A Prospective Analysis of

INTRAMEDULLARY FIXATION OF UNSTABLE PERITROCHANTERIC FRACTURES WITH INTERLOCKING PROXIMAL FEMORAL NAIL

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CERTIFICATE

This is to certify that this dissertation on **"PROSPECTIVE ANALYSIS OF INTRAMEDULLARY FIXATION OF UNSTABLE PERITROCHANTERIC FRACTURES WITH INTERLOCKING PROXIMAL FEMORAL NAIL"** is a bonafide work done by **Dr. S. ALFRED SATHIYA SEKAR,** Post Graduate, Department of Orthopaedic Surgery, Government Royapettah Hospital, Kilpauk Medical College, Chennai, under my guidance and supervision in partial fulfillment of the regulations of **The Tamilnadu Dr. M.G.R. Medical University**, Chennai for the award of **M.S. Degree in Orthopedic Surgery (Branch – II)** during the academic period - 2004-2007.

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DECLARATION

I declare that this dissertation entitled **"PROSPECTIVE ANALYSIS OF INTRAMEDULLARY FIXATION OF UNSTABLE PERITROCHANTERIC FRACTURES WITH INTERLOCKING PROXIMAL FEMORAL NAIL"** has been conducted by me at Department of Orthopaedic Surgery, Govt. Royapettah Hospital, Kilpauk Medical College Chennai-10, under the guidance and supervision of my Chief **Prof. Dr. K. NAGAPPAN**, **M.S. (Ortho)., D.Ortho.,** Govt. Royapettah Hospital and Kilpauk Medical College Chennai. It is submitted in part of fulfillment of the award of the degree of M.S (Ortho) for the March 2007 examination to be held under the Tamil Nadu Dr. M.G.R Medical University, Chennai. This has not been submitted previously by me for the award of any degree or diploma from any other university.

(Dr. S. ALFRED SATHIYA SEKAR)

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CONTENTS

INTRODUCTION

Fractures around the trochanteric region of femur are one of the commonest fractures encountered in orthopaedics and also the most devastating injuries of the elderly. The incidence of this fracture increases with advancing age. These patients are more limited to home ambulation and are dependent in basic and instrumental activities of daily living. Growing number of population and the road traffic accidents have resulted in an enormous increase in these type of fractures. In younger patients the fractures usually result from high energy trauma like RTA and fall from height and accounts for only ten percent .Older patients suffering from a minor fall can sustain fracture in this area because of weakened bone due to osteoporosis or pathological fracture and this accounts for 90%.

Since the femur is the longest and the strongest bone in the body and one of the principal load bearing bone in the lower extremity fracture of this bone may result in prolonged morbidity and extensive disability unless the treatment is appropriate. These fractures are associated with substantial morbidity and mortality. Approximately 15 to 20% patients die within one year of fracture. After one year patients appear to resume their age – adjusted mortality rate. Until 1960’s non operative treatment was the option available for these type of fractures in the form of traction with prolonged bed rest with fracture healing occurring in ten to twelve weeks (usually) followed by a lengthy programme of ambulation training. These are associated with complications of prolonged recumbence like decubitus ulcer, UTI, joint contractures, pneumonia and thrombo- embolic complications resulting in high mortality rate.

During this century a better understanding of the biomechanics of the fracture and the development of better implants have lead to radical changes in treatment modalities. Increasing emphasis on the preservation of blood supply to the fracture fragments and autogenous bone grafting has improved biological results. While the development in biomedical research have yielded implants of greater strength and longer fatigue life. With the thorough understanding of fracture geometry and biomechanics optimal treatment can be selected for individual cases.

