1990. These included 7 compound and 3 comminuted fractures. The union rate was 98% and there were no instances of deep infection.

- Wu et al 1992[17] conducted a prospective study of 66 consecutive unstable comminuted supracondylar fracture femur in adults, 28 were fixed with plates and 38 with GK interlocking nails. Patients were followed up for at least 1 year. Interlocking nails led to higher union rate and more satisfactory functional result. They concluded that for a cooperative pt a closed static interlocking nail with strict non weight bearing should be the treatment of choice and for an uncooperative pt closed static nailing must be supplemented with a cast brace to reduce complication rate.
- Anastopoulos George et al 1993[18] treated 108 femoral shaft fractures in 106 adult patients by closed interlocking nailing. The procedure was done with the pt in supine position. All the fractures united in an average of 18 weeks (12-24). Dynamisation was done in 15 fractures. No infection or delayed union was seen. They concluded that closed interlocking nailing seems to be the treatment of choice for comminuted and segmental fractures of femoral shaft provided all technical details are followed by the surgeon.
- Nipatasajet al[19] 1995 treated 44 femoral shaft fractures with AO interlocking technique. All the cases were comminuted, segmental or rotationally unstable fractures caused by road traffic accidents. All pts had more than 90° flexion of the knee within 2 weeks and resumed full range of knee motion within 2 months postop. They noticed no serious complications in the period of 29 months follow-up. They concluded that closed intramedullary nailing is one of the treatment of choice for comminuted segmental or rotationally unstable fractures.
- Grover J and Donald A W, 1995 conducted a prospective study on 267 fractures of shaft femur treated with a static interlocking I.M. nail comparing

one verses two distal screws. They concluded that proximal and middle third fractures of femur could be successfully treated with single distal screw without compromising fracture fixation, thus reducing operating and radiation exposure time and incidence of soft tissue irritation by new screw head. In distal third fractures, however two distal screws should be used to avoid potential angulatory deformity[20].

- Williams M.M et al in 1995 reported a study of primary immediate and delayed reamed intramedullary nailing of open femoral shaft fractures. The infection and nonunion rate was 2.4%. Comparison between the two groups showed no significant difference in incidence of infection, nonunion, malunion or time to union[21].
- Wu et al[22] 1997 retrospectively studied the effect of dynamising a static interlocking nail to promote fracture healing. He concluded that dynamisation is a method that can be tried to improve fracture healing in femoral fractures that show delayed healing after interlocking procedure.
- Brumback R J et al[23] 1999 concluded that 2 part investigation to test feasibility, safety and efficacy of immediate weight bearing after treatment of femoral fracture with static interlocking nailing. They concluded that immediate weight bearing after stabilization of a comminuted fracture of femoral shaft with a statically locked nail is a safe procedure when the construct has a relatively high fatigue strength. Immediate weight bearing after stabilization permits pts with multiple fractures to walk and to participate in physical therapy earlier decreasing duration of hospital stay or reducing the need for rehabilitation on a prolonged basis.

- Wolinsky et al[24] 1999, treated 51 cases of femoral shaft fractures with reamed interlocking nail. They concluded that reamed nailing of femoral shaft fractures result in a low rate of malunion, nonunion, infection and hardware failure.
- Brumback RJ et al[25] in 2000 compared reamed and unreamed IM nailing. They showed that femoral shaft fracture treated with unreamed nailing have slightly higher rates of delayed and nonunion compared to those treated with reamed nails. Reaming is not concomitantly associated with pulmonary complications in multiply injured pts although this point is still controversial. Reamed interlocking nail remains the treatment of choice for treating shaft fractures in adults.
- Arazi et al 2001[26] studied the effect of early weight bearing after statically locked reamed IM nailing of comminuted femoral fractures. 30 cases were included (Winquist type I, II, III, IV) and treated with static reamed interlocking nailing. 24 patients were followed up at least 1 year, early weight bearing was encouraged and most of the patients would start between the first 2 and 4 weeks post-operatively. All fractures healed without complications. No cases of nail bending or breakage were reported. One case each was reported in both proximal and distal locking screw bending. They concluded that early weight bearing in static reamed interlocking nailing of Winquist type II, III, IV femoral fractures is a safe and effective method.
- Keita I. et al in 2001 reported a study on improved intramedullary interlocking nailing in osteoporotic bones. They showed the biomechanical benefits of increasing the bone–implant interface surface for improving the acute stiffness and strength of fracture fixation in osteoporotic cancellous

bone. The fixator–bone construct withstood higher forces before failure in these fragile bones[27].

- Pihlajamaki H.K et al in 2002 reported a study on the treatment of nonunions following intramedullary nailing of femoral shaft fractures. They concluded that exchange nailing without extracortical bone grafting seems to be the most effective method to treat a disturbed union of a femoral shaft fracture after intramedullary nailing[28].
- Liao J.C et al in 2003 reported a study on mini-open intramedullary nailing of 82 acute femoral shaft fractures: reduction through a small incision without a fracture table. The surgical technique involved a mini-wound at the fracture site, and fracture reduction was performed with 1 finger or a bone hook without the use of a fracture table. Seventy four fractures (97%) healed in the first 6 months. The mean operation time for the procedure was 75 minutes[29].
- Wolinsky, Philiph MD, University of California 2004[30] studied effect of reamed intramedullary nailing and systemic inflammatory response. Stabilization of the femoral shaft with reamed intramedullary nailing could cause complications in certain subset of patients. Initially, it was though that patients with thoracic injuries were at risk of complications. But this has been shown not to be the case. Current thought is avoiding reamed intramedullary nailing in patients who have an over stimulated immune system and/or who are under resuscitation. These patients could react better to initial treatment with an external fixator with later conversion to reamed intramedullary nailing.
- Tigani, Fravisini, Stagni, Pascarella, Boriani, 2005[31] studied 175 closed femoral shaft fractures to evaluate the effect of dynamization on time to bony

union. They concluded that time to union was significantly shorter in static group(103 days) compared to the dynamized group(126 days)

- Meena RC, Kundnani V, Hussain Z, 2006[32] studied closed vs open interlocking nailing for fracture shaft femur and concluded that open interlocking of fracture of long bones can be applied at very basic level of Indian health infrastructure where facilities of IITV and surgical expertise are still lacking. The results obtained by them were comparable to closed nailing.
- Gharehdaghi M. et al in 2007 reported a prospective study of closed and open reamed intramedullary nailing of 136 femoral shaft fractures in adults. Total union rate was 96%, nonunion was observed in 2 cases in closed and in 4 cases in open method[33].
- Crist BD, Wolinsky PR in 2009[34] studied reamed intramedullary nailing is the current gold standard for the treatment of diaphyseal fractures of the femur. Current concepts of orthopaedic damage control surgery for patients with multiple injuries have placed an emphasis on appropriate surgical timing, limiting blood loss, and the duration of the initial operative procedure(s). Proponents of unreamed nailing have stated that reaming places polytraumatized patients "at risk," in part because it adds to the length of the surgical procedure and may exacerbate the severity of a patient's pulmonary injury.
- Attal R, Blauth M in 2010[35] studied effect of reaming and non-reaming of intramedullary nails in long bone fractures as a controversial and even emotional topic in recent decades. This study gives a historical overview of the development in this field and presents the background to the need for unreamed nailing. Furthermore, the current state of knowledge is illustrated by

describing the results of a series of randomized controlled trials. Before the year 2000 nearly all German handbooks on orthopaedic and trauma surgery recommended unreamed intramedullary nailing as a more "biological" treatment that causes less harm to vascularity with equal or even better results. Unreamed nailing was in particular advocated for the treatment of open fractures. The tide turned as randomized controlled trials conducted since 2000 gave evidence that unreamed nailing leads to a higher rate of delayed or non-union, while the advantages to blood supply and infection rate could not be proven.

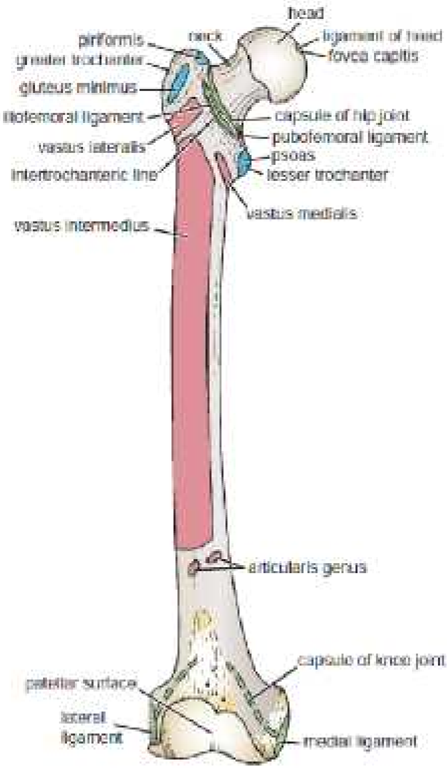
ANATOMY[36]

The femur articulates above with the acetabulum to form the hip joint and below with the tibia and the patella to form the knee joint. The upper end of the femur has a head, a neck, and greater and lesser trochanters. The **head** forms about two thirds of a sphere and articulates with the acetabulum of the hip bone to form the hip joint. In the center of the head is a small depression, called the **fovea capitis,** for the attachment of the ligament of the head. Part of the blood supply to the head of the femur from the obturator artery is conveyed along this ligament and enters the bone at the fovea. The **neck,** which connects the head to the shaft, passes downward, backward, and laterally and makes an angle of about 125° (slightly less in the female) with the long axis of the shaft. The **greater** and **lesser trochanters** are large eminences situated at the junction of the neck and the shaft. Connecting the two trochanters are the **intertrochanteric line** anteriorly, where the iliofemoral ligament is attached, and a prominent **intertrochanteric crest** posteriorly, on which is the **quadrate tubercle**.

The **shaft** of the femur is smooth and rounded on its anterior surface but posteriorly has a ridge, the **linea aspera**, to which are attached muscles and intermuscular septa. The margins of the linea aspera diverge above and below. The medial margin continues below as the **medial supracondylar ridge** to the **adductor tubercle** on the medial condyle. The lateral margin becomes continuous below with the **lateral supracondylar ridge.** On the posterior surface of the shaft below the greater trochanter is the **gluteal tuberosity** for the attachment of the gluteus maximus muscle. The shaft becomes broader toward its distal end and forms a flat, triangular area on its posterior surface called the **popliteal surface**. The lower end of the femur has **lateral** and **medial** condyles, separated posteriorly by the **intercondylar notch.**

The anterior surfaces of the condyles are joined by an articular surface for the patella. The two condyles take part in the formation of the knee joint. Above the condyles are the **medial** and **lateral epicondyles**. The adductor tubercle is continuous with the medial epicondyle.

The important muscles and ligaments attached to the femur are shown below (figures 1,2)



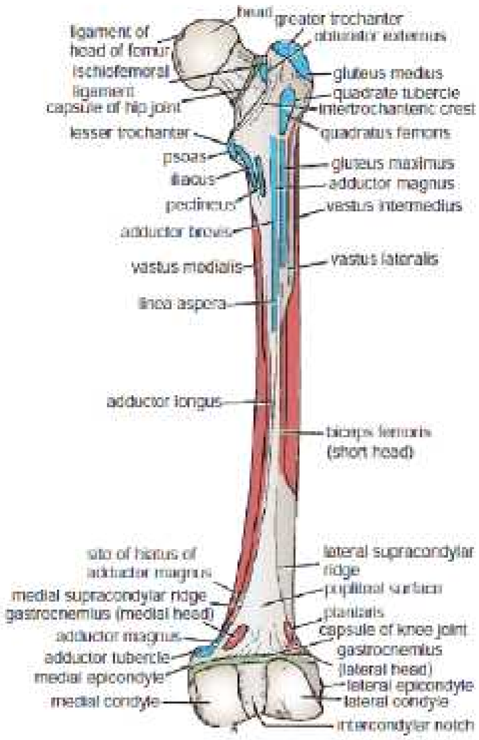


FIGURE-1: MUSCLES AND LIGAMENTS ATTACHED TO THE ANTERIOR SURFACE OF FEMUR

FIGURE-2: MUSCLES AND LIGAMENTS ATTACHED TO THE POSTERIOR SURFACE OF FEMUR

Muscles Of The Anterior Fascial Compartment Of The Thigh					
Muscle	**Origin**	**Insertion**	**Nerve Supply**	**Nerve Root**	**Action**
Sartorius	Anterior superior iliac spine	Upper medial surface of shaft of tibia	Femoral nerve	L2, 3	Flexes, abducts, laterally rotates thigh at hip joint; flexes and medially rotates leg at knee joint
Iliacus	Iliac fossa of hip bone	With psoas into lesser trochanter of femur	Femoral nerve	**L2,** 3	Flexes thigh on trunk; if thigh is fixed, it flexes the trunk on the thigh as in sitting up from lying down
Psoas	Transverse processes, bodies, and intervertebral discs of the 12th thoracic and five lumbar vertebrae	With iliacus into lesser trochanter of femur	Lumbar plexus	**L1, 2,** 3	Flexes thigh on trunk; if thigh is fixed, it flexes the trunk on thigh as in sitting up from lying down
Pectineus	Superior	Upper end of linea	Femoral	**L2,** 3	Flexes and adducts

	ramus of pubis	aspera of shaft of femur	nerve		thigh at hip joint
Quadriceps femoris					
Rectus femoris	Straight head: anterior inferior iliac spine Reflected head: ilium above acetabulum	Quadriceps tendon into patella, then via ligamentum patellae into tubercle of tibia	Femoral nerve	L2, **3, 4**	Extension of leg at knee joint; flexes thigh at hip joint
Vastus lateralis	Upper end and shaft of femur	Quadriceps tendon into patella, then via ligamentum patellae into tubercle of tibia	Femoral nerve	L2, **3, 4**	Extension of leg at knee joint
Vastus medialis	Upper end and shaft of femur	Quadriceps tendon into patella, then via ligamentum patellae into tubercle of tibia	Femoral nerve	L2, **3, 4**	Extension of leg at knee joint; stabilizes patella
Vastus intermedius	Anterior and lateral surfaces of shaft of femur	Quadriceps tendon into patella, then via ligamentum patellae into tubercle of tibia	Femoral nerve	L2, **3, 4**	Extension of leg at knee joint; articularis genus retracts synovial membrane

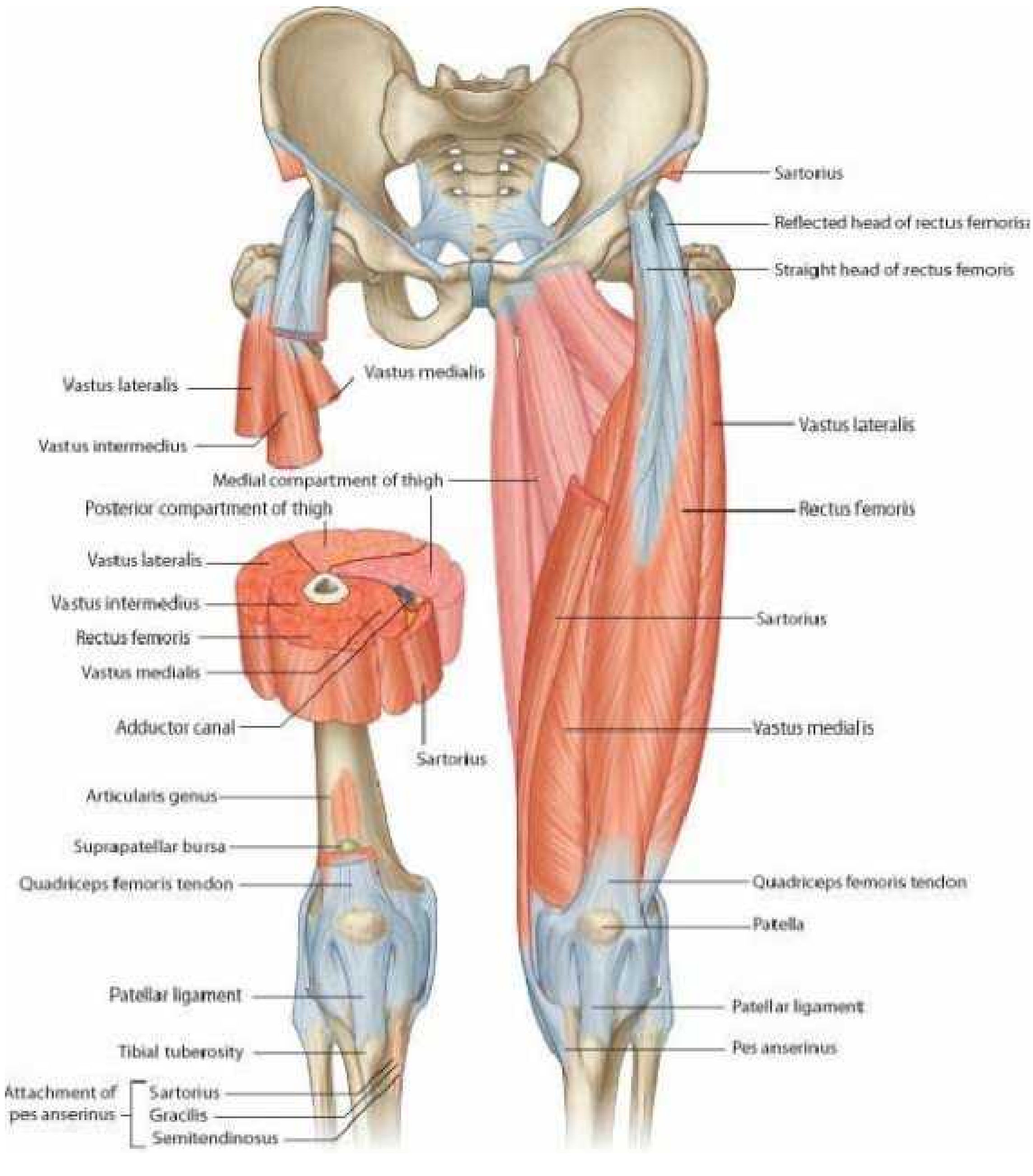


FIGURE-3: ANTERIOR VIEW OF THIGH

Muscles of the Medial Fascial Compartment of the Thigh					
Muscle	**Origin**	**Insertion**	**Nerve Supply**	**Nerve Root**	**Action**
Gracilis	Inferior ramus of pubis, ramus of ischium	Upper part of shaft of tibia on medial surface	Obturator nerve	**L2,** 3	Adducts thigh at hip joint; flexes leg at knee joint
Adductor longus	Body of pubis, medial to pubic tubercle	Posterior surface of shaft of femur (linea aspera)	Obturator nerve	L2, **3, 4**	Adducts thigh at hip joint and assists in lateral rotation
Adductor brevis	Inferior ramus of pubis	Posterior surface of shaft of femur (linea aspera)	Obturator nerve	L2, **3, 4**	Adducts thigh at hip joint and assists in lateral rotation
Adductor magnus	Inferior ramus of pubis, ramus of ischium, ischial tuberosity	Posterior surface of shaft of femur, adductor tubercle of femur	Adductor portion: obturator nerve Hamstring portion: sciatic nerve	L2, **3, 4**	Adducts thigh at hip joint and assists in lateral rotation; hamstring portion extends thigh at hip joint
Obturator externus	Outer surface of obturator membrane and pubic and ischial rami	Medial surface of greater trochanter	Obturator nerve	L3, **4**	Laterally rotates thigh at hip joint