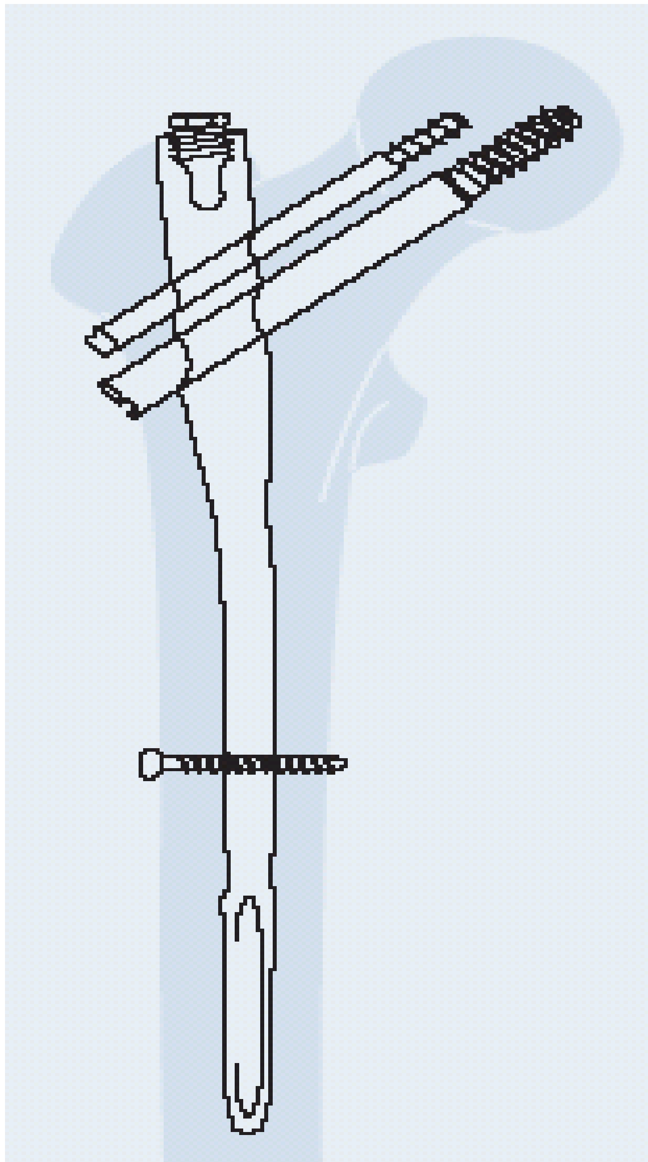
After 1960's the first successful implants were fixed angle - nail plate devices like Jewett and Holt nail which provided stabilization of femoral head and neck fragment to the femoral shaft but failed to provide controlled impaction. This gave rise to sliding – nail plate devices like Massie nail and Ken-Pugh nail which provided both. Then modification of this resulted in the introduction of sliding hip screws like DHS in which the nail portion was replaced by a blunt ended screw with a large outside thread diameter to improve proximal fragment fixation and decrease the risk of screw cutout by eliminating sharp edges. Then the concept of bidirectional sliding came into play by the introduction of Egger's plate and Medoff plate. The sliding hip screw device with its modification has been used widely and successfully for more than a decade for the treatment of these fractures.

In unstable trochanteric fractures where there is loss of postero-medial cortex continuity, when load is applied increased bending force on the DHS lead to implant breakage, screw cutout or separation of plate from shaft. This lead to the introduction of Intramedullary devices which theoretically due to its position provides more efficient load transfer and shorter lever arm can decrease tensile strain thereby decreasing the risk of implant failure. Though Zickel introduced his nail long ago it was not very popular due to higher incidence of complications, so was the case with ender's nail. Zickel nail was later modified and renewed interest is being given to intra medullary fixation with devices like the IMHS (intra medullary hip screw), Gamma nail, Russell – Taylor reconstruction nail, ATN (Ante grade trochanteric nail), TFN (Trochanter fixation nail) and the PFN (Proximal femoral nail) due to advantages of reduced operating time, less blood loss, better biomechanical stability and earlier mobilization provided by this devices.

In 1997, PFN (Proximal femoral nail) was introduced in Czechoslovakia by Synthes company which has the biomechanical advantage of all IM devices and considered to be as a second generation nail. Several recent studies are going on for comparison with DHS and other IM devices and the results are encouraging but needs time and further evaluation to be accepted.