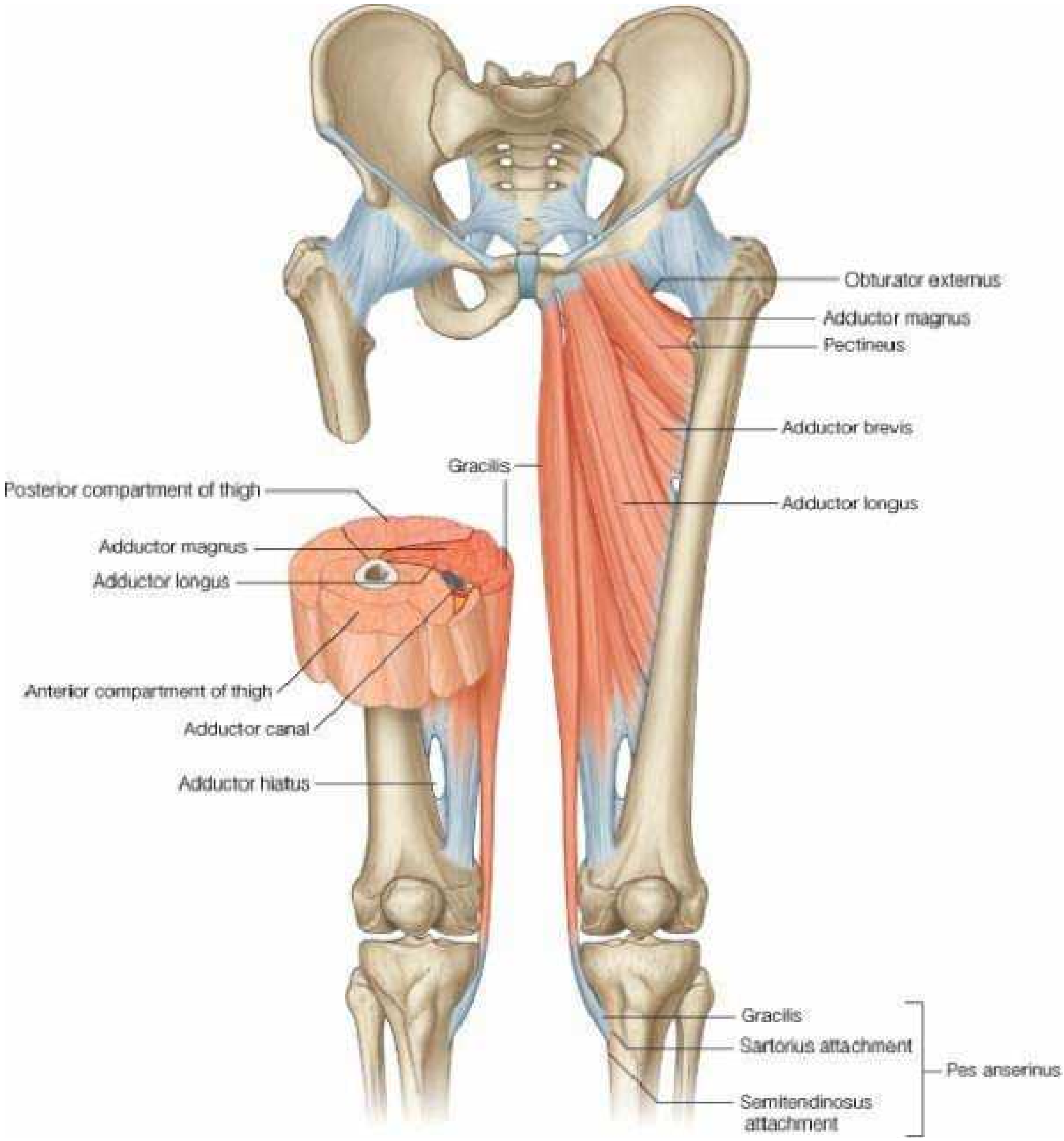


FIGURE-4: ANTERIOR VIEW OF THIGH SHOWING MEDIAL COMPARTMENT

Muscles of the Posterior Fascial Compartment of the Thigh					
Muscle	**Origin**	**Insertion**	**Nerve Supply**	**Nerve Root**	**Action**
Biceps femoris	Long head: ischial tuberosity Short head: linea aspera, lateral supracondylar ridge of shaft of femur	Head of fibula Short head: Linea aspera, lateral supracondylar ridge of shaft of femur	Long head: tibial portion of sciatic nerve Short head: common peroneal portion of sciatic nerve	L5; **S1,** 2	Flexes and laterally rotates leg at knee joint; long head also extends thigh at hip joint
Semitendinosus	Ischial tuberosity	Upper part of medial surface of shaft of tibia	Tibial portion of sciatic nerve	**L5; S1,** 2	Flexes and medially rotates leg at knee joint; extends thigh at hip joint
Semimembranosus	Ischial tuberosity	Medial condyle of tibia	Tibial portion of sciatic nerve	**L5; S1,** 2	Flexes and medially rotates leg at knee joint; extends thigh at hip joint
Adductor magnus (hamstring portion)	Ischial tuberosity	Adductor tubercle of femur	Tibial portion of sciatic nerve	L2, **3, 4**	Extends thigh at hip joint

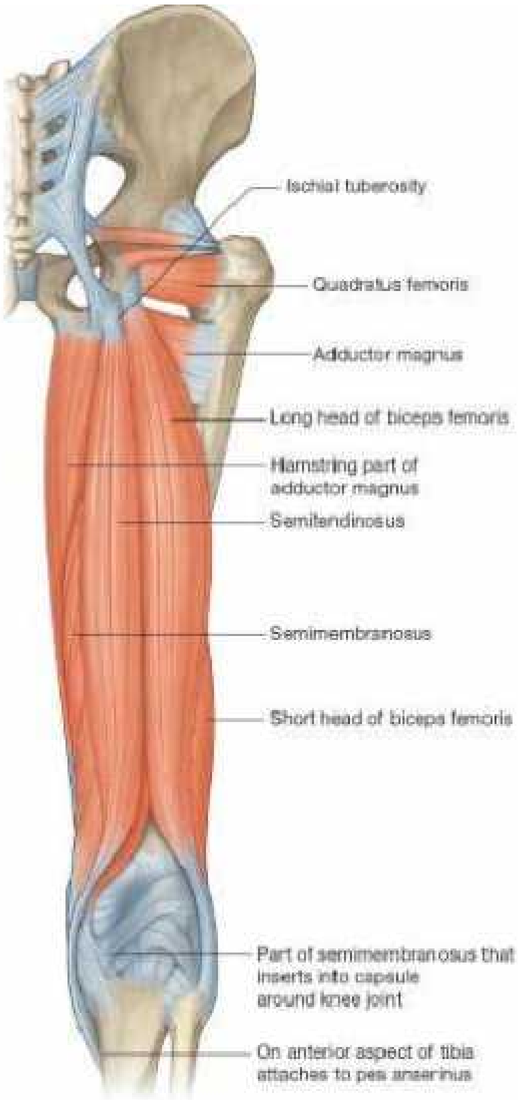


FIGURE-5: POSTERIOR VIEW OF THIGH MUSCLES

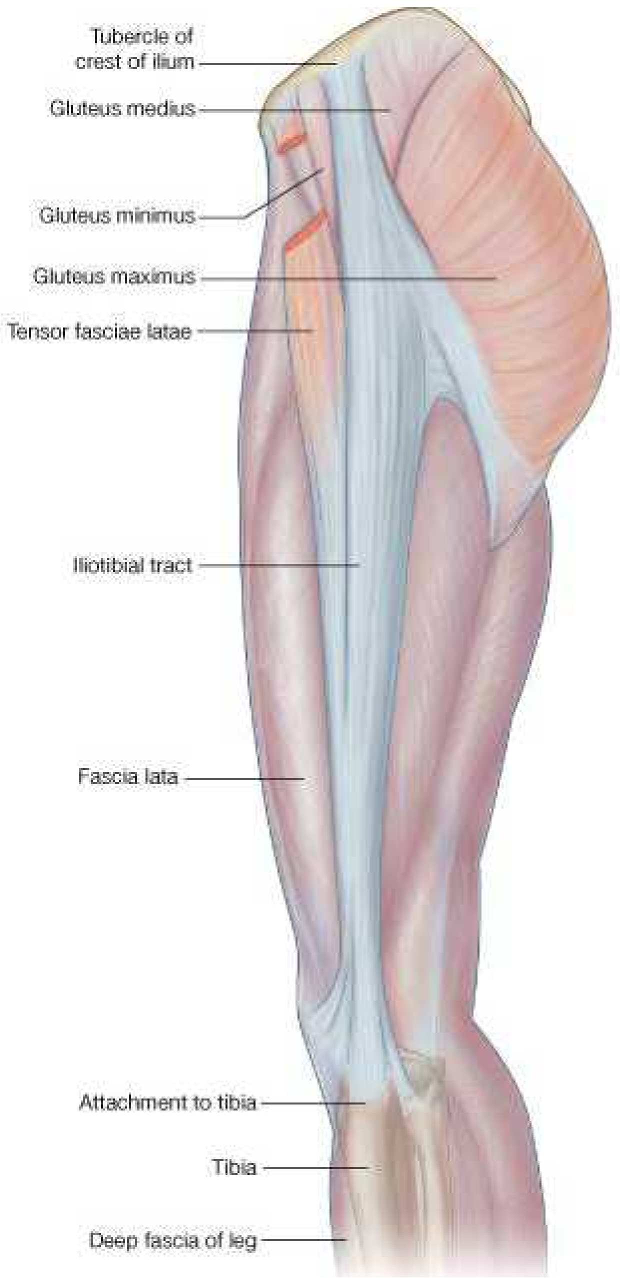


FIGURE-6: LATERAL VIEW OF THIGH MUSCLES

The Perforating Arteries

These cross the linea aspera from medial to lateral side under the tendinous arches in the adductor magnus and short-head of biceps femoris. The foramina for nutrient arteries are situated close to the linea aspera. The popliteal surface of the shaft of the femur forms the floor of the fossa. It is covered by a variable amount of fat which separates the popliteal artery from the bone.

The Medullary Cavity of Femur

The shaft of femur is a cylinder of compact bone with a large medullary cavity. The wall of the cylinder is thick in the middle third of the shaft, above and below this, the wall becomes thinner. Thus, the narrowest region of the medullary canal is located immediately proximal to the middle. The usual diameter is from 8 to 12mm but may be as wide as 16mm. In the isthmic region, the cortex has its greatest thickness; proximally the cavity becomes slightly larger towards the lesser trochanter. After that, it widens rapidly and is filled with dense network of trabeculae. Distal from the middle, the canal widens gradually towards the distal diaphysis. The distal half of the medullary cavity is filled with wide meshed spongiosa trabeculae. The distal end shows dense spongiosa on the walls which becomes thickest beyond epiphyseal line.

Blood Supply of Femur[37]

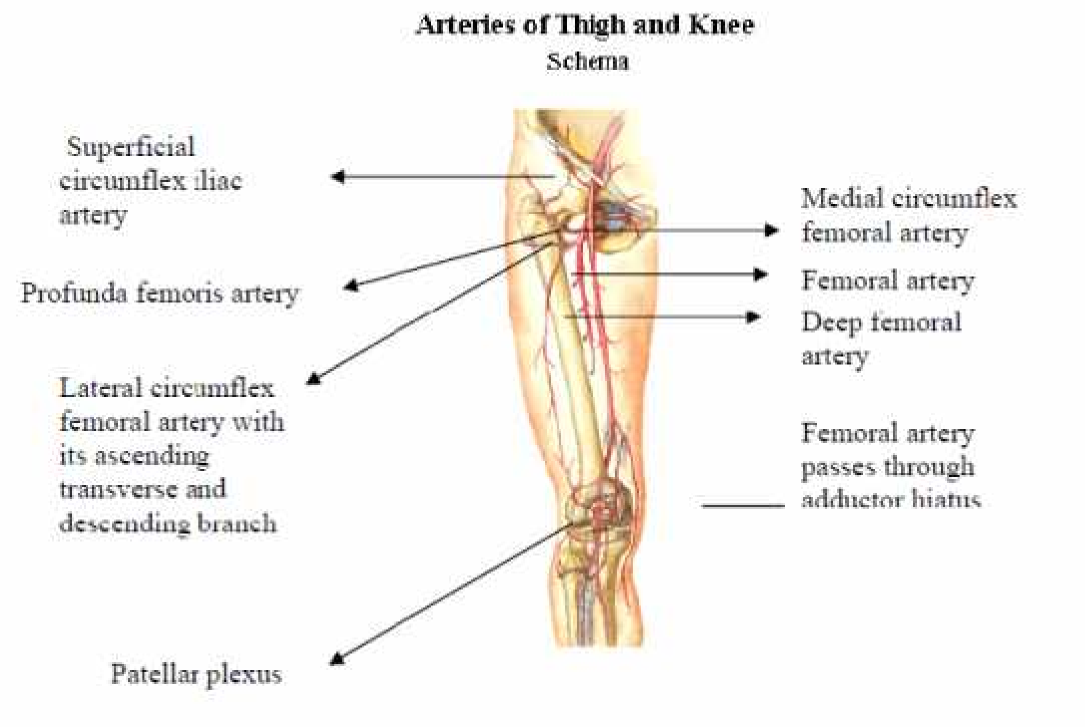


FIGURE-7: ARTERIES OF THIGH AND KNEE

In 1953 P.G. Laning gave a detailed report of the blood supply of the femoral shaft. His study revealed 4 main arterial systems supplying femur- Periosteal, Diaphyseal, Metaphyseal and Epiphyseal. Nutrient arteries of femur are 2 in number and enter the shaft at linea aspera. The nutrient arteries arise as branches of one or the other of the perforating branches of profunda femoris. Once inside the bone, the vessels arborize proximally and distally to form endosteal circulation of the shaft. Similarly the small periosteal vessels that enter the femur do so along the linea aspera. At the linea, periosteal vessels wrap around the surface of the femur and send small penetrating vessels into the cortical bone.

These vessels align themselves perpendicular to cortical surface few, if any transversing longitudinally along the periosteum. These small periosteal vessels supply the outer 1/3rd to 1/4th of the cortical bone whereas endosteal vessels supply inner 2/3rd to 3/4th inside the cortex. There is direct communication between periosteal vessels and endosteal vessels. The normal blood flow is centrifugal, although some blood returns to the large venous sinusoids of the medullary canal.

The arteries branch as soon as they enter the medullary cavity. Most of the medullary branches of the nutrient vessels are destroyed by the passage of correctly fitting medullary nail. Least damage should be done to the periosteum and linea aspera. Linea aspera should never be stripped off from its muscular attachments.

After diaphyseal fractures, this circulation pattern is radically altered. The endosteal blood flow is interrupted by fracture displacement and periosteal vessels must assume the dominant role. Proliferation of these periosteal vessels to meet metabolic demands of the bone is paramount vascular response to the fracture. Thus, preservation of periosteal circulation is a high priority during any surgical procedure in the femur. Avoiding any soft tissue stripping of linea aspera minimize damage to these vessels.

Reaming of the intramedullary canal as preparation for placement of intramedullary nail obliterates the endosteal circulation. However, it has been shown experimentally that the endosteal vessels recover from this injury fairly rapidly usually within 3-4 weeks. As these endosteal vessels recover, the periosteal vessels proliferate and as stated previously, assume the dominant role in meeting the metabolic demands of the healing bone.

The rapid healing and remodeling of fractures after closed intramedullary nailing attest to the abundant collateral circulation of the femoral shaft.

MECHANISM OF INJURY

A fracture of normal femoral shaft requires major trauma. Young adults sustain most fractures, during high-energy injuries like motor vehicular accidents, auto pedestrian accidents, and fall from height or gunshot injuries. The femoral shaft fails under tensile strain. The most common mechanism of injury is bending load, resulting in a transverse fracture. Higher magnitude injuries cause varying degrees of fracture comminution. It has been estimated that 250Nm of bending moment are needed to fracture a normal adult femoral shaft.

- Angulation force: produces transverse fracture with butterfly fragment or segmental fracture.
- Torsional force : produces oblique or spiral oblique fracture.
- Penetration force: caused by missiles produce usually comminuted fractures.
- Impaction force: produces comminution of the shaft of femur or segmental fractures

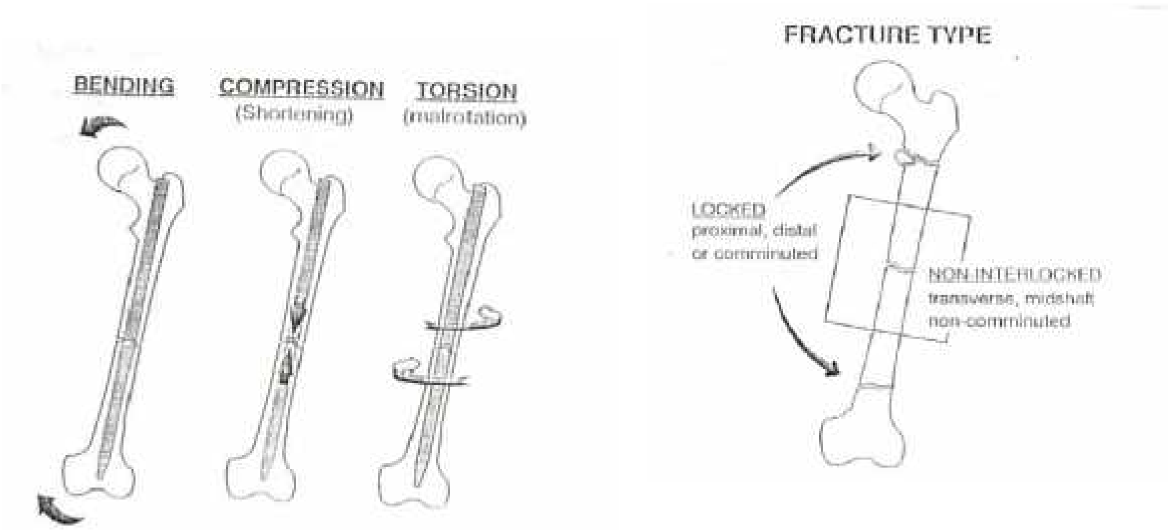


FIGURE – 8 : FORCES PRODUCING INJURY

Etiology of fracture shaft femur[37,38]

1) Violence:

a) Direct

b) Indirect

2) Stress fracture or fatigue fracture

3) Pathological fracture

Displacement

Displacement of fracture fragments depends upon the fracturing forces and the final position is largely dependent on the pull of the attached muscle and the effect of gravity upon the limb. Complete displacement, overriding of the fragments and shortening of the limb is the rule, although very rarely the ends remain engaged and simple angulation may occur. Because muscle pull varies in fractures at different levels, the displacement is characteristic at each level.

a) Fracture of the upper third of femur:

Proximal fragment is usually in a position of flexion, abduction and external rotation. Flexion is due to iliopsoas, which is attached to the lesser trochanter. Abduction is due to gluteus medius and external rotation is due short external rotators. The distal fragment is drawn upwards, inwards and backward by the hamstrings, adductors and pull of gravity.

b) Fracture of the lower third of femur:

The lower fragment is always drawn upwards and medially and there is variable amount of overriding. The proximal fragment is in a flexed position, but this position may be reversed.

CLASSIFICATION

AO/ASIF classification[39]

A) Simple fracture

Al - Simple spiral

A2 - Simple Oblique (30^0 or more)

A3 - Simple transverse

B) Wedge fractures

B1 -Spiral wedge

B2 - Bending wedge

B3 - Fragmented wedge

C) Complex fractures

C1 –Complex Spiral

i) With 2 intermediate fragments

ii) With 3 intermediate fragments

iii) With >3 intermediate fragments

C2 – Complex segmental

i) With 1 intermediate segment

ii) With 1 intermediate segment and an additional wedge fracture

iii) With 2 intermediate segments

C3 – Complex irregular

i) With 2 or 3 intermediate fragments

ii) With shattering limited to <5cm length of bone

iii) With shattering >5cm of bone

AO /ASIF (Association for the study of Internal fixation) classification of fractures of the shaft of the femur. Simple fractures (type A) are distinguished by the degree of obliquity of the fracture line. Wedge fractures (type B) are subclassified according to the anatomy of the wedge fracture. Complex fractures (type C) can be spiral, segmental, or irregular

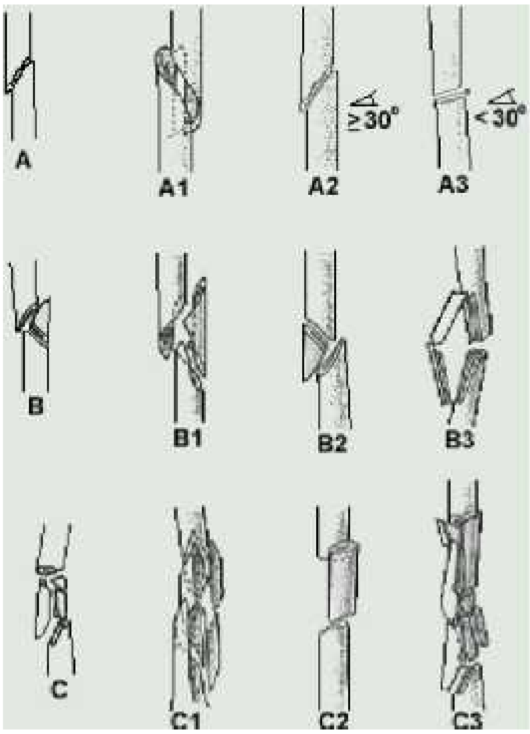


Figure – 9: AO Classification

Winquist and Hansen classification[40]

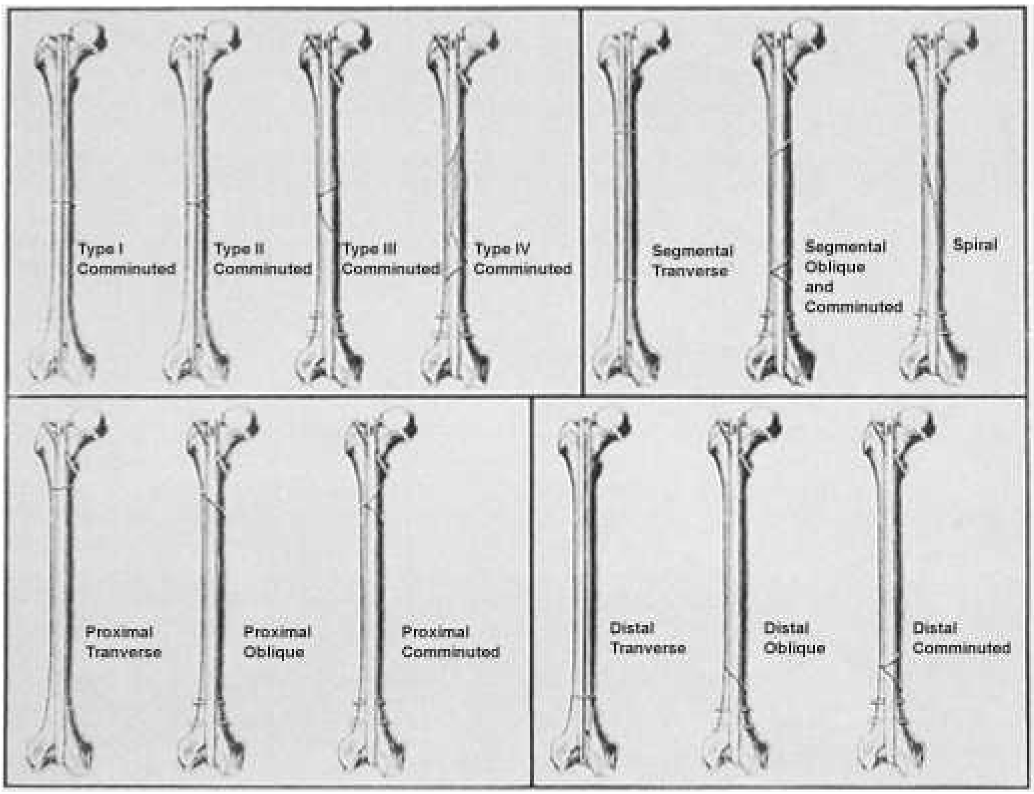


FIGURE – 10: WINQUIST AND HANSEN CLASSIFICATION

This is the most widely accepted classification. It divides the diaphyseal fractures into four types based on comminution.

Type I. A comminuted fracture in which a small piece of bone has broken off not affecting the fracture stability

Type II. A comminuted fracture in which at least 50% contact of abutting cortices

Type III. A comminuted fracture which has less than 50% cortical contact

Type IV. A comminuted fracture which has lost circumferential buttress of bone and no fixed contact between the two major proximal and distal fragments

Depending on geometry of fracture line[38]

- Transverse < 30^{o}
- Oblique > 30^{o}
- Spiral
- Segmental
- Wedge Butterfly fragment
- Comminuted

OPEN FRACTURES - GUSTILO ANDERSON'S CLASSIFICATION [41]

Type I < 1cm wound on skin and clean wound

Type II > 1cm laceration on skin but is without extensive soft tissue damage, skin flaps, or avulsions.

Type III

- **IIIA -** Soft tissue laceration or flaps but maintain adequate soft tissue coverage of bone, or resulting from high energy trauma regardless of the size of the wound
- **IIIB -** Extensive soft tissue loss with periosteal stripping and exposure of bone with massive contamination.
- **IIIC -** Open fracture with arterial injury which requires repair regardless of the size of the soft tissue wound

Depending on location

- Proximal third
- Mid shaft
- Distal third

DIAGNOSIS AND MODALITIES OF TREATMENT

The diagnosis of femur shaft fractures is usually obvious with history and examination findings such as swelling and deformity of the limb, and any attempt to move the limb is painful. The large forces needed to break the femur usually produce accompanying injuries nearby and sometimes further afield. Examination should be done to rule out neurovascular problems and other lower limb or pelvic fractures. The effects of blood loss and other injuries, some of which can be life-threatening, may dominate the clinical picture.

X-ray

It should include femur full length AP and lateral view, Pelvis with both hip joints AP view, Knee joint AP and lateral view. A baseline chest X-ray is useful as there is a risk of adult respiratory distress syndrome (ARDS) in those with multiple injuries. The fracture pattern should be noted; it will form a guide to treatment.

Emergency treatment

Traction with a Thomas splint, or one of the modern derivations of this practical device is first aid for a patient with a femoral shaft fracture. It is applied at the site of the accident, and before the patient is moved. This temporary stabilization helps to control pain, reduces bleeding and makes transfer easier. Shock should be treated; blood volume is restored and maintained, and a definitive plan of action instituted as soon as the patient's condition has been fully assessed.

Treatment options for fracture of the femoral diaphysis include the following:

1. Closed and non-operative treatment
   a. Spica casting
   b. Traction
   c. Cast braces

d. Combination of the above

2. External fixation
3. Plate fixation
4. Intramedullary nailing

TRACTION[38]

Skeletal and skin traction can be used to regain the length of the limb. Skin traction has limited utility because of the inability to apply sufficient and sustained forces without damaging the skin. Skin traction can be used in the initial stabilization of a patient in the field before evaluation at a hospital.

Skeletal traction can be applied by placing Steinman pin at the distal femur or the proximal tibia. Safe pin placement is usually from medial to lateral at the distal femur and from lateral to medial at the proximal tibia. For definitive treatment of femoral shaft fractures with traction, the angle of limb, applied weight, and direction of the applied traction will all require adjustment based on the fracture location. Definitive treatment of femoral shaft fractures has been successfully accomplished with Neufeld roller traction

As sole means of treatment, problems with rotational deformity, limb length discrepancy complicate treatment.

Current indications for traction are

1. Non availability of implant
2. Temporary immobilization before definitive fixation
3. Contiguous soft tissue or bony infection.

CAST BRACES[38]

Cast braces are now used uncommonly for the treatment of femoral shaft fractures but they can be used successfully. Success depends on the technique of application and the proper implementation of weight bearing. For distal and femoral shaft fractures, cast braces allow early patient mobilization and may be used in combination with a period of traction. They work by converting the thigh into a semi-rigid hydraulic tube that maintains the alignment of the femur. Typically, traction is initially used until there is some stability to the fracture, usually for 6 to 8 weeks. Clinical resolution of fracture site discomfort, radiographic evidence of callus formation, and lack of fracture instability on clinical examination are all good indicators of early healing. Functional and anatomical results are inferior to those of standard internal fixation techniques.

EXTERNAL FIXATION[38]

Indications for external fixation

1. Severe soft tissue injuries with extensive contamination
2. Evolving muscular crush that requires an extensive secondary debridement
3. Medullary contamination
4. Associated vascular injury requiring stabilization prior to repair
5. Polytrauma or injuries that prevent other treatments; as a temporary bridge to femoral nailing.

Technique

The goals of application of external fixator are limb realignment, patient comfort, and prevention of further soft tissue damage. Pins can be placed anteriorly, anterolaterally, or laterally. In adults, the pins should be atleast 5mm in diameter and a minimum of 2 pins per segment should be placed. A pin should be placed near the fracture but out of the predicted fracture hematoma. Another pin should be placed as far away from the fracture in each segment.

Advantages

1. It acts as a temporizing measure for the initial stabilization of the fractured femur.
2. The procedure is rapid, and can be applied in less than 30 minutes.
3. The vascular supply to the femur is not damaged to a significant degree during the application of an external fixator
4. No additional foreign material is introduced in the region of the fracture, which may be particularly advantageous in open fractures and injuries with infection.
5. It allows access to the medullary canal and the surrounding tissues in open fractures with significant contamination.

Disadvantages

1. Pin tract infections occur commonly and are related to the time the fixator is in place, the amount of soft tissues that the pins must traverse, and the sterility at the time of the initial application.
2. Loss of knee motion occurs commonly.
3. Angular malunion and femoral shortening occur more frequently than with other methods.
4. Finally, unilateral external fixation has limited ability to adequately stabilize the femoral shaft.

PLATE FIXATION[38]

Indications for plating

1. Patients with an extremely narrow medullary canal
2. Fractures around or adjacent to a previous malunion
3. Fractures extending proximally or distally into the pertrochanteric or metaphyseal region
4. Associated vascular injury requiring repair
5. Ipsilateral neck shaft fractures
6. Fractures at or near previously placed implants e.g., peri-prosthetic or peri-implant fractures
7. Skeletal immaturity
8. May be possible or considered for any femoral shaft fracture

Technique

The patient can be positioned supine or lateral on a completely radiolucent table. Depending on the fracture configuration, an open or a submuscular technique may be applicable. Irrespective of the technique chosen, the vascularity to the femoral shaft and the associated fracture segments should be preserved. For open compression plating of simple fracture patterns, a lateral approach to the femur is used. Reduction of the femur can be difficult, and can be achieved by direct or indirect methods. The plate can be applied and fixed to one end of the femur followed by the use of a push screw or the articulated tensioner-distractor. A 10-hole, 4.5-mm plate should be considered a minimum length. A lag screw through the plate increases the construct rigidity and should be used if appropriate.

The goal of submuscular plating is to minimize any associated trauma to the muscular envelope and the periosteum surrounding the femur. This can be accomplished by using small incisions at the palpable proximal and distal aspects of the lateral femur. A plate of appropriate length can be contoured and slid beneath the vastus lateralis along the length of the femur. After the plate is placed on the mid-lateral aspect of the femur, the length, alignment, and rotation of the femur should be restored. Screws can then be fixed proximally and distally without difficulty. Additional screws are placed through percutaneous stab incisions along the lateral femur.

Postoperatively, early active range-of-motion exercises should be encouraged as soon as wound healing allows. Weight bearing should be limited to the weight of the leg until there is radiographic evidence of healing and resolution of fracture site discomfort.

Advantages

1. Plating after open reduction allows for anatomic restoration of length and alignment
2. Direct visualization of the major fragments facilitates achievement of anatomic reduction and broad plates afford rigid fixation.
3. Predictable primary bone healing occurs and early limb rehabilitation is possible.

Disadvantages

1. Extensile approach needed for plate application leads to greater soft tissue and bony injury.
2. Devitalisation of fracture fragments by sub-periosteal dissection, injury of the adjacent soft tissues and loss of the fracture hematoma may contribute to delay healing of the fracture.

3. Compression plates are load bearing and the normal loads are borne by plates and screws. This may have a deleterious effect on fracture healing.
4. Stress shielding and local osteoporosis beneath the plate also routinely occurs and increases the risk of fracture after plate removal.

INTRAMEDULLARY NAILING[38]

Indications for closed interlocking intramedullary nailing

1. Closed femoral diaphyseal fractures
2. Open grade I and grade II femoral fractures
3. Aseptic non-unions of femur
4. Pathological fractures of femur
5. High proximal and low distal fractures
6. Subtrochantric femoral fractures
7. Ipsilateral shaft and neck fractures
8. Malunions
9. Shortening, lengthening and derotation osteotomies of femur

Surgical technique

Intramedullary nailing can be done either in supine or lateral position. Both open and percutaneous approaches for insertion of an antegrade nail are possible. The traditional open approach is accomplished through a longitudinal incision that begins at the proximal tip of the greater trochanter and extends proximally over a variable distance depending on the size of the patient. Curving the incision posteriorly in line with the natural bow of the femur maximizes access to the proper starting point. The gluteus maximus fascia is incised in line with the incision, and the muscle fibers can be separated bluntly. The greater trochanter can be palpated directly, as can the enveloping fascia of the gluteus medius. The piriformis fossa (or more accurately, the trochanteric fossa) can then be palpated directly, allowing placement of a curved awl. The position of the awl should be confirmed fluoroscopically on the AP and lateral planes. The awl can then be advanced in line with the intramedullary canal on both views. With the patient positioned supine on a radiolucent table, access to the proper starting point is improved with maximal adduction of the leg.

After the starting hole has been made, a ball-tipped guidewire can be passed down the canal of the femur and confirmed with biplanar fluoroscopic imaging. In young patients with dense bone, T-handled hand reamers may be necessary to define the intramedullary canal in the pertrochanteric region. This step can be avoided if a cannulated drill technique is used for initiation of the starting point, assuming that the drill is passed distally enough in line with the medullary canal. The guidewire should be bent distally to allow some directional control. A guidewire without a ball-tip should not be used if reaming is planned. The guidewire is then advanced down the canal of the femur to the level of the fracture. With pharmacologic relaxation, the fracture is then reduced to allow passage of the guidewire across the fracture and into the distal segment. The guidewire is then advanced distally and should terminate centrally in the distal femur. Any residual angulation should be corrected before advancement of the guidewire distally. A mallet is used to seat the guidewire into the dense bone of the distal femur to ensure that it remains in position during reaming. For distal fractures, a true AP and lateral image of the distal femur should be obtained to ensure central placement of the guidewire. Femoral length should then be confirmed before determining the desired nail length. A second guidewire of equal length can be used to determine the proper length of the nail necessary.

Flexible reamers can then be passed over the guidewire and down the canal of the femur. The fracture should be maintained in a reduced position during the passage of each reamer to minimize eccentric bone removal. The process of reaming produces elevated intramedullary canal pressures and embolism of fat into the venous system. Reamers should be advanced slowly and gradually increased in diameter to minimize the pressure and fat embolism. A nail diameter that is coincident with isthmic cortical chatter felt during reaming is probably adequate in most cases. The canal is over-reamed by 1.0 to 1.5 mm to allow passage of the nail.

The ball-tipped guidewire can then be exchanged for a straight guidewire using a flexible exchange tube. The selected nail dimensions are then confirmed, and the nail is attached to the proximal locking jig and placed over the guidewire. The anterior bow of the nail can be used to ease the initial insertion into the starting hole at the piriformis fossa. By internally rotating the nail by 90 degrees, the tip of the nail can be placed around the medial greater trochanter. The rotation of the nail is then corrected to match the rotation of the femur. The nail is advanced to the level of the fracture. At this point, the length, alignment, and rotation of the femur should be corrected accurately. The nail is advanced across the fracture, and the reduction parameters should be confirmed. The nail is then driven distally to the appropriate depth.