PFN

PROXIMAL FEMORAL NAIL

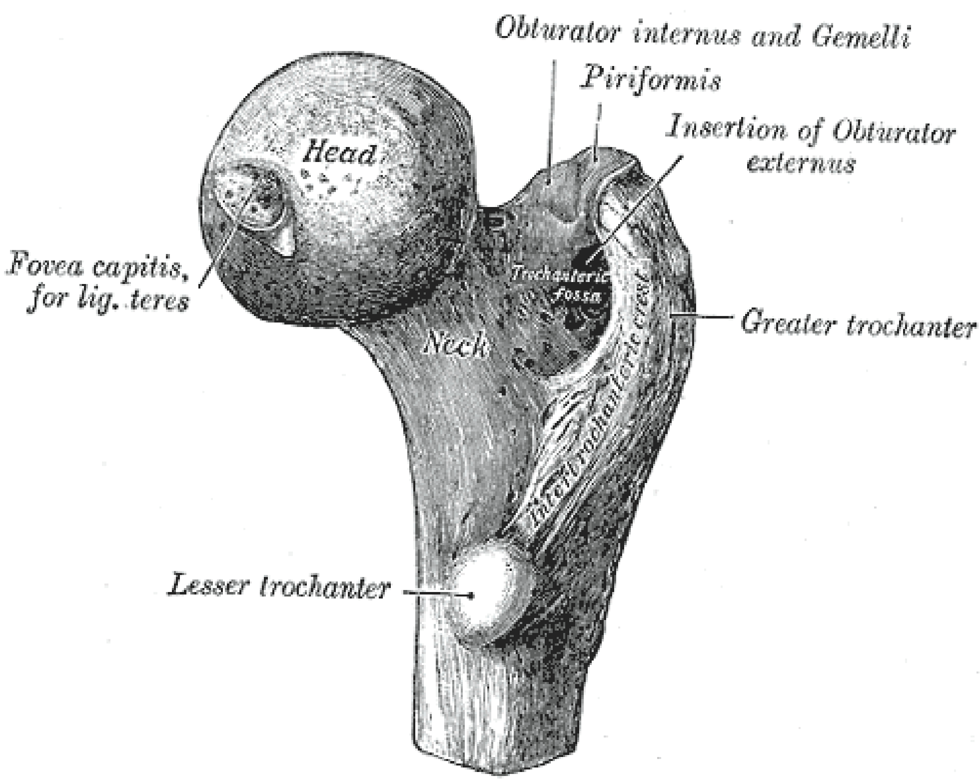


AIM OF THE STUDY

To assess the effectiveness of Intramedullary fixation of unstable peritrochanteric fractures with interlocking proximal femoral nail.

FIG 1

FIG 2


Obturator internus and Gemelli
Piriformis
Insertion of Obturator externus
Head
Fovea capitis, for lig. teres
Trochanteric fossa
Neck
Greater trochanter
Intertrochanteric crest
Lesser trochanter

ANATOMY

The proximal femur

Head

The head of the femur is capped with hyaline cartilage and is more than half a sphere. The medial convexity has a pit, the "Fovea" entered for the ligament of teres. Anteriorly the articular cartilage extends on the neck for weight bearing in the flexed hip. **(Fig – 1**)

Neck

The neck of the femur is an upward extension of shaft strengthened internally by the calcar femorale. The neck joins the greater trochanter in front along a rough ridge, the inter-trochanteric line. The back of the neck joins the greater trochanter at a prominent rounded ridge, the inter-trochanteric crest. The neck of the femur is inclined at an angle with the shaft. This angle is about 160◦ in young children and about 125◦ in adults with an ante version of 15◦ in adults.

Greater trochanter

The GT of the femur is a large, irregular, quadrilateral eminence, situated at the junction of the neck with the upper part of the shaft. It is directed a little lateral and backward and in the adult is about 1cm lower than the head. **(Fig 2)** It has two surfaces (medial & lateral) and four borders (superior, inferior , anterior & posterior).

Lateral surface : serves for the insertion of the tendon of the gluteus medius.

The medial surface : the trochanteric fossa (digital fossa), for the insertion of the tendon of the Obturator externus, and the insertion of the Obturator internus and Gemelli.

The superior border : insertion of the Pyriformis.

The inferior border : gives origin to the upper part of the Vastus lateralis.

The anterior border : at its lateral part insertion to the Gluteus minimus.

The posterior border : bounds the back part of the trochanteric fossa.

Lesser trochanter :

The Lesser Trochanter (small trochanter) of the femur is a conical eminence. From its apex three well-marked borders extend; two

FIG3

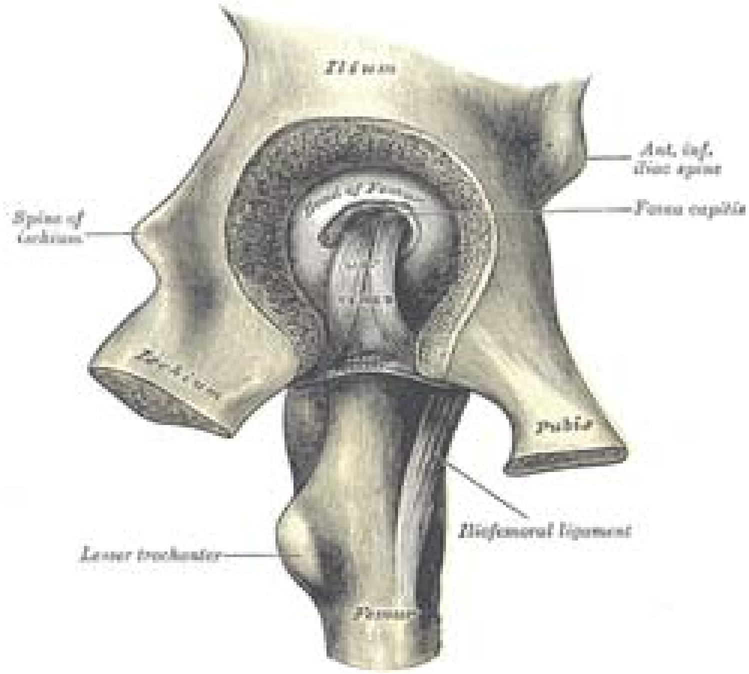

Ilium
Ant. inf. iliac spine
Fossa capitis
Spine of ischium
Ischium
pubis
Iliofemoral ligament
Lesser trochanter
Femur

FIG 4


1
2
3
4
5
6
7
8
9

of these are above—a medial continuous with the lower border of the neck, a lateral with the intertrochanteric crest; the inferior border is continuous with the middle division of the linea aspera **(Fig 3).** The summit of the trochanter is rough, and gives insertion to the tendon of the Psoas major.

Proximal Shaft (Fig 4)

1. Trochanteric fossa
2. Greater trochanter
3. Quadrate tubercle
4. Inter – trochanteric crest
5. Gluteal tuberosity
6. Linea aspera
7. Fovea for ligamentum teres attachment
8. Lesser trochanter
9. Spiral line

APPLIED ANATOMY

Proximal femur

The form of the femur is relatively complex, with bows and twists that distort its basically tubular structure. The anterior bow of the midportion of the femur is well recognized and has even been built into some current prostheses. This is commonly envisioned as an anterior bow because of the position that the separate femur assumes when it is placed on a horizontal surface, resting on the posterior margin of the trochanter and the posterior aspects of the condyle **(Fig 5)**.

However, in vivo the orientation is somewhat different. In the erect position, the central portion of the femur is more in the coronal plane of the body, with the distal portion inclined posteriorly to the knee and the proximal portion inclined anteriorly to the acetabulum **(Fig 6).**

The posterior bow of the proximal femur is just as constant as the midportion anterior bow. The central portion of the proximal posterior bow is opposite the level of the lesser trochanter. This bow is constant.

FIG 5

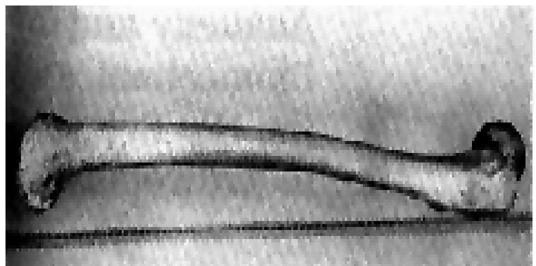


FIG 6

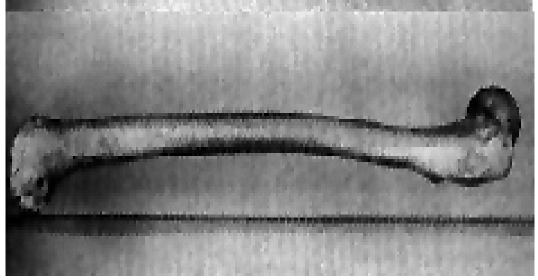
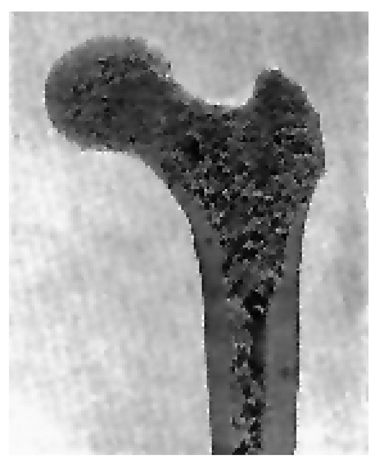