Proximal Interlocking

Proximal interlocking is simplified with the use of an external jig that allows placement of screws using multiple sleeves. The configuration and location of these screws are unique to each nailing system and may be transverse or oblique in direction. Static and dynamic screws may be available proximally or distally. The choice to use one or two proximal interlocking screws depends on the fracture stability after nailing, fracture location, patient's size, nail and screw diameters, and predicted postoperative activity

Distal Interlocking - It is usually accomplished using a free hand technique with the help of C-arm image intensifier.

Advantages of interlocking nails

1. Early ambulation in polytrauma patients
2. Shorter stay in the hospital
3. No rotational instability at fracture site.
4. Length of bone is maintained in comminuted fractures.
5. Axial micromotion is possible in dynamically locked nails.
6. Reamed products act as internal bone graft.
7. No periosteal stripping and hence bone vascularity and osteogenic potentials are preserved.
8. Minimal soft tissue injury during surgery aiding in quicker rehabilitation.
9. Negligible rates of infection, maluninon and non-union.
10. No refracture at fracture site.
11. Union occurs as secondary bone union, which is more physiological.

BIOMECHANICS OF INTRAMEDULLARY FIXATION

Intramedullary nailing offers many theoretical and practical advantages compared with other methods of treatment. Interlocking of the intramedullary nails has expanded the scope of intramedullary fixation for the fracture shaft femur, since 1980. It achieves positive fixation of proximal and distal fragments in fracture shaft femur.

Femur, having long narrow isthmus, surrounding muscle envelop and predominance of closed fractures, is well suited for intramedullary nailing. It provides stability by close contact between nail and internal surface of the diaphyseal cortex. Also elastic recoil of the nail after negotiating the isthmus upon the endosteum, provides good fixation by interference fit, by generating pressure between nail and bone. A rigid nail fits the bone by 3 point fixation principle [42,43], while a flexible nail conforms to the curve of femur. Interlocking intramedullary nails designed for static maintenance of a limb, also provide the greatest degree of rotational stability by rigidly locking the nail to the bone, both proximally and distally through the use of cortical screws.

Intramedullary fixation stabilizes the fracture and permits functional use of the limb, with some motion at the fracture site, during activities. It acts like internal splint, with load sharing properties while fracture healing progresses[42,44]with formation of peripheral callus[45]. Stress shielding is minimal with this technique. There is optimal transfer of stress to the bone, from the nail, as healing progresses.

A better physiologic working length of the nail would be obtained, if the nail were to assume the natural anterior bowing of the femur. Flexible reamers were introduced to provide medullary canal a constant diameter and provide a broader contact area.

Fatigue Properties of Interlocking Nails

The force required to fracture a femur is approximately 250 N-m in bending. Under normal conditions, the bone must withstand approximately half of the force that cause a fracture, therefore the femur fracture fixation construct should ideally resist forces about 100 to 125 N-m in a given 150 Lb patient. Femoral fracture fixed with static locking of nail, fail at about 4 times body weight.

Load deflection curve

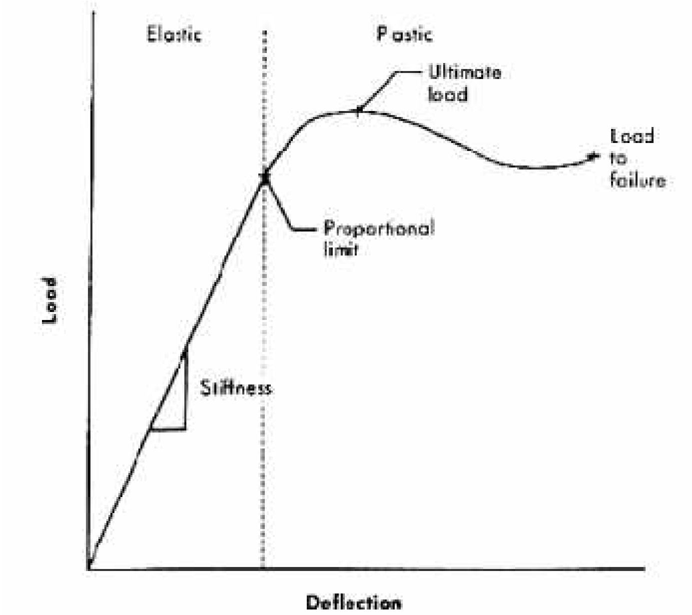


FIGURE – 11: LOAD DEFLECTION CURVE

Load Deflection curve shows material and structural properties. Note elastic phase, which is working area of intramedullary implant[46]

If a structure is loaded to failure to test frame, the resulting load deflection curve describes the mechanical behavior of that device, under that set of conditions.

The shape of curve is divided into:-

- Elastic region – initial linear portion
- Plastic region – non linear portion of curve

The slope of elastic region of curve is called as stiffness of the structure. The higher the stiffness, the more rigid the structure and as the stiffness decreases, the structure becomes more flexible[42,47]. Within the elastic portion, an object will return to its original shape, following load removal. After load exceeds the proportional limit, a permanent plastic deformation takes place and shape changes. Hence implant should not be loaded beyond the proportion limit, as it creates potential for complications, like malunion or nonunion in fracture healing.

Fracture femur fixed with a standard intramedullary nail, measuring 12 to 14 mm in diameter, is only 50% to 70% as stiff as intact femur in bending.

The fatigue failure, through the mid portion of standard large diameter (12-15 mm) nail or a thick walled diameter nail, is rare. Once fracture healing has proceeded sufficiently to restore 50% of the normal stiffness of the distal femur, the stresses are diminished below that of the endurance limit of the nail. Improvements in cold working of the holes and thicker nail walls have lessened the prevalence of nail fatigue at this level. Nevertheless infraisthmal fractures stabilized with interlocking nail, should be managed with delayed weight bearing, until bridging callus is evident on radiography.

Deformation and breakage is more common at proximal or distal ends of interlocking nails. Several factors may predispose to failure at these locations-

- Over-reaming of medullary canal and the use of undersized interlocking nail, leads to little contact of nail on the endosteum and concentration of loading at proximal and distal screw sites

- The holes in the nail decrease the amount of metal and the strength of a nail to an appreciable degree. Therefore fatigue failure can occur, if fracture healing is delayed or early excessive loading is permitted. The most common site for fatigue failure is at the most proximal of the two distal locking holes, for most interlocking nails.
- Finite element and analysis of interlocking nails has revealed that, if fracture is located within 5 cm of this hole, stresses are generated in the nail above its endurance limit.
- Another weak area of certain interlocking nails is at the proximal weld, between cylindrical and slotted portions of the nail. In one study, prototypical nails were welded at this junction. The fatigue failure was common when the nails were used for high subtrochanteric fractures and cases of non-union.

Stress Strain Curve[42]

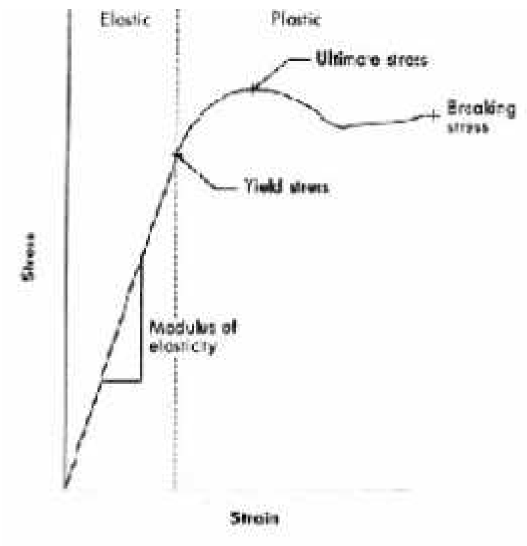


FIGURE – 12: STRESS STRAIN CURVE

Stress – strain curve shows material properties in single cycle stress until failure. Testing usually is performed in fixed sample with stress applied under tension.[46]

Stress is defined as load (force) per unit area.

Strain is defined as change in length divided by its original length.

The linear portion of the curve is still the elastic region and materials, loaded within their elastic range to return to their original shape i.e. the slope of this straight line. The linear portion of the curve is termed as modulus of elasticity (e) or Young's modulus. It is a very important material property because it defines elastic material.

The transition from elastic to plastic behavior is termed yield strength. It is defined as, the stress required to give a 0.2% plastic strain offset. Once yield stress for a material is exceeded a permanent change in structure occurs.

Strength

Strength refers to the amount of load (force), that a device can withstand without undergoing a permanent change in shape.

Bending strength of an IM nail is defined as, the bending moment required to produce a permanent deflection of 0.005 inches (0.13 mm), in a nail loaded in four-point bending.

Bending rigidity of an IM nail is defined as, the ratio of the bending strength to the total deflection produced by that load.

Torsional rigidity it is a torque required, to produce an angular deflection of 1 degree, when a 10-inch gauge length is rotated about the longitudinal axis of the nail.

Working length [42,48] It is defined as the length of nail spanning the fracture site, from its distal point of fixation in the proximal fragment to its proximal point of fixation in the distal fragment. This dimension also affects the stiffness of a nail.

In the bending, the stiffness is inversely proportional to the square of the working length. In torsion, this relationship is simply the inverse of the working length. Thus in considering only the intramedullary nail, working length should be as short as possible to increase the stiffness in both bending and torsion. However, total nail contact should be distributed over the long section of the bone, both proximally and distally, to increase the gripping strength of the nail.

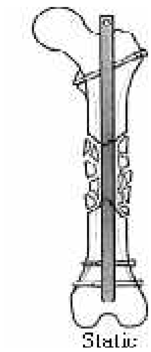
Length of nail is adequate when it extends from tip of greater trochanter to upper pole of patella.

Width of nail is selected depending on the diameter of medullary canal and amount of reaming. Nail's strength is directly proportional to the width of nail.

The **curvature** of a nail is slightly less than that of femur, to create mismatch to femoral medullary canal. This makes insertion easier and improves functional fixation. It is about 109 cm, in most of the nails.

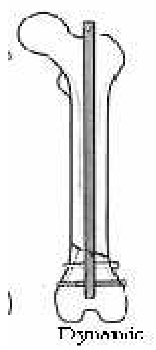
Long bones are loaded in bending, compression and torsional forces. Interlocking nails are capable of restoring adequate stiffness and strength of the femoral shaft in all three planes of loading.

Static locking



Screws are inserted at the ends of the nail; interlock it with proximal and distal fragment. This technique prevents sliding of fragments along the nail and is called as a static locking. It neutralises the rotational stresses and prevents shortening. Static locking gives stability of the fracture and helps in the maintenance of the length and correct alignment. However the axial loading of the fracture is minimized.

Dynamic locking



When screws are inserted only at one end of a nail, the fixation is called as a dynamic. To some extent, it loses the rotational control and is effective only when contact area in between two fragments is at least 50%. Dynamic locking of unstable fractures causes shortening of average 2 cm and malrotation.

Dynamisation

Removal of proximal or distal screws or both in statically locked nails, at about 12 to 16 weeks to cause micromotion at fracture site, for new bone formation is called dynamisation. The theoretical advantage of dynamic locking is that, it permits axial movement at fracture site which is thought to be useful for fracture healing and hence it is a common practice in locking nail treatment that after initial static locking, it is converted to dynamic mode for fracture healing.

Newer nails have 1 oval shaped hole in the proximal part of nail, which allows controlled collapse and dynamisation.

But now most studies report that healing of fracture occurs in about 80% without any dynamisation and so this is usually carried out, if the fracture is not consolidating between 12 to 16 weeks.

There has been much debate, concerning whether or not dynamisation is beneficial in the healing of fracture of the long bones. Numerous comminuted or other types of fractures consolidate very well without dynamisation. So procedure of dynamisation is oriented solely to time intervals and not to radiological observation of fracture healing.

NAIL DESIGN:

Cross section:

Intramedullary nails come in many designs from solid to cylindrical and in such shapes as the cloverleaf, diamond, V and cylindrical with flutes. The shape, the diameter and the area of the nail determines its bending and torsional strengths. A circular nail has an area and polar moment of inertia proportional to its diameter. Similarly a square cross sectional nail has an area and polar moment of inertia proportional to its edge length.

Complex cross sectional shapes need complex calculations to assess their moments of inertia. In simple terms the further the material is distributed from the principal axis, the greater the moments of inertia.

Slotted and Non Slotted Nails

The presence of a longitudinal slot, beginning at the distal end of the nail and extending up to or within a few centimeters of the proximal tip has several effects on the mechanical properties of the nail. The groove in between, allows space for vascular ingrowth following reaming.

The slot permits elastic impingement of the compressed nail on the endosteal surface of the bone and also help in achieving radial compliance by expanding after insertion. Kuntscher and others have postulated that this tight interference fit with femoral canal minimizes malrotation and shortening of the fracture. It makes the nail flexible, making it easier to insert.

It also decreases the stiffness of the nail in torsional stresses by 15 to 20 fold compared with nonslotted nails. It decreases the fatigue strain of the nail and decreased amount of metal around the locking screw holes. Thickness of the nail wall of slotted nails can lessen this problem but then diminishes any change of elastic impingement on the proximal and distal fracture fragments.

Closed section nonslotted nails have experienced a renewed popularity. They markedly increase the amount of metal around the screw holes, thereby lessening the risk of metal fatigue. Cold working of the screw holes also has been used to strengthen the metal around them. By varying the wall thickness, the bending stiffness of nonslotted nails can be changed to mimic that of slotted nails, thus lessening the risk of damage to the femur during insertion of an overly stiff nail. Such splintering of the distal fracture fragment has been described, especially in elder patients in whom large diameter nails are used.

Change in the cross-sectional design to a delta configuration and in the wall thickness has improved the mechanical strength of these small diameter, nonslotted nails. Such implants now are widely regarded as the interlocking nails of choice for most femoral shaft fractures.

BIOLOGY OF FRACTURE HEALING WITH INTRAMEDULLARY FIXATION

Intramedullary fixation offers many advantages in fracture healing when compared to other methods. They are aimed at preserving periosteal blood supply while stabilizing the fragments[42,49]. Union is rapid because of peripheral callus formation. It allows early return to function. Unlike rigid plate fixation, the external callus is seldom completely suppressed, so the fracture unites by secondary healing.

As nail is load sharing device, stress shielding is minimized and disuse osteoporosis is prevented with progressive function. Axial micromotion at the fracture site stimulates vascular invasion and thermal, mechanical, chemical as well as electrical environmental factors, which regulate fracture healing.

Another variable is the effective and optimal load transfer between the nail and the bone. Prolonged stress shielding of the bone should be avoided. As the fracture is stabilized by an interference fit, the nail should occupy the entire cross section of the medullary canal and extend throughout its entire length for rigid fixation. Intramedullary nailing in any of its forms, damages the endosteal blood supply[50,51]. This blood supply is rapidly re-established when a loose fitting nail is used. But when reamed well fitting nail is used, the viability of bone depends on the alternative periosteal blood supply. If this blood supply is damaged following some soft tissue damage, the whole of the diaphysis may get devascularised. This leads to two problems –

1. There may be delayed union as revascularisation can occur only slowly.
2. Dead bone is prone to infection.

The healing pattern following intramedullary nailing depends on the type of fracture as well as degree of stabilization. Reaming and intramedullary nailing of simple fracture without major traumatic damage of soft tissue, is followed by circulatory deficiency that extends to the peripheral part of the cortical bone at fracture site. Within 3 – 4 weeks visible external callus appears on radiograph. In histologic sections, callus formation can be demonstrated even earlier[52].

If sufficient stabilisation is obtained, the fracture is primarily bridged by woven bone. When the stability is somewhat less, healing occurs by the formation of fibrous cartilage, which will be mineralized, subsequently replaced by woven and finally lamellar bone. Callus formation starts in the peripheral perfused cortical bone, from there grows over the fracture site.

Remodelling of the intermediate fragments occur from peripheral periosteal circulation and propagates in a central direction.

Reamed and Unreamed Nailing

Reaming involves the widening of medullary canal by progressively wider reamers. It is common practice to allow insertion of thicker and more stable intramedullary devices, although it destroys endosteal blood supply, which perfuse inner $2/3^{rd}$ of the bone. The nail corresponding to the last reamer would provide adequate stability for the fracture healing and it also does not impede the formation of external callus. Intramedullary nailing of femoral shaft fracture without reaming results in a significantly higher rate of nonunion, compared with intramedullary nailing with reaming[53]

Necrosis of the inner 50-70% of the cortex takes place due to the loss of the medullary blood supply; the essential damage is caused by the first reaming. Subsequent reaming has little effect on cortical vascularity or viability.

Experiments have shown that time of revascularization largely depends on the size of the defect. In rabbits, with comparatively small bones, it takes about 4 weeks until revascularization is completed. For dogs and sheeps with larger bones, it takes 8-12 weeks for active total revascularization. In humans the time is even longer[54]. Observations at 8 weeks emphasize significant differences between 2 sectors of femoral cortex with respect to the microvascular and histologic responses after medullary reaming and fixation by a nail that fills the medulla almost completely. 12 weeks after medullary reaming and nailing, the most immediate striking angiographic feature is the thick and highly vascular endosteal membrane surrounding the entire nail tract. Another impressive development is a group of relatively large intracortical arteries in the posterior cortex. They appear to be short stubs as they traverse the entire thickness of the tissue slice of the microangiogram. When viewed in stereo, their longitudinal orientation within the femur is clear[45]. Throughout the remainder of the cortex, fine and irregular vessels are well distributed, indicating a more complete generalized revascularization than was present at 8 weeks. This new blood supply is chiefly from the endosteal membrane or from intraosseous longitudinal channels, but some extraosseous arteriolar connections are still present.

At the border between vascularized and non-vascularized tissue the haversian canals form a surrounding closed ring. As the repair process continues, expansion of these viable canals in the direction towards malperfused bone with deposition of new lamellae in the previously widened canals can be observed. It is assumed that porosity is a consequence of stress protection by the implant as well as an expression of the proceeding revascularization process.

Reaming particles which possess bone inductive potential, are occasionally considered to be of great importance in fracture healing[55]. Indeed, intensive new bone formation can be observed around the reaming dust on histologic sections and in roentgenograms, if it is surrounded by vital tissue. On the other hand, the reaming dust represents a large amount of necrotic particles or micro-sequestra, if they are deposited in devitalized zones of the medullary canal. This must be considered in view of the possible bacterial contamination, when conducting open intramedullary nailing[54].