FIG 7

FIG8



The Neck-Shaft Angle

The head of the femur considerably overhangs the femoral shaft. This occurs because the neck makes an oblique angle with the shaft of an average of 135°. Although there is considerable variability in both the neck-shaft angle and neck length, in general the center of the femoral head is extended medially and proximally by the femoral neck so that the center of the femoral head is at the level of the tip of the trochanter. The effect of the overhanging head and neck is to lateralize the abductors, which attach to the greater trochanter, from the center of rotation (center of the femoral head). This increases the torque generated by the abductors and reduces the overall force necessary to balance the pelvis during single leg stance. Reducing this level arm (coxa valga) increases total load across the hip, and coxa vara reduces it to the extent it increases the lever arm. (Coxa vara with a short neck would have a negative affect.)

Femoral Anteversion

The coronal plane of the femur is generally referenced to the posterior distal femoral condyles. When oriented in this plane, it can be seen that the proximal femur, including the femoral head and neck, are rotated anteriorly. This is commonly referred to as femoral head-neck ante version 10 to 15 ◦ **(Fig 7)**.

Distribution of Cancellous Bone in the Proximal Femur

A critical look at a good quality anteroposterior (A-P) x-ray of the femur gives a good idea of the distribution of cancellous bone in the femur. It appears to be a characteristic of the articulating ends of long bones that the broad ends, covered with articular cartilage, are supported principally by cancellous bone and a very rudimentary cortex in the form of a subchondral plate. The forces applied to the articular surfaces are carried by the cancellous bone out to the cortex. It does not appear to be a coincidence that where the cortex reaches its full thickness, the cancellous bone essentially stops.

The distribution of cancellous bone that is suggested in the x-ray is vividly illustrated in the coronal cut through a desiccated femur **(Fig 8).**

Trabecular pattern: The upper end of femur consists of five trabecular groups, they are **(Fig 9 & 10).**

A. **Principal Compressive Group** – It is the upward projection of the calcar femorale to the weight bearing superior dome of head of femur.

B. **Principal Tensile Group** -It is also called the arcuate bundle of Gallois and Bosquette. It starts in the inferior region of head,

FIG 9

FIG 10

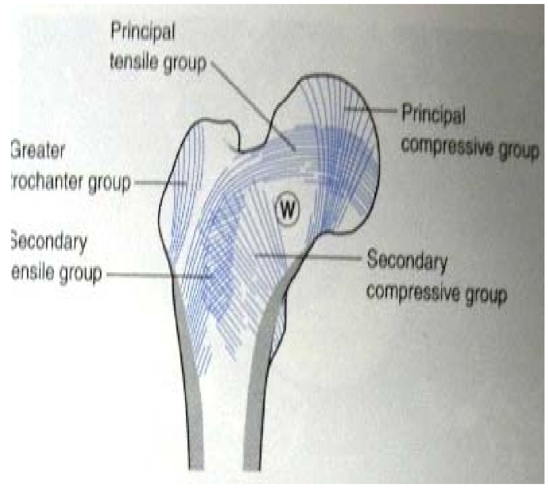
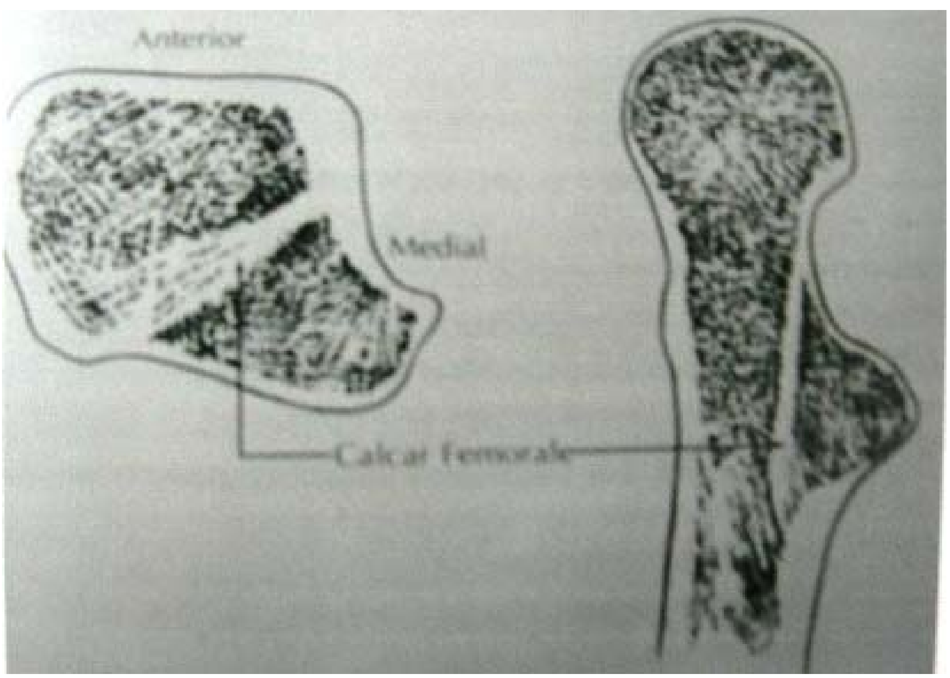