Rhinelander[56] showed that after reaming there is a reversal of the normal centrifugal blood supply to the cortex to a centripetal pattern. This occurs within the first few weeks after nailing. Complete revascularization process occurs relatively early in the fracture healing process.

The fat and bone marrow intravasation occurs during reaming and nailing in long bones. The maximum embolisation of marrow contents, demonstrated by echocardiography, is seen during nail insertion, independent of the changes in intramedullary pressure[57]. Intramedullary pressure of 420-1510 mm of Hg can give rise to embolus.

Intramedullary pressure at various stages-

- During entry with the awl - 200-300mm of Hg
- During guide rod insertion - 40mm of Hg
- During manipulation - 150-160mm of Hg
- During reaming - 425-1510mm of Hg
- Solid unreamed nailing - 40-70mm of Hg[58]

Advantages of reaming

- It allows insertion of larger diameter nail, which increases endosteal purchase of nail by giving contact over longer length thus increasing stability of fixation.

- Reaming particles are said to have osteoinduction potential due to its bone graft effect and causes new bone formation, thus lesser frequency of delayed or nonunion.
- Insertion of a nail can be done smoothly without force and without hoop stresses at the fracture site, preventing bursting of the femur.

Disadvantages of reaming

- Destruction of vessels in medullary canal lead to necrosis of inner 50%-70% of cortex[52]. However inner cortex does not impede the formation of external periosteal callus. Thus it doesn't impede fracture healing.
- There can be rise of temperature up to 44 degree C causing thermal bone necrosis[42].
- In case of open fractures that already have loss of nutrients, periosteal and surrounding soft tissue blood supply, cannot sustain an additional loss of blood flow caused by reaming.
- Reaming produces bone debris that can occlude the bone vessel, preventing microvascular tissue from regenerating. Fat emboli from the medullary canal can pass along the vessels and this may be responsible for fat embolism and acute respiratory distress syndrome (ARDS). It is documented intraoperatively using transoesophageal echocardiography[58].

Conclusion

Intramedullary nailing of the femur without reaming of medullary canal, has been advocated as a method to reduce marrow embolisation to the lungs and rate of infection after open fractures. The use of nailing without reaming however has been associated with lower rates of fracture healing.

COMPLICATIONS[38]

Nerve Injury

Iatrogenic nerve injury occurs infrequently with closed intramedullary nailing. The primary nerves at risk are the femoral, sciatic, peroneal, and pudendal. Patient positioning and intraoperative traction are usually implicated as causal.

Associated pudendal nerve injury and erectile dysfunction are complications of femoral nailing and are likely related to the use of traction table with a perineal post.

Sciatic and peroneal nerve injuries may occur during the process of femoral nailing. This complication is likely caused by stretching of the nerve during various reduction maneuvers. It is important to avoid any prolonged over distraction of the limb during the procedure. Knee flexion during surgery can relax the sciatic nerve and its terminal branches; knee extension should be avoided. In addition, circumferential dressings, especially at the knee, should be avoided postoperatively.

Muscle Weakness and Entry Site Injury

Femoral fractures are associated with traumatic injury to the surrounding muscles in addition to the obvious and treatable osseus injury. In addition, surgical treatment is associated with a further insult to the lower extremity musculature. In the case of open plating, this usually involves a lateral approach to the femur with associated dissection of the vastus lateralis. In antegrade femoral nailing, injury to the hip abductors and external rotators may occur as a result of the surgical approach, nail insertion, or both. The approach for antegrade femoral nailing, whether percutaneous or open, may have an effect on subsequent muscle function.

Angular Malalignment

An angular deformity of the femur is usually defined as greater than 5 degrees of angulation in either the coronal (varus-valgus) or sagittal (flexion-extension) planes. Overall, the rate of angular malalignment after medullary nailing is between 7% and 11%. Angular malalignment of fractures in the middle third of the femur occurs infrequently after intramedullary nailing, largely because of the intimate fit between the medullary implant and the cortical bone of the femoral isthmus. However, in the proximal and distal thirds of the femur, the more voluminous medullary canal ensures that cortical contact with the nail will not occur, allowing for angular deformities to occur.

Prevention of angular deformities during placement of a medullary implant in the proximal or distal thirds of the femur requires attention to detail during reduction, reaming, nail passage, and interlocking.

Rotational Malalignment

Rotational malalignment of the femur may occur after any method of femoral stabilization. The amount of femoral rotation that can be well tolerated by the patient is largely unknown, but there appears to be increased symptoms and the need for operative correction in patients with more than 15 degrees of rotational malalignment.

Femoral rotation can be determined intraoperatively and postoperatively using clinical examination and radiologic evaluations.

Knee Stiffness, Knee Pain, and Hip Pain

Some degree of temporary knee stiffness is commonly observed after a fractured femoral shaft. Stiffness is thought to be related to the type of treatment, fracture location, quadriceps scarring and associated injuries. An associated head injury and the formation of ectopic bone can both contribute to limited knee motion.

High-energy mechanisms such as a motor vehicle crash, multiple procedures, and a delay in union are also associated with persistent knee stiffness after treatment.

Heterotopic Ossification

Proximal thigh pain and ipsilateral hip pain after intramedullary nailing may be related to the surgical procedure, the fracture, muscle weakness, or the presence of heterotopic ossification. Formation of ectopic bone at the entry site and overlying the starting point for an intramedullary nail is observed commonly, especially after reamed nailing. Overall, the incidence of heterotopic ossification ranges from 9% to 60%. Clinically significant heterotopic ossification occurs in only 5% to 10% of patients.

Heterotopic ossification formation has been found to be increased in association with male gender, head injury, reamed antegrade nails, a delay to surgery, and prolonged intubation.

Refracture

Femoral refracture after operative fixation with plates or intramedullary nail is rarely encountered. If the fracture is truly healed, refracture of the femur through the implant would suggest additional trauma capable of injuring both the femur and the implant. However, fractures at the ends of plates can occur.

Implant Complications: Broken Nails, Broken Interlocking Screws, and Bent Nails

The main implant-related complications of antegrade and retrograde intramedullary nailing procedures are broken implants. With advances in nail design and an appreciation for the biomechanics of these implants, fatigue failure of the implant occurs much less frequently. Broken nails are indicative of femoral nonunion. If a fracture fails to heal, the nail will eventually fatigue and break. The timing of nail failure is dependent on numerous factors including the size of the implant, type of metal, location of the nonunion, fracture pattern, patient's weight, and patient's activity level.

Broken interlocking screws occur commonly and are seen more frequently if small-diameter bolts and nails are used. The screws typically break at either the medial or lateral aspects of the nail. This location is important to determine before attempting removal. Bent nails do not occur commonly with current nail designs

Compartmental Syndrome

The incidence of a thigh compartmental syndrome complicating a femur fracture has been estimated at 1% to 2%. The diagnosis requires suspicion and frequent examination, especially given the amount of swelling that is commonly observed after a femoral shaft fracture. Intense thigh pain and tense swelling should alert the physician to the possibility of a thigh compartmental syndrome in the awake and cooperative patient. Pain with passive stretching of the involved muscles corresponding to the anterior, posterior, and medial compartments is consistent with the diagnosis. Loss of sensation in the distribution of the sensory nerves passing through the thigh provides further evidence. Thigh muscle weakness further supports the diagnosis.

The predisposing risk factors for development of a thigh compartmental syndrome are systemic hypotension, coagulopathy, vascular injury, a history of external thigh compression, and trauma to the thigh with or without a fracture of the femur.

Treatment of a thigh compartmental syndrome consists of emergency decompressive fasciotomy through an extensile lateral incision with or without an additional medial approach.

Delayed Union and Nonunion

Nonunion occurs uncommonly after reamed nailing of femoral shaft fractures. The major identifiable treatment-related risk factor for delayed or nonunion appears to be treatment with an unreamed intramedullary nail.

Femoral nonunions may be caused by infection, the use of anti-inflammatory medications , impaired vascularity, lack of mechanical stability, fracture site distraction, bone loss, and/or soft tissue interposition.

There are several methods of treatment for femoral diaphyseal nonunions that were initially treated with an intramedullary nail. This includes nail dynamization, exchange nailing, plate fixations, bone grafting, and combinations thereof.

Aseptic nonunions in femoral shaft fractures previously treated with plate fixations are less commonly observed, largely due to the relative infrequency with which plates are used as a primary treatment for femoral shaft fractures given the success of intramedullary devices.

The principles for treatment in a previously plated femoral shaft fracture are similar to that for other diaphyseal nonunions. Treatment is largely dictated by the combined goals of achieving mechanical stability in a biologically attractive environment that maximizes healing. In most cases, removal of the plate and placement of a reamed intramedullary nail achieves these goals and is the most reliable method of treatment.

Infection and Infected Nonunions

Infection occurs uncommonly after treatment of closed femoral shaft fractures. The reported incidence of infection complicating reamed intramedullary nailing is less than 1%. The reported infection rates in patients treated with intramedullary nailing for open femoral fractures ranges from 2.4% to 4.8%. The increased infection risk is likely related to the extent of soft tissue stripping, amount of contamination, and adequacy of debridement. The diagnosis should be suspected in any patient with a femoral nonunion, regardless of whether the original injury was open or closed.

Diagnosis can be made by clinical features, laboratory investigations and radiological evaluation.

In general, the treatment for an infection of the femur is surgical. All infected and necrotic tissue should be removed, and the bone should be assessed for viability. This requires an open surgical approach. Intraoperatively, the stability of the nail should be assessed. If the implant fits tightly and is providing adequate stability, the nail can potentially be left in position. Antibiotic selection should be based on the intraoperative cultures. After healing, the nail can be removed.

If the nail is found to be loose at the time of debridement, the nail should be removed and the canal should be reamed to remove the contaminated membrane and any residual medullary purulence. Replacement of the nail is desirable whenever possible. There are several choices for maintaining stability at this juncture including external fixation, plate fixation, locked intramedullary nailing, and temporary placement of an antibiotic impregnated nail.

Intraoperative Problems related to the interlocking procedure:

- Difficulty to locate the perfect point of entry in the trochanter.
- Entering too laterally causing proximal fragment comminution.
- Entering too medially causing fracture neck of femur.
- Difficulty in getting a closed reduction.
- Missing of the central fragment in a segmental fracture.
- Difficulty in reaming
- Difficulty in introducing interlocking bolts
- Bolts missing the hole, backing out of bolts
- Perineal haematoma.

MATERIALS AND METHODS

Our study was conducted between the period of 1^{st} October 2012 to 31^{st} march 2014 in Shri. B.M. Patil medical college, hospital and research centre, Bijapur. 30 patients with diagnosis of fracture shaft of femur were treated with intramedullary interlocking nailing. The patients were informed about the study in all respects and written informed consent was obtained. Ethical clearance for this study was obtained from the committee.

INCLUSION CRITERIA

1. All closed Gustilo-Anderson type 1 and 2 femoral shaft fractures in adults aged 20 years and above of either sex
2. Patients willing for treatment and giving informed and written consent

EXCLUSION CRITERIA:

1. All fractures in pediatric and adolescent age-group
2. All Gustilo-Anderson type 3 fractures
3. Pre-existing femur deformities
4. Pathological fractures
5. Delayed-union, mal-union and non-union cases

SAMPLE SIZE:

Period of study: 1^{st} October 2012 – 31^{st} March 2014

In case of any statistical analysis and in the presence of non-availability of prevalence and incidence rate, the Sample Size 30 and above is sufficient to study the significance of the procedure. This is because all standard statistical distributions will merge into normal distribution. Further, the conclusion/inference that can be drawn using sample size more than 30 will almost remain the same as that with n=30.[59]

All patients were admitted, a careful history was elicited from patient and attendants to reveal the mechanism of the injury and the severity of the medical history and preinjury functional status. The patients were then assessed clinically to evaluate their general condition and the local injury.

In general condition of the patient, the vital signs were recorded. Comprehensive examination, not only of the injured limb, but also of all the limbs, to avoid missing the other associated injuries, if any, was done. The involved extremity was examined for swelling, deformity, abnormal mobility, crepitus, shortening, discoloration, skin integrity, neurological and vascular compromise, and signs or symptoms of compartment syndrome. Medical consultation was sought for geriatric patients. General surgeon consultation was sought to evaluate all high energy accident victims to rule out abdominal and head injuries.

Radiographic evaluation included anteroposterior and lateral radiographs of the entire femur, including the hip joint and the knee joint. Application of manual traction of the limb during radiographs will often clarify fracture morphology.

Occasionally, oblique radiographs were helpful. Radiographs should always include the hip and knee joint because of the risk of ipsilateral hip and knee injuries. Anteroposterior and lateral radiographs of the uninjured femur may help to plan fracture fixation, determine alignment, and preoperatively determine nail length. The limb was then immobilized in a Thomas splint with skin traction. The patient was then taken up for surgery after investigations and as soon as the patient was medically fit for surgery

Routine investigations done:

1. Complete blood count
2. Bleeding time, Clotting time
3. Urine- albumin, sugar and microscopy
4. Random blood sugar, blood urea and serum creatinine
5. HIV, HBs Ag
6. Blood group, Rh typing
7. ECG
8. X-ray CHEST- Postero-anterior view
9. Other investigations depending on patient's pre-morbid conditions

Multiple surgeons performed the surgeries in this study. The interval between the injury and the definitive operation ranged from 2 to 5 days with an average of 2 days.

Any delay in the surgery was usually attributable to multiple trauma or poor medical condition of the patient.

Pre-operative planning

Appropriate length of the nail to be used was measured clinically and radiographically. Preparation of the part was done prior to surgery.

Operative procedure

Type of anaesthesia- In all the cases spinal anaesthesia was used

Position- All pts were positioned supine on the fracture table. Hip adducted and flexed to about 15 degrees.

Incision - Centered on the tip of the greater trochanter and extended 4 cm proximally and slightly posterior, distal extension carried out if necessary.

Entry portal- Using the C-arm image intensifier, entry was made at the lateral aspect of piriform fossa at the junction with medial wall of greater trochanter. This was confirmed both in the AP and lateral views.

Guidewire insertion and fracture reduction - Ball tipped guidewire was inserted through the entry point passed upto the fracture site closed reduction achieved using traction and manipulation and guidewire passed across the fracture site. This was confirmed by image intensifier in both the views. Reaming of the canal done in 0.5 mm increments using intramedullary reamers. Ball tipped guidewire replaced by a straight guidewire.

Nail insertion- the desired nail was mounted onto the proximal jig. Alignment of proximal jig holes to nail holes confirmed before insertion.

Distal locking- Done using freehand technique under C-arm imaging. Locking of the bolts confirmed in both the views. The cortex was drilled using a 4mm drill bit and 4.5mm locking bolts were inserted.

Proximal locking - Done using the proximal jig. The cortex was drilled using a 4mm drill bit and 4.5mm locking bolts were inserted. Wound closed in layers.

In patients where surgical intervention was delayed due to some reason and closed reduction of fracture was difficult, open interlocking was done.

POST-OPERATIVE MANAGEMENT

- The limbs were kept elevated with pillows
- Intravenous antibiotics continued for first five days and then shifted to oral.
- Drain removed after 48 hours depending on the amount of collection.
- Check X-RAY on 3rd post-operative day
- Ankle, toe movements and static quadriceps exercises started on the 2nd and 3rd post-operative day.

- Active movements of knee in bed on 4th and 5th post-operative day.
- Patient allowed to stand with the help of a walker and non-weight bearing ambulation on 7th to 10th day
- Partial weight bearing ambulation with the help of a walker 14th post-operative day onwards
- Dressing done on 2nd, 5th and 8th post-operative day.
- Sutures removed on 12th post-operative day.
- Patient advised regarding partial weight bearing, walking started at about 14 days post operatively with the help of a walker.
- Full weight bearing walking allowed after radiological and clinical assessment.

Follow up

All the patients were followed up. With each follow up, clinical and radiological examinations were performed at 6 weeks, 12 weeks, 24 weeks and thereafter once in three months. Clinical examination included evaluation of complaints by the patients, assessment of the range of motion, assessment of the soft tissues, evaluation of the rotational alignment, leg length discrepancy and deformities, if any. Finally the functional implications were evaluated. Radiological examination was performed in two planes and assessed for callus formation and varus - valgus and flexion - extension deformities. 'Union' was defined as the appearance of bridging callus and trabeculations extending across the fracture site. 'Nonunion' was defined as no evidence of fracture union progression in 6 months of follow up. 'Delayed union' was defined as the appearance of the signs of fracture union, but the progress of union to consolidation is delayed than is otherwise expected.

FUNCTIONAL RESULTS:

Functional results were graded based on the classification system for the results of treatment by Thoresen B.O., et al.[12]

The results were designated as excellent, good, fair or poor according to the alignment of the fracture, the range of motion of ipsilateral knee, and the shortening of femur, and the degree of pain or swelling.