FIG 11



arches across the superior region and terminates in the lateral cortex.

C. **Greater Trochanter Group** – Seen in the region of greater trochanter.

D. **Secondary Compressive Group** – Seen between the two primary groups.

E. **Secondary Tensile Group** – Also seen between the two primary groups.

The primary compression and primary tensile trabeculae enable the proximal femur to withstand considerable tensile and compressive forces to which it is normally subjected. In the greater trochanter a gothic arch is formed by the intersection of arcuate bundle and trochanteric bundle. Head and neck also contains gothic arch by the intersection of arcuate bundle and supporting bundle. At the point of intersection the bone is denser and constitutes the nucleus of the head.

There are two areas of paucity of trabeculae - the Babcock triangle situated in the inferior aspect of the head , the ward's triangle situated lateral to primary compression trabeculae and below tension trabeculae in the middle part of the neck. They play a prominent role in the causation of femoral neck fractures in the elderly. They offer less rigid fixation to any implant in this area. It also offers little resistance to shearing forces in fracture neck of femur even after fixation of the fracture.

Calcar femorale:

It is a dense vertical plate of bone extending from the postero medial portion of the femoral shaft under the lesser trochanter and radiating later to the greater trochanter reinforcing the femoral neck postero-inferiorly. It is thickest medially and gradually thins as it passes laterally **(Fig 11).**

Singh's index for osteoporosis:

Grades osteopenia based on the reduction in trochanteric, tensile and ultimately primary compressive trabeculae. The grade is determined from the AP projection of an intact proximal femur **(Fig – 12).**

Normal – (grade 6 : all trabecular groups are visible) to

Definite - (grade 3 : thinned trabeculae with a break in the principal tensile group) to

Severe – (grade 1 : only the primary compressive trabeculae are visible and they are reduced)