Classification system for the results of treatment –Thoresen et al[12]

	Result			
	Excellent	Good	Fair	Poor
Malalignment of femur (degrees)				
Varus or valgus	5^0	5^0	10^0	$> 10^0$
Antecurvatum or recurvatum	5^0	10^0	15^0	$> 15^0$
Internal rotation	5^0	10^0	15^0	$> 15^0$
External rotation	10^0	15^0	20^0	$> 20^0$
Shortening of femur (cm)	1 cm	2 cm	3 cm	> 3 cm
Range of motion of knee (degrees)				
Flexion	$> 120^0$	120^0	90^0	$< 90^0$
Extension deficit	5^0	10^0	15^0	$> 15^0$
Pain or swelling	None	Sporadic, minor	Significant	Severe

Figure-13: Operative photographs

Instruments and nails

Femur nail **Rigid reamers**

Flexible reamers

Fracture reduction **Draping and Incision**

Entry point with awl **Ball tipped guide wire in C-arm**

Ball tipped guide wire in C-arm **Ball tipped guide wire in C-arm**

Reaming **Exchange to non-ball tipped guide wire**

Nail loading **Nail insertion**

Nail in situ **Proximal locking**

Perfect circles of distal screw holes adjusted on C-arm

Distal locking done with free hand technique- AP view

Distal locking done with free hand technique- lateral view

INTRA-OP

CLOSURE

DRESSING

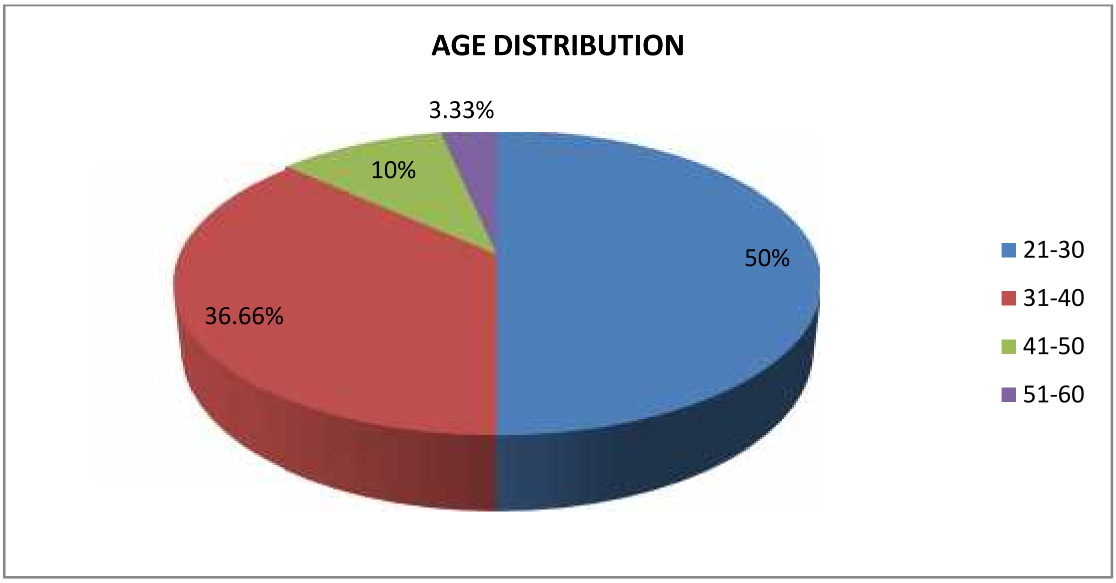
OBSERVATION AND RESULTS

AGE DISTRIBUTION

Table no. 1

Age in years	Number of patients	Percentage (%)
21-30	15	50%
31-40	11	36.66%
41-50	3	10%
51-60	1	3.33%

Graph No. 1



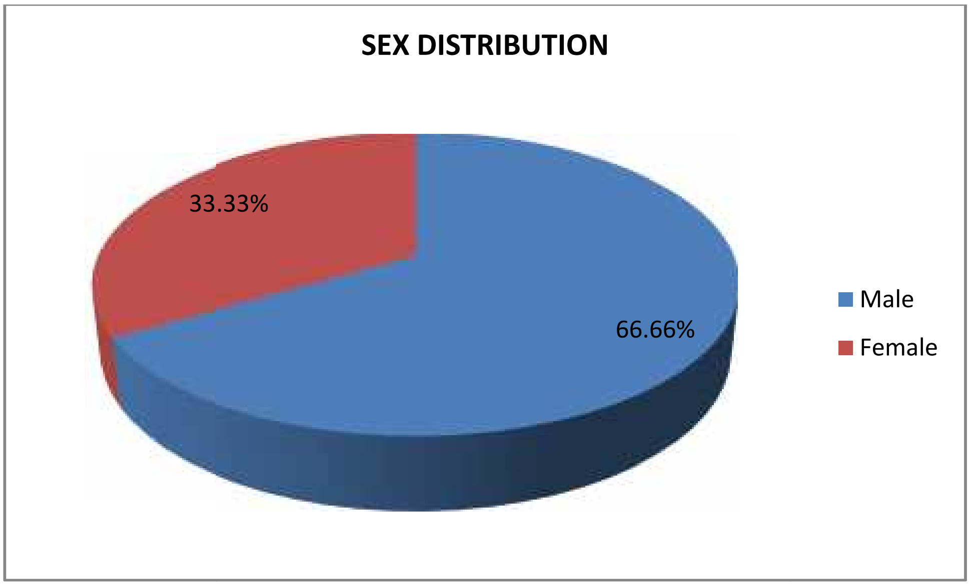
Age group ranged from 21-60 years with the mean age of 31.63 years.

SEX DISTRIBUTION

Table no. 2

Sex	No. of patients	Percentage
Male	20	66.66%
Female	10	33.33%

Graph No. 2



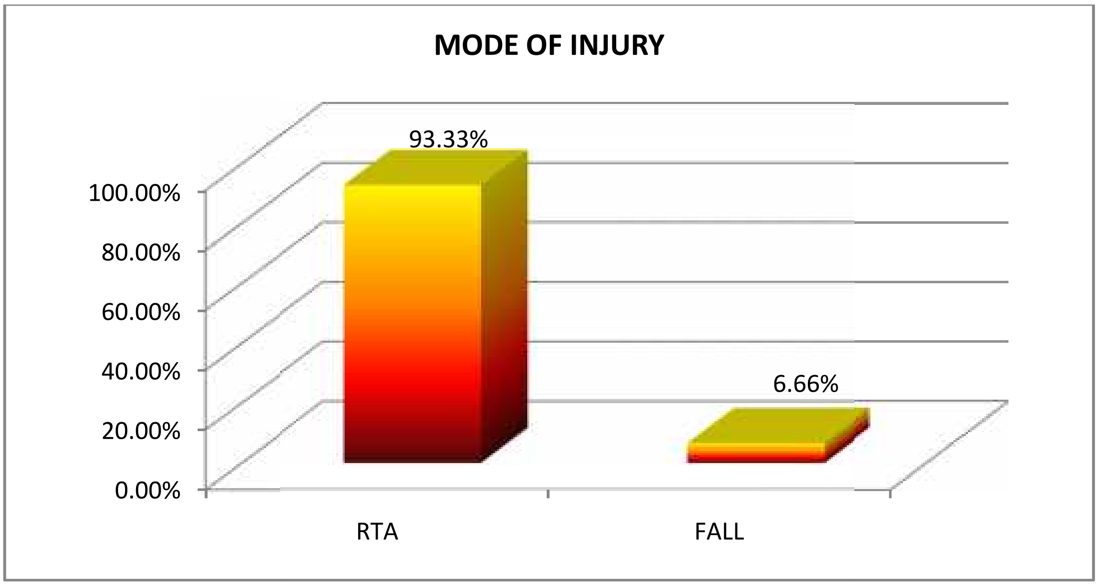
Male predominance was seen in our series i.e. 20 (66.66%) of our patients were male and 10 (33.33%) were female

MODE OF INJURY

Table no. 3

Mode of injury	No. of patients	Percentage
RTA	28	93.33%
FALL	2	6.66%

Graph No. 3



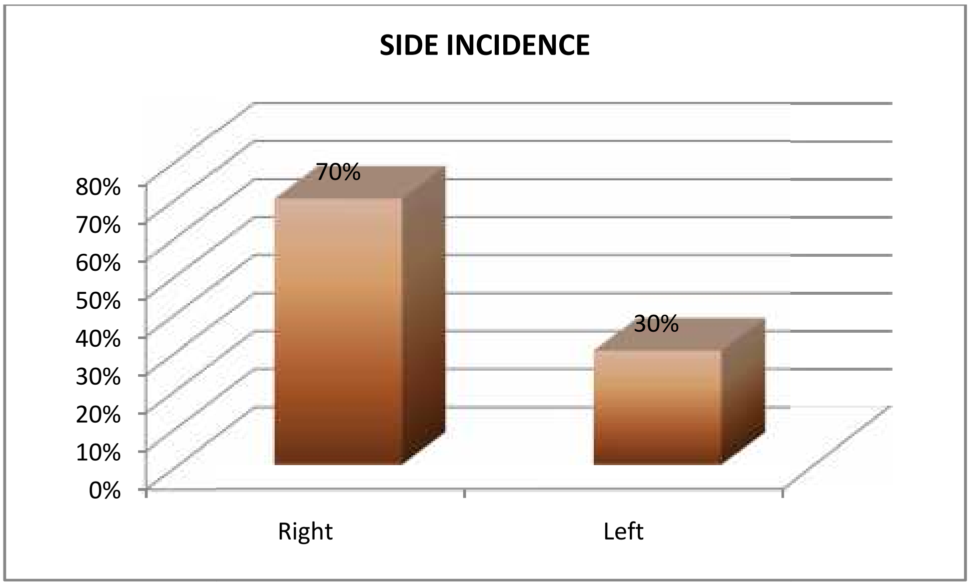
Vehicular accident in 28 (93.33%) patients was observed to be the main cause of fracture in our series

SIDE INCIDENCE

Table no. 4

Side	No. of patients	Percentage
Right	21	70%
Left	9	30%

Graph No. 4



21 cases were right sided and 9 cases were left sided fracture shaft of femur

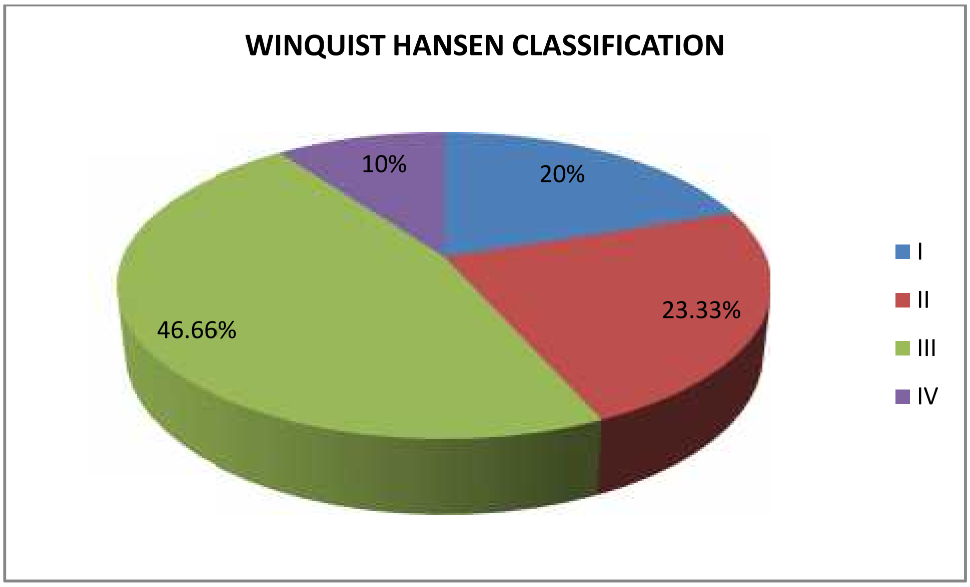
TYPE OF FRACTURE

WINQUIST HANSEN CLASSIFICATION

Table no. 5

Grade	No. of patients	Percentage
I	6	20%
II	7	23.33%
III	14	46.66%
IV	3	10%

Graph No. 5



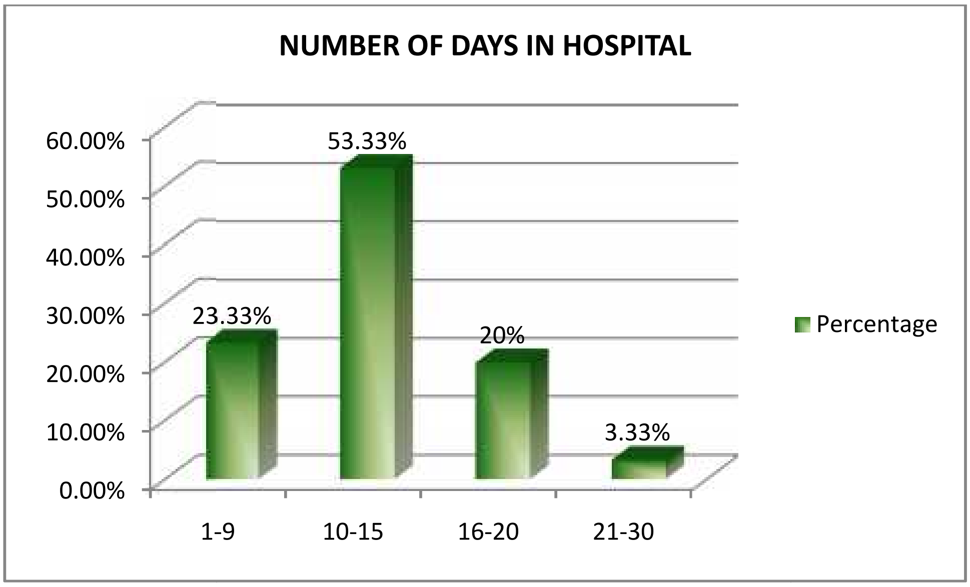
We found Winquist type III as the most common fracture pattern i.e. 14 patients (46.66%), type II in 7 patients (23.33%), type I in 6 patients (20%) and type IV in 3 patients (10%)

NUMBER OF DAYS IN HOSPITAL

Table no. 6

Number of days	No. of patients	Percentage
1-9	7	23.33%
10-15	16	53.33%
16-20	6	20%
21-30	1	3.33%

Graph No. 6



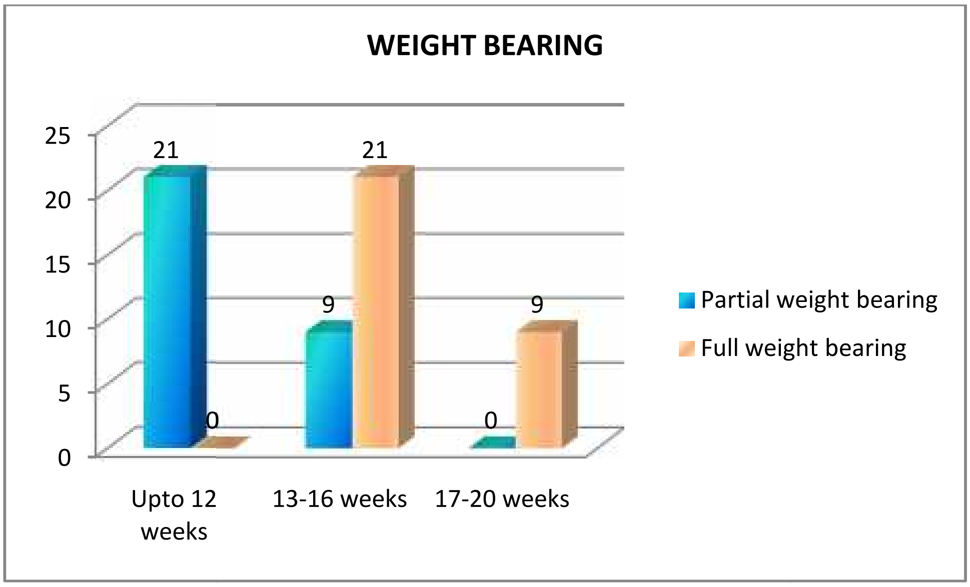
In our study, majority of the patients i.e. 16 patients (53.33%) had duration of hospital stay between 10-15 days

WEIGHT BEARING

Table no. 7

Time period	Partial weight bearing	Full weight bearing
Upto 12 weeks	21	0
13-16 weeks	9	21
17-20 weeks	0	9

Graph No. 7

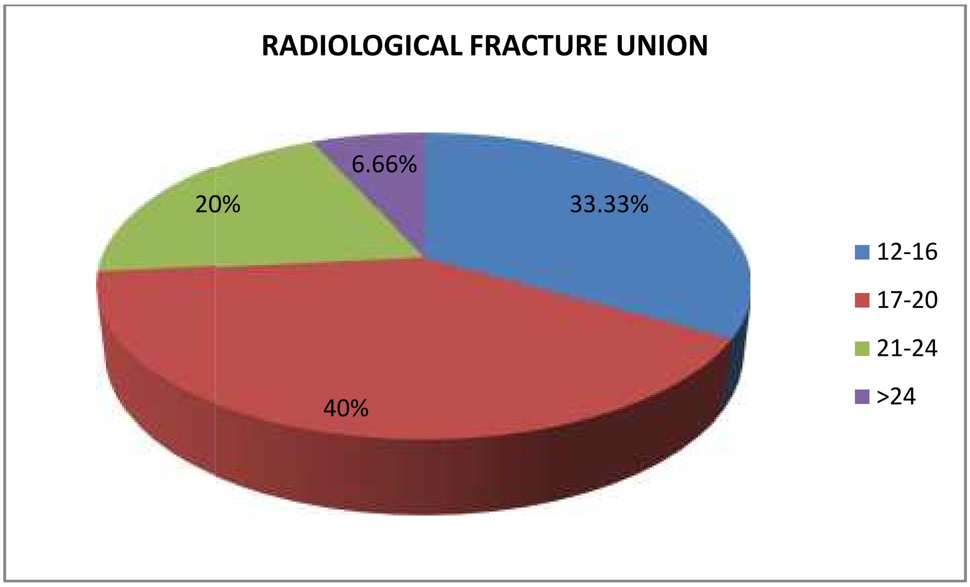


RADIOLOGICAL FRACTURE UNION

Table no. 8

Weeks	No. of patients	Percentage
12-16	10	33.33%
17-20	12	40%
21-24	6	20%
>24	2	6.66%

Graph No. 8



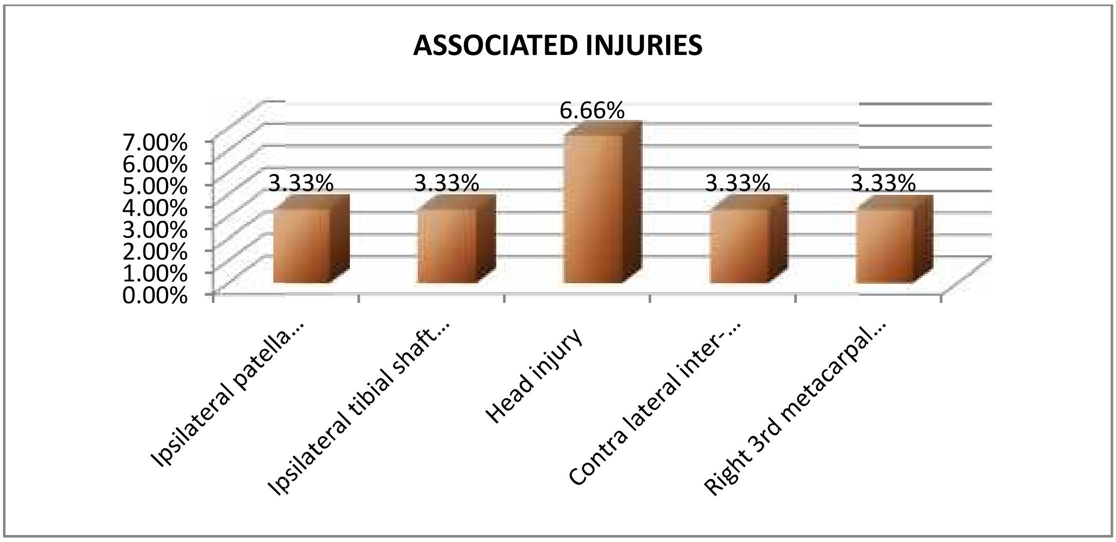
The average time for union in our series was 20.27 weeks ranging from 16 – 32 weeks.

ASSOCIATED INJURIES

Table no. 9

Associated injuries	No. of patients	Percentage
Ipsilateral patella fracture	1	3.33%
Ipsilateral tibial shaft fracture	1	3.33%
Head injury	2	6.66%
Contralateral inter-trochanteric fracture and proximal tibial fracture	1	3.33%
Right 3rd metacarpal fracture	1	3.33%

Graph No. 9



In our series, one patient had an associated patella fracture on the same side. One patient had ipsilateral tibial shaft fracture. One patient had right sided 3rd metacarpal fracture. Two patients had head injury. One patient had inter-trochanteric fracture and proximal tibial fracture on the contralateral side

SECONDARY PROCEDURE

One patient who had patella fracture was managed by TBW fixation

One patient who had tibia shaft fracture was managed by IMIL nailing

One patient who had 3^{rd} metacarpal fracture underwent closed reduction with K-wire fixation.

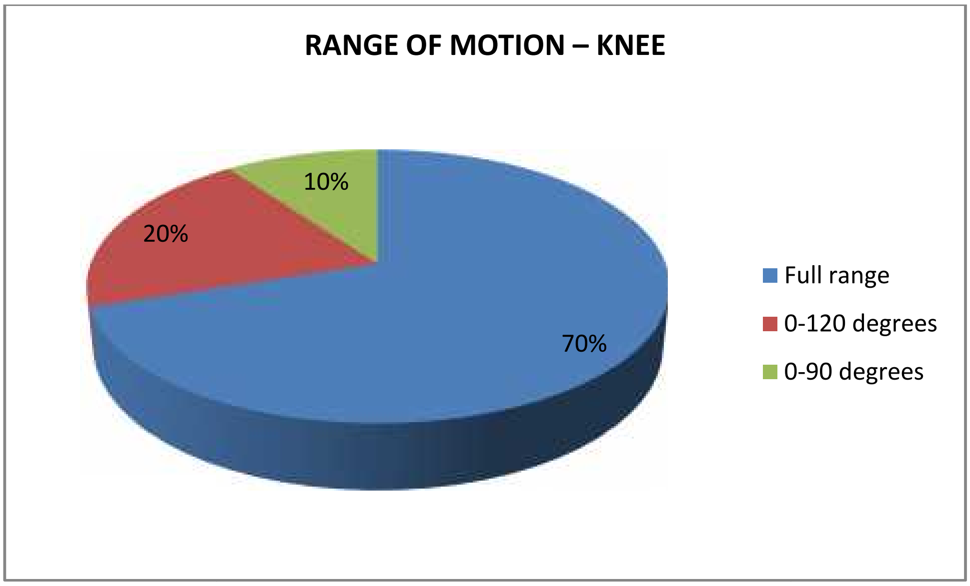
One patient who had contralateral inter-trochanteric fracture and proximal tibia fracture underwent trochanteric femoral nailing and CC-screw fixation respectively.

RANGE OF MOTION – KNEE

Table no.10

Range of motion – knee	No. of patients	Percentage
Full range	21	70%
0-120 degrees	6	20%
0-90 degrees	3	10%

Graph No. 10



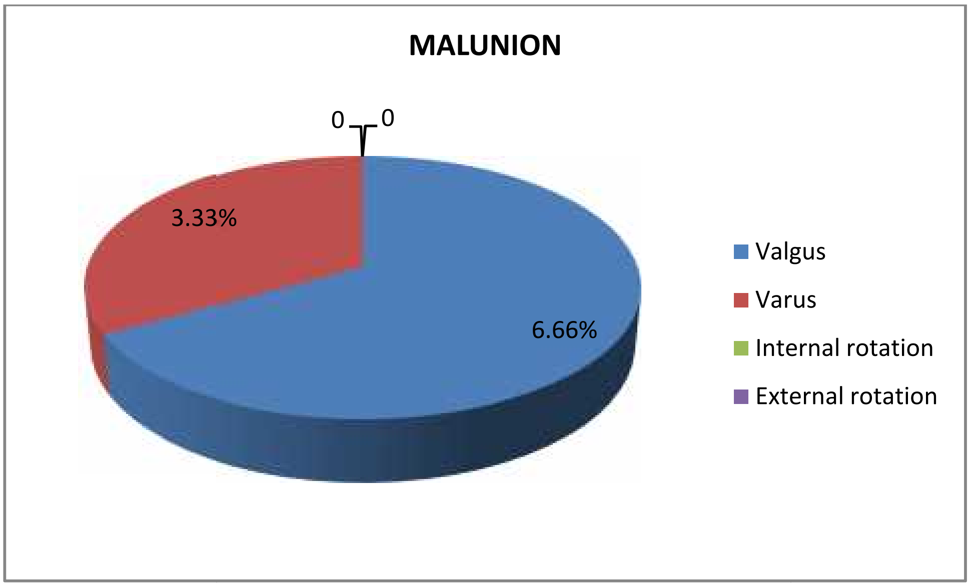
21 patients (70%) had full range of motion at the knee, 6 patients (20%) had 0-120 degrees of range of motion at the knee and only 3 patients (10%) could flex the knee upto 90 degrees

MALUNION

Table no.11

Malunion according to Thoresen grading	No. of patients	Percentage
Valgus	2	6.66%
Varus	1	3.33%
Internal rotation	-	
External rotation	-	

Graph No. 11



Valgus angulation of 10 degrees was observed in 2 patients and varus malalignment of 10 degrees was observed in 1 patient.

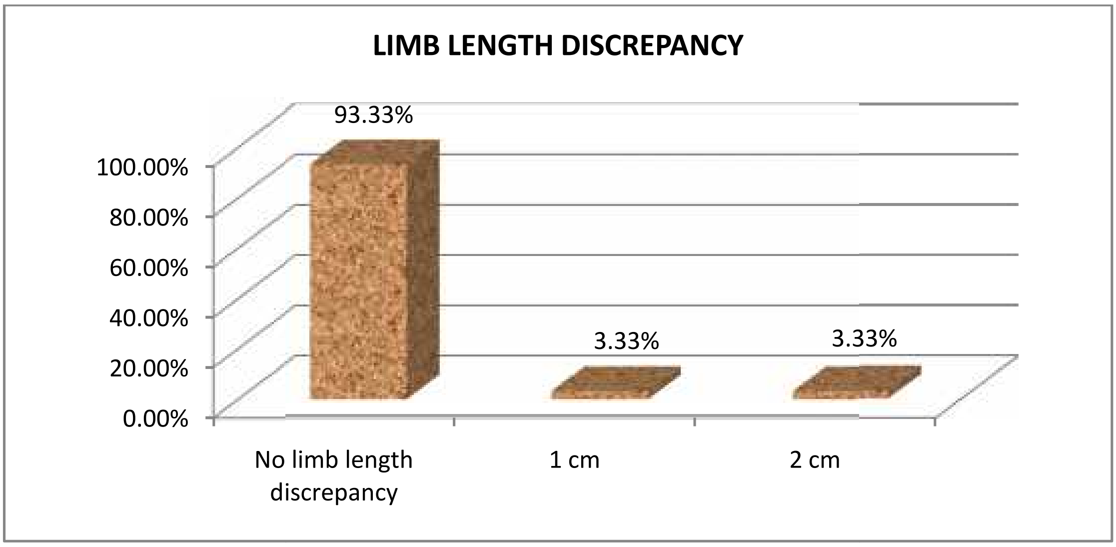
There were no cases with rotational deformities.

LIMB LENGTH DISCREPANCY

Table no. 12

Limb length discrepancy	No. of patients	Percentage
No limb length discrepancy	28	93.33%
1 cm	1	3.33%
2 cm	1	3.33%

Graph No. 12



1 patient had shortening of 1 cm and 1 patient had shortening of 2 cms.

NON-UNION

There were no cases of non-union noted in our series but 2 patients had delayed union in whom fracture united at 32 weeks

INFECTION

1 patient had superficial infection that resolved with antibiotics.

There were no instances of deep infection

IMPLANT FAILURE

There were no instances of nail breakage in our series, nor any cases with breakage of locking bolts.

KNEE PAIN

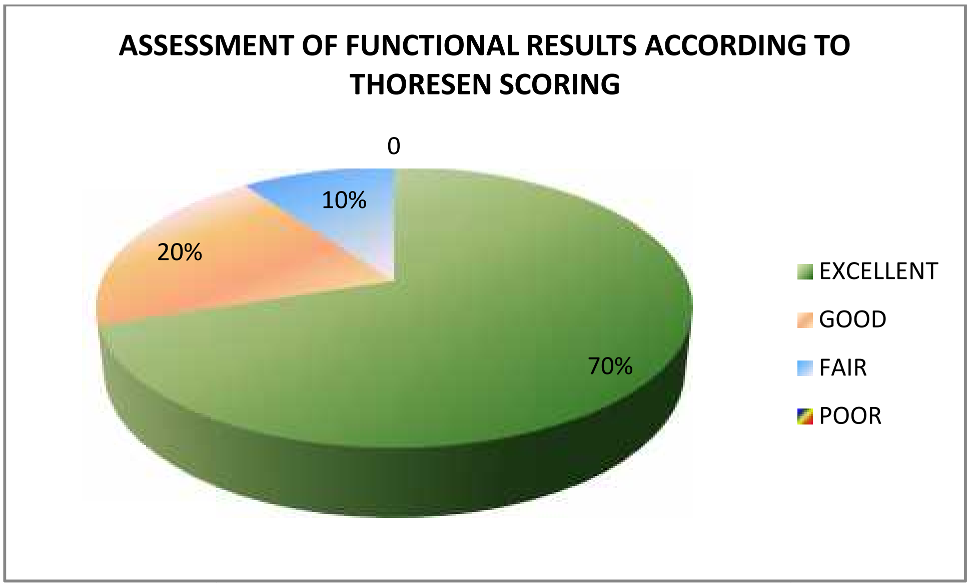
3 patients complained of sporadic knee pain and 3 patients complained of significant knee pain after fracture union

ASSESSMENT OF FUNCTIONAL RESULTS ACCORDING TO THORESEN[12] SCORING

Table no. 13

Results	No. of patients	Percentage
EXCELLENT	21	70%
GOOD	6	20%
FAIR	3	10%
POOR	-	-

Graph No. 13



We had excellent to good results in 90% of the cases and 10% of the patients had fair results.

FIGURE-14: CLINICAL PHOTOS AND RADIOGRAPHS

CASE NO. 1

PRE - OPERATIVE

POST-OPERATIVE **FOLLOW-UP**

UNION – AP VIEW

UNION - LATERAL VIEW

HIP FLEXION AND KNEE EXTENSION

HIP AND KNEE FLEXION

SITTING CROSS LEGGED

SQUATTING

FULL WEIGHT BEARING

CASE NO. 2

PRE-OPERATIVE

POST-OPERATIVE

FOLLOW-UP

UNION

SITTING CROSS LEGGED

HIP AND KNEE FLEXION

KNEE EXTENSION AND HIP FLEXION

FULL WEIGHT BEARING

CASE NO. 3

PRE-OPERATIVE **POST-OPERATIVE**

POST-OPERATIVE **UNION**

FULL WEIGHT BEARING

HIP AND KNEE FLEXION

SITTING CROSS LEGGED

KNEE EXTENSION AND HIP FLEXION

SQUATTING

DISCUSSION

The treatment of fracture diaphysis of femur has evolved from the old conservative management to the most recent methods of interlocking nails. This is the era of biological fixation. Interlocking nails have greatly expanded the indications for closed IM nailing of femoral fractures. The rationale for internal fixation is that it restores the anatomical alignment and allows early mobilization of the patient and limb.

The use of a plate to achieve osteosynthesis necessitates wide operative exposure and excessive soft tissue stripping, resulting in increased blood loss and operating time. The risk of infection is increased. Failure of the plate is common and the need for primary bone grafts adds additional morbidity to the procedure.

Early mobilization following fractures of the femoral diaphysis has been shown to have a significant advantage in terms of both joint mobility and economic impact which has very well attained by the use of interlocking nails.

AGE INCIDENCE

Majority of our patients were in the age group 21-30 years. The mean age was 31.63 years in our current study.

In the study of Wiss et.al mean age was 29 years [60]. Series of Thoresen of 48 cases of femoral shaft fractures stated a mean age of 28 years[12].

White et al observed mean age of 28 years in their study[61].

Most of the patients were manual laborers and agriculturist whose early return to work was important.

	MEAN AGE (years)
PRESENT STUDY	31.63
Wiss et.al[60]	29
Thorensen et.al[12]	28
White et.al[61]	28

SEX INCIDENCE

In most of the studies and in ours too the incidence was significantly higher in males. (20 males and 10 females).

Wiss – Fleming et.al[60] Male predominance (83.7%) was found in their 111 patients series.

Alho et al[62] reported 55% male predominance in 120 patients

STUDY	MALE PERCENTAGE	FEMALE PERCENTAGE
PRESENT STUDY	66.66%	33.33%
Wiss – Fleming et.al[60]	83.7%	16.3%
Alho et al[62]	55%	45%

SIDE INCIDENCE

In the series of Johnson and Greenberg right side was predominantly involved[63].

In the series of Wiss et al of comminuted fractures right side was predominantly involved[60].

In our series also right side was most commonly affected

STUDY	MOST COMMON SIDE
PRESENT	Right
Johnson et al[63]	Right
Wiss et al[60]	Right

MODE OF INJURY

The mode of injury in this series we had 28 cases of road traffic accident i.e. 93.33%. The incidence of road traffic accident has been on the increasing scale.

Winquist et al[40] also had 77% of cases because of motor vehicular accidents. This observation by various authors implies that fracture shaft femur is usually a result of high energy trauma. So it is commonly associated with other injuries.

STUDY	RTA	FALL
PRESENT STUDY	93.33%	6.66%
Winquist et al[40]	77%	23%

FRACTURE PATTERN

Wiquist Hansen Classification[40]

Our study had Winquist type III 46.66% (14 patients), type II 23.33% (7 patients), type I 20% (6 patients) and type IV 10% (3 patients)

Lhowe[64] 1984 reported type III 36%, type I 29%, type II 21% type IV 14% in 67 cases.

Brumback[65] (1988) showed Winquist type III as commonest 52%, type II 20%, IV 18% & I 10% in 81 cases.

Wiquist Hansen Classification[40]	PRESENT STUDY	Lhowe[64]	Brumback[65]
Type I	20%	29%	10%
Type II	23.33%	21%	20%
Type III	46.66%	36%	52%
Type IV	10%	14%	18%

TIME DURATION OF HOSPITAL STAY

The average time of hospital stay in our study was 12.3 days, compared to Wiss et al[60] which showed 12 days.

STUDY	AVERAGE TIME OF HOSPITAL STAY (DAYS)
PRESENT STUDY	12.3
Wiss et al[60](IMIL)	12
Winquist Hansen[66]	44
Gross Kempf[11]	21

AVERAGE TIME FOR UNION

The average time for union in our series was 20.27 weeks

Gross Kempf et al, (1985) reported union at 18 weeks, Thoresen et al, (1985) at 16 weeks , Wiss et al (1986) obtained union at 26 weeks.

STUDY	UNION IN WEEKS
PRESENT STUDY	20.27
Gross Kempf et al[11]	18
Thoresen et al[12]	16
Wiss et al[60]	26

COMPLICATIONS

- There was no case of intraoperative fracture in our study
- Christie et al[67] reported intra operative comminution in 6 patients out of 117 patients(5.1 %) due to wrong entry point.
- Alho et al[68] reported 9 patients(7.5 %) in 120 cases with splintering of proximal fragment

Rotational Deformity

In the present study, valgus angulation of 10 degrees was observed in 2 patients and varus malalignment of 10 degrees was observed in 1 patient. There were no rotational deformities.

Rotational control of unstable fractures can be very well achieved with locked intramedullary fixation[46]

Rothwell[69] reported 12% malrotation incidence with nonlocked fixation.

Wiss[60] reported 7% (8 patients) with 10^o-30^o external rotation deformity in 111 cases.

Winquist Hansen reported 7% with rotation deformities in type III and IV comminuted fractures.

Christie[67] reported 15^o external rotation in 1 patient of his 117 patients study.

Lhowe[64] reported in 2% of patients, in 67 cases.

Knee Range of movement

We had excellent knee range of movement in our cases. Early resumption of range of movement exercises were started after surgery as per patient tolerance. 21 patients had full range of motion of the knee, 6 patients had knee movement between 0-120 degrees and 3 patients had knee movement between 0-90 degrees.

Wiss et.al[60] reported average knee flexion 125^o with only 3 patients had less than 90^o flexion.

Shortening

In all, there was shortening in 2 patients (6.66%). 1cm shortening was noted in 1 patient (3.33%) and 1 patient had 2cm shortening (3.33%). For a patient with 2 cm shortening, shoe raise was given and now patient is managing well, without any difficulty in daily activities.

Interlocking nail has decreased incidence of the problem of shortening at the fracture site, which was seen when conventional nailing was used for unstable comminuted fractures.

Christie et al[67] reported 2 patients (1.7 %) with more than 2 cm shortening both had spiral fractures, which were dynamically locked, study of 117 patients.

Brumback in his study of 133 patients treated with Russel Taylor or Brooker Willis Nail had 1 cm shortening in 2 patients and 1 patient had 2 cm shortening. All were due to intraoperative fixation in a shortened position and not due to postoperative loss of fixation.

Wiss[60] 1985 reported 2.5% cases showing shortening in 117 patients.

Johnson[70] reported shortening of 1-2 cm in 13% of cases.

Lhowe[64] reported 7% cases with 1-2 cm shortening.

Infection

One patient developed superficial infection that resolved with antibiotics.There were no cases of deep infection.

Christie et al[67] had 1 superficial infection, 14 patients had prolonged wound discharge with no osteomyelitis.

Lhowe, Hansen[66] had reported 67 open fractures treated by immediate nailing with 5% wound seroma and 5% wound infection.

Klemm[71] reported study of 293 patients with deep infection in 7 patients, 3 of which were closed fractures.

Wiss[60] reported only 1 superficial infection in 112 patients at the trochanteric incision with no deep infection and no osteomyelitis.

Nonunion

There were no cases of non-union noted in our series.

Rothwell[69] in his study showed 6 % of non-union rate.

Alho et al[68] had 0% rate with Grosse-Kempf nail in120 patients.