FIG 12

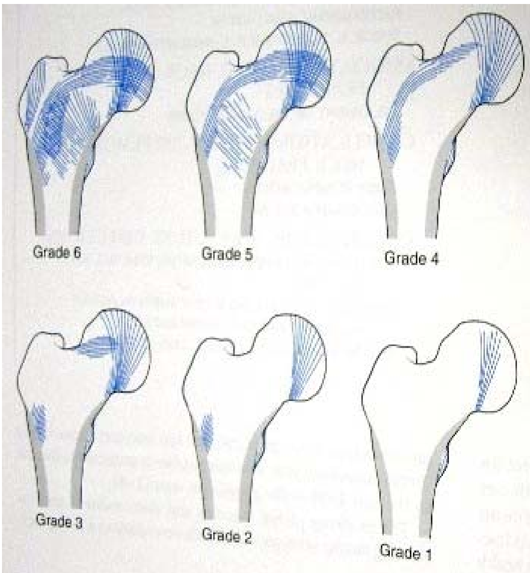


FIG 5

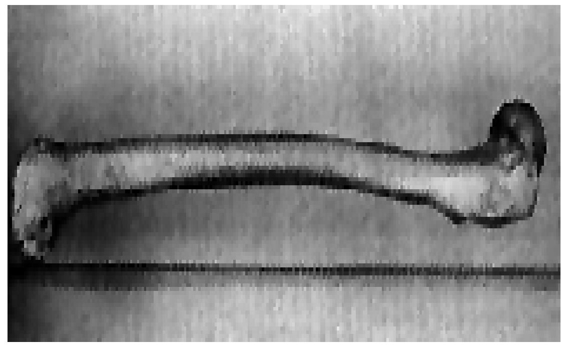


FIG 12 a

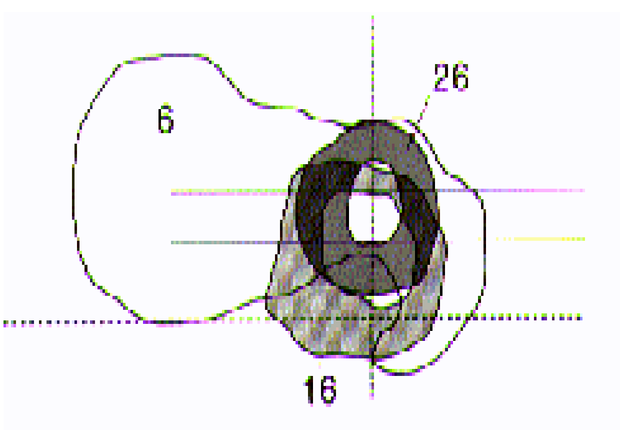
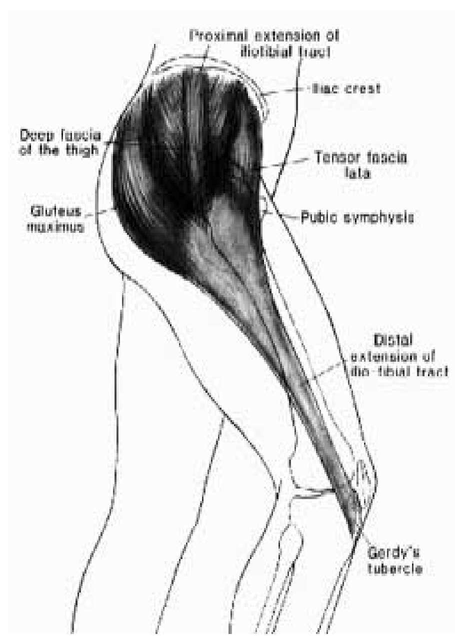


FIG 12 b



Cross – sectional analysis:

On the lateral view, the posterior bow of the proximal femur can be seen with its apex opposite the lesser trochanter **(Fig-5).** The three aspects of the anatomy of the femur that limit the access of stems that are straight in the lateral plane are the posterior margin of the femoral neck, the anterior margin of the cortex opposite the lesser trochanter, which represents the apex of the posterior bow of the femur, and the posterior cortex of the shaft where the bow of the femur is reversing into an anterior bow**.** The straight stem would bind proximally at the posterior margin of the neck, in the mid-portion at the anterior cortex, and distally at the posterior cortex. A larger stem prosthesis would have the tendency to blow out the posterior neck as the stem follows the anterior bow of the midfemur or to punch through the posterior cortex 5-6 inches down the shaft. **(Fig 12 a)**

Anatomy of soft tissues around hip:

The first structure encountered after the incision of the skin is the fascia lata with its muscular inputs from the tensor fascia lata and the gluteus maximus **(Fig 12b)**. Kapandji has referred to this as the deltoid of the hip.