White et al[72] has 1.1 % of nonunion with Brooker-Willis nail.

Delayed Union

In this series delayed union was seen in 2 patients. Fracture united at 32 weeks in both the cases.

Christie et al[67] reported delayed union in 2 patients (i.e.1.7 %) in 117 patients.

Klemm, Borner[71] had 0.7% delayed union in 293 fractures.

Other complications

There was no case of femoral neck fracture, nail breakage, screw breakage, lengthening, and medical complications like ARDS or pulmonary embolism intraoperatively. There was no perioperative mortality.

FUNCTIONAL OUTCOME

The functional outcome in our present study was 90% for excellent and good results.

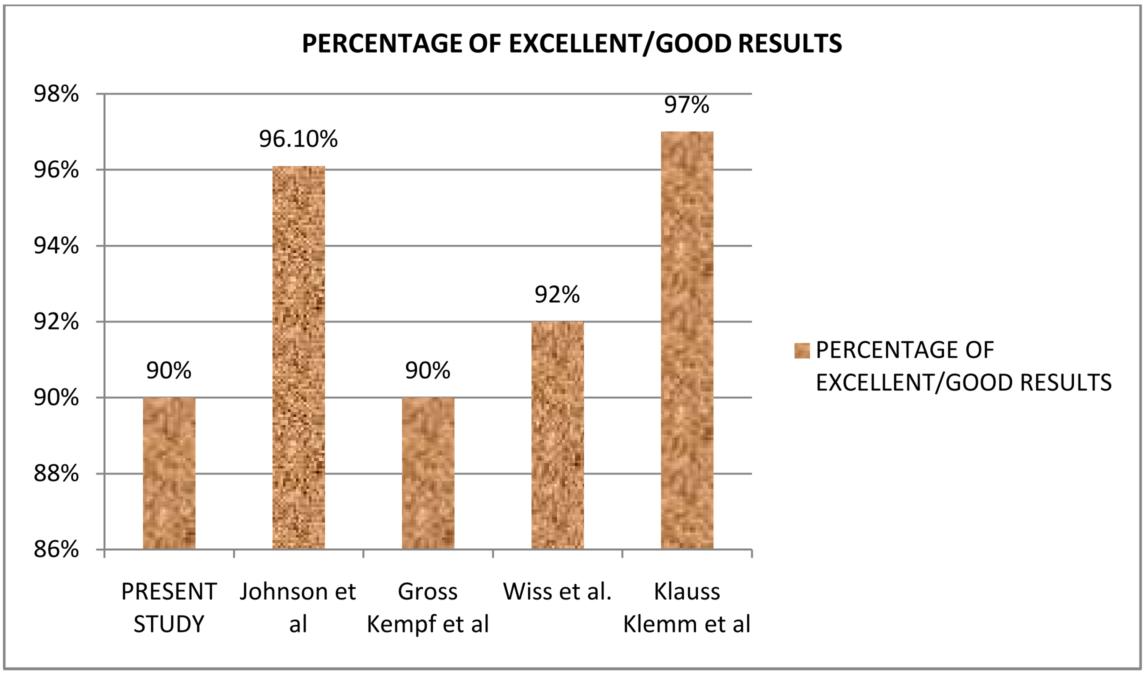
Study	Number of cases	Duration of hospital stay (days)	Shortening (%)	Union in weeks	Deep infection
PRESENT STUDY	30	12.3	6.66	20.27	0
Thoresen et al	48	-	7.5	16	0
Gross Kempf et al	49	21	7.5	18	2.1
Winquist & Hansen	245	26	7.3	14	0.4

COMPARATIVE STUDIES

Table no. 14

STUDY	PERCENTAGE OF EXCELLENT/GOOD RESULTS
PRESENT STUDY	90%
Johnson et al[63]	96.1%
Gross Kempf et al[11]	90%
Wiss et al[60].	92%
Klauss Klemm et al	97%

Graph No. 14



CONCLUSION

Fractures of the femoral diaphysis are one of the commonest injuries sustained in high velocity trauma.

Intramedullary interlocking nailing is a very effective and successful method of definitive primary treatment in most types of fractures of the shaft of the femur.

It achieves strength of femoral diaphyseal fracture shaft in all three planes of load-bending, compression and torsion.

Fractures in any zone from the subtrochanteric to distal supracondylar part of the femur are accessible to nailing.

The anatomy of the femur, the loading conditions by gravitational, muscular and ligamentous forces – all are in favor for intramedullary interlocking nail fixation.

Interlocking techniques lead to fewer complications of nonunion/malunion, lesser soft tissue dissection, earlier fracture healing and lesser chances of infection.

Closed nailing results in less intraoperative blood loss, shorter operative time, earlier weight bearing, early union rates and early return to work with reduced morbidity compared to the open techniques.

The results in our series confirm as have those of other series that intramedullary interlocking nailing is the treatment of choice for shaft fractures of the femur.

SUMMARY

- 30 cases were studied in our series, admitted to SHRI. B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, BIJAPUR during 1st October 2012 to 31st March2014.
- Age group ranged from 21-60 years with the mean age of 31.63 years.
- Out of study subjects, 20 patients were male and 10 were female
- Right sided fractures were more commonly encountered – 21 cases (70%)
- Most common mode of injury was RTA – 28 cases (93.33%)
- Our study had Winquist type III 46.66% (14 patients), type II 23.33% (7 patients), type I 20% (6 patients) and type IV 10% (3 patients)
- Average duration of hospital stay was 12.3 days
- One patient had an associated patella fracture on the same side. One patient had an ipsilateral tibial shaft fracture, one patient had third metacarpal fracture, two patients had head injury, one patient had intertrochanteric fracture and proximal tibial fracture on the contralateral side.
- The average time for union in our series was 20.27 weeks.
- In the present study, valgus angulation of 10 degrees was observed in 2 patients and varus malalignment of 10 degrees was observed in 1 patient. There were no rotational deformities.
- We had excellent knee range of movement in our cases. Early resumption of range of movement exercises were started after surgery as per patient tolerance. 21 patients had full range of motion of the knee, 6 patients had knee movement between 0-120 degrees and 3 patients had knee movement between 0-90 degrees.

- In all, there was shortening in 2 patients (6.66%). 1cm shortening was noted in 1 patient (3.33%) and 1 patient had 2cm shortening (3.33%). For a patient with 2 cm shortening, shoe raise was given and now patient is managing well, without any difficulty in daily activities.
- One patient developed superficial infection that resolved with antibiotics. There were no cases of deep infection.
- There were no cases of non-union noted in our series.
- Delayed union was seen in 2 patients. Fracture united at 32 weeks in both the cases.
- There was no case of femoral neck fracture, nail breakage, screw breakage, lengthening, and medical complications like ARDS or pulmonary embolism intraoperatively. There was no perioperative mortality.
- Our study yielded excellent to good results in 90% of the cases.

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ANNEXURE-I

ETHICAL CLEARANCE CERTIFICATE

BIJAPUR-586 103
OUTWARD
No. 046/12
Date 18/10/12

B.L.D.E. UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103

INSTITUTIONAL ETHICAL COMMITTEE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 18-10-2012 *at* 3-30pm *to scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis has been accorded Ethical Clearance.*

Title "Functional outcome of fracture shaft of femur treated by intramedullary interlocking nailing"

Name of P.G. student Dr. Mapari Yogesh Madhukar
Orthopaedics

Name of Guide/Co-investigator Dr O.B. Pattanashetty
Prof & HOD, Orthopaedics

DR.TEJASWINI. VALLABHA
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project.
2) Copy of informed consent form
3) Any other relevant documents.

ANNEXURE II

CONSENT FORM

TITLE OF RESEARCH: FUNCTIONAL OUTCOME OF FRACTURE SHAFT OF FEMUR TREATED BY INTRAMEDULLARY INTERLOCKING NAILING

Principle Investigator : DR. MAPARI YOGESH MADHUKAR

P.G. Guide Name : DR. O. B. PATTANASHETTY

M.S (ORTHOPAEDICS)

All aspects of this consent form are explained to the patient in the language understood by him/her.

I) INFORMED PART

i. Purpose of study

I have been informed that this study will test the effectiveness of one particular method of INTRAMEDULLARY INTERLOCKING NAILING OF FRACTURE SHAFT OF FEMUR. This method requires hospitalization.

ii. Procedure

I will be selected for the treatment after the clinical study of my age, type of fracture, condition of bone seen in radiograph and after study of fitness for anaesthesia and surgery .I will be admitted immediately. I will have to attend follow-up to OPD regularly. I will be assessed in physiotherapy department also.

iii. Risk and Discomfort

I understand that I may experience some pain and discomfort during the post operative period. This condition is usually expected. These are associated with the usual course of treatment

iv. Benefits

I understand that my participation in this study will have no direct benefit to me other than the potential benefit of treatment which is planned to heal my fracture in the shortest possible period and restore my function.

v. Alternatives

I understand that, the various alternative modes of treatment available to me in this fracture pattern with their merits and demerits have been explained to me.

vi. Confidentiality

I have been assured that all information furnished to the doctor by me regarding my medical condition will be kept confidential at all times and all circumstances except legal matters.

vii. Requires for more information

It has been made clear to me that I am free at all time under any circumstances to touch based with doctor by directly approaching or otherwise to satisfy any query , doubt regarding any aspect of research concerns.

viii. Refusal or withdrawal of participation

It has been made clear to me that participation in this medical research is solely the matter of my will and also that right to withdraw from participation in due course at any time.

II) CONSENT BY PATIENT

I, the undersigned, have been explained by Dr. O. B. Pattanashetty in the language understood by me. The purpose of research, the details or procedure that will be implemented on me, the possible risks and discomforts of surgery and anaesthesia have been understood by me. I have also been explained that participation in this medical research is solely the matter of my will and also that I have the right to withdraw from this participation at any time in due course of the medical research.

Signature of participant/patient   date: time:

Signature of witness: date: time:

ANNEXURE- III

PROFORMA

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

Presenting complaints with duration:

History of presenting complaints:

Family History:

Personal History:

Past History:

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized Lymphadenopathy:	present/absent
Build:	Poor/Moderate /Well
Nourishment:	Poor / Moderate /Well

Vitals

PR:	RR:
BP:	TEMP:

Other Systemic Examination:

- Respiratory System
- Cardiovascular System
- Central Nervous System
- Per Abdomen

Local examination

Gait:

<u>Inspection:</u>

-Attitude

-Swelling

-Deformity

-Skin

-Compound injury – yes/no

-Actively bleeding – yes/no

-Contamination

-Other fractures ,if any

Palpation:

-Tenderness

-Local rise of temperature – yes / no

-Bony irregularity – yes/ no

-Fracture crepitus – yes / no

-Abnormal mobility

-Loss of continuity of bone

-Swelling

-Effusion of knee

-Pain elicited by manipulation from distance

-Absence of transmitted movements

-Peripheral pulses

-Neurovascular deficits distal to the fracture site

Movements :

		Active	Passive
Hip :	Flexion		
	Extension		
	Internal rotation		
	External rotation		
	Adduction		
	Abduction		
Knee :	Flexion		
	Extension		

Measurements :

Apparent length: Xiphisternum to Medial malleolus

True length : - Anterior superior iliac spine to medial malleolus

- Anterior superior iliac spine to medial Joint Line of Knee Joint

- Medial joint line of knee joint to medial malleolus

Girth of the Limb:

MANAGEMENT:

INVESTIGATIONS:

The following investigations will be done on patients before surgery with their consent.:

1. X-ray of thigh with hip and knee joint of affected side-Antero-posterior & lateral view
2. X-ray pelvis with both hips- Antero-posterior view
3. Complete blood count
4. Bleeding time, Clotting time
5. Urine- albumin, sugar and microscopy
6. Random blood sugar, blood urea and serum creatinine
7. HIV, HBsAg
8. Blood group, Rh typing
9. ECG
10. X-ray CHEST- Postero-anterior view
11. Other investigations depending on patient's pre-morbid conditions

FINAL DIAGNOSIS:

TREATMENT:

1. Preliminary treatment on admission- Thomas splint, analgesics, (debridement of wound and antibiotics if required)
2. Anaesthesia used – SA/GA
3. Approach used
4. Type of position
5. Type of table – Normal/ fracture table
6. Reamed or unreamed
7. Size of nail and bolts used
8. Intra-operative complications
9. Final inspection of the nail, bolts and fracture reduction under 'C'-ARM image intensifier

POST-OPERATIVE MANAGEMENT:

- The limbs will be kept elevated with pillows
- Intravenous antibiotics will be continued for first five days and then shifted to oral.
- Suction drainage will be removed after 48 hours depending on the amount of collection.
- Check X-RAY on 3rd post-operative day
- Ankle, toe movements and static quadriceps exercises will be started on the 2nd and 3rd post-operative day.
- Active movements of knee in bed on 4th and 5th post-operative day.
- Patient is allowed to stand with help of a walker and non-weight bearing ambulation on 7th to 10th day

- Partial weight bearing ambulation with the help of a walker 14th post-operative day onwards
- Dressing will be done on 2nd, 5th and 8th post-operative day.
- Sutures will be removed on 12th post-operative day.
- Patient will be advised regarding partial weight bearing, walking will be started at about 14 days post operatively with the help of a walker.
- Full weight bearing walking will be allowed after radiological and clinical assessment.
- Functional outcome following interlocking nailing in shaft fracture of femur will be evaluated based on Bjorn O. Thoresen et al criteria.

FOLLOW-UP:

Duration after surgery : 6 weeks/ 3 months/ 6 months

Radiological evaluation – Check X-RAY – femur full length AP & lateral view

Complaints : 1. Deformity

2. Shortening

3. Range of motion of knee – flexion and extension

4. Pain

5. Swelling

RESULTS	EXCELLENT	GOOD	FAIR	POOR

ANNEXURE-IV

MASTER CHART

SL NO.	NAME	AGE(years)	SEX	IP NO.	MOI	SIDE	TOF	DOHS (Days)	AI	COMP	UNION (WEEKS)	FUNCTIONAL OUTCOME				RESULT
												MOF (Degrees)	SH (CM)	K – ROM (Degrees)	PAIN/SWELLING	
1	Harish	35	M	2478	RTA	R	1	12			16	NIL	NIL	FULL	NONE	EXL
2	Prakash Kotyat	32	M	18219	RTA	R	3	12			20	NIL	NIL	FULL	NONE	EXL
3	Akash Halamani	37	M	9371	RTA	L	1	10			16	NIL	NIL	FULL	NONE	EXL
4	Shantappa Ragali	30	M	22267	RTA	R	2	14			16	NIL	NIL	FULL	NONE	EXL
5	Savitribai Sajjan	41	F	1531	RTA	L	3	12			16	NIL	NIL	FULL	NONE	EXL
6	Sangeetha	24	F	17548	RTA	R	3	16	Rt. Patella #	SHORTENING	24	NIL	1	120	MINOR	GOOD
7	Arun Kaparkar	27	M	30060	RTA	R	1	10			20	NIL	NIL	FULL	NONE	EXL
8	Priyanka Chawan	24	F	27224	FALL	R	3	9			24	NIL	NIL	120	NONE	GOOD
9	Gopal Hippargi	36	M	24986	RTA	R	3	13			16	NIL	NIL	FULL	NONE	EXL
10	Kalavathi	42	F	17541	RTA	L	2	10			20	NIL	NIL	FULL	NONE	EXL
11	Suhas	26	M	10175	RTA	L	4	18	Lt. tibia shaft #	SHORTENING	24	10	2	0-90	SIGNIFICANT	FAIR
12	Neran Kuntoji	30	M	15339	FALL	R	3	9			16	NIL	NIL	FULL	NONE	EXL
13	Maruti Pawar	25	M	7121	RTA	R	1	10			20	NIL	NIL	FULL	NONE	EXL
14	Farhan Mujawar	22	M	2421	RTA	L	3	16			24	10	NIL	120	MINOR	GOOD
15	Rajani Pawar	34	F	7910	RTA	R	2	12			20	NIL	NIL	FULL	NONE	EXL
16	Hamida Nadaf	26	F	8660	RTA	R	2	16			20	NIL	NIL	FULL	NONE	EXL

17	Santosh	24	M	23513	RTA	L	3	19	Head injury		24	NIL	NIL	120	NONE	GOOD
18	Swamyrao Jahagirdar	60	M	24726	RTA	R	4	22	Lt. IT #, Lt. Prox. Tibia #	DELAYED UNION	32	10	NIL	0-90	SIGNIFICANT	FAIR
19	Irayya Biradar	38	M	6886	RTA	R	3	11			20	NIL	NIL	FULL	NONE	EXL
20	Sharnappa Biradar	33	M	26613	RTA	L	1	9			16	NIL	NIL	FULL	NONE	EXL
21	Kaderbasha Devalsab	36	M	24828	RTA	R	3	10			20	NIL	NIL	120	MINOR	GOOD
22	Nagamma Kannali	30	F	21081	RTA	R	2	9			16	NIL	NIL	FULL	NONE	EXL
23	Ramesh Biradar	23	M	24631	RTA	R	3	9			16	NIL	NIL	FULL	NONE	EXL
24	Shankargouda	32	M	16987	RTA	L	2	12			20	NIL	NIL	FULL	NONE	EXL
25	Boramma Dashavant	40	F	23670	RTA	L	4	17	Head injury	DELAYED UNION	32	NIL	NIL	0-90	SIGNIFICANT	FAIR
26	Tajuddin	21	M	3566	RTA	R	3	12		Superficial infection	24	NIL	NIL	120	NONE	GOOD
27	Tayawwa	35	F	5789	RTA	R	3	9			20	NIL	NIL	FULL	NONE	EXL
28	Kaveri Bhosale	22	F	24529	RTA	R	1	10			16	NIL	NIL	FULL	NONE	EXL
29	Anand	41	M	8385	RTA	R	2	9			20	NIL	NIL	FULL	NONE	EXL
30	Chandan	23	M	5002	RTA	R	3	12	Rt. 3rd Metacarpal #		20	NIL	NIL	FULL	NONE	EXL

KEY TO MASTER CHART

IP NO	-	Inpatient number
MOI	-	Mode of injury
TOF	-	Type of fracture
DOHS	-	Duration of hospital stay
AI	-	Associated injuries
COMP	-	Complications
MOF	-	Malalignment of femur
SH	-	Shortening
K-ROM	-	Knee - Range of motion
M	-	Male
F	-	Female
RTA	-	Road traffic accident
R	-	Right
L	-	Left
#	-	Fracture
EXL	-	Excellent
Rt	-	Right
Lt	-	Left