Fig 12 c

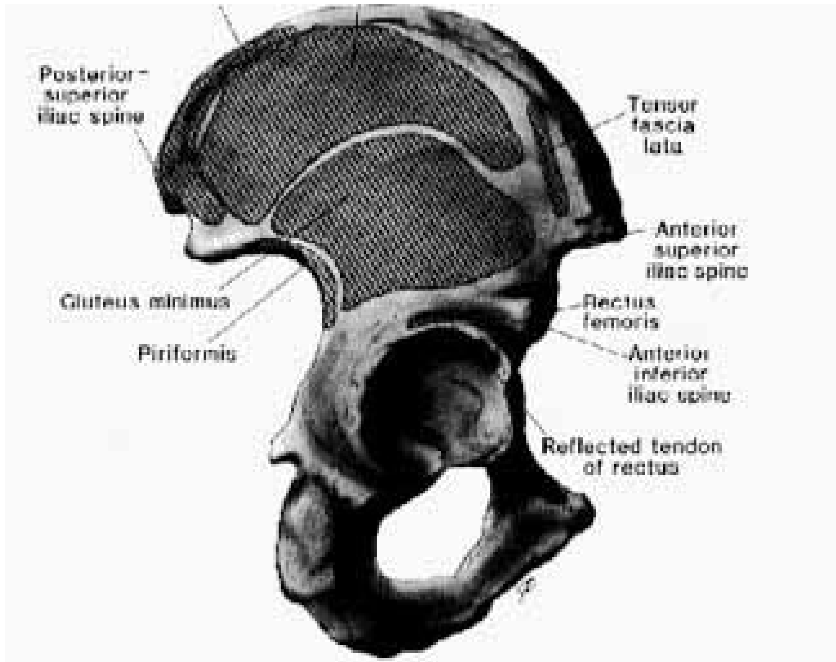
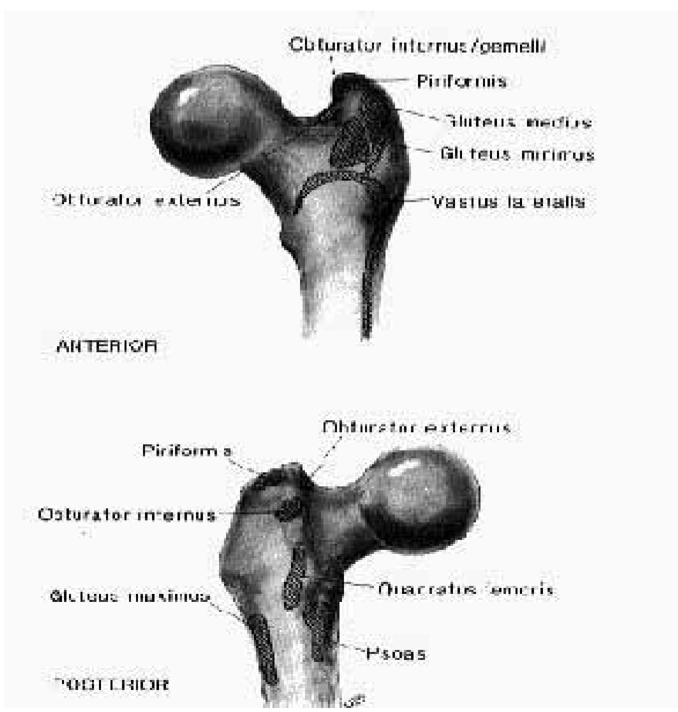


FIG 12 d



The tensor fascia lata functions as a flexor and abductor of the hip. In combination with the gluteus maximus, the tensor serves to tense the iliotibial tract, which itself functions as a tension band in offsetting the bending forces that are applied to the femoral head. The tensor fascia lata is innervated by a branch of the superior gluteal nerve coming out from underneath the gluteus medius. Muscles origin and insertion around the hip joint is shown in **(Fig – 12 c and 12 d)**

Extensors: The gluteus maximus is the largest and strongest muscle of the body. From its origin on the posterior third of the iliac crest and the dorsum of the sacrum and coccyx, it runs obliquely, inferiorly, anteriorly to insert into the fascia lata and also into the posterolateral margin of the femur just below the level opposite the lesser trochanter. The superior fibers of the gluteus maximus function as abductors and contribute to the tension in the iliotibial tract. The main body of the gluteus maximus, however, functions as a hip extensor. The innervation of the gluteus maximus is from the inferior gluteal nerve, which leaves the pelvis through the greater sciatic notch below the pyriformis. Other extensors are the semimembranosus, semitendinosus and biceps femoris are located in the posterior aspect which also flexes the knee.

Abductors: The next structures encountered are the abductors **(Fig 12e and 12 f).** The most important of these is the gluteus medius,

FIG 12 e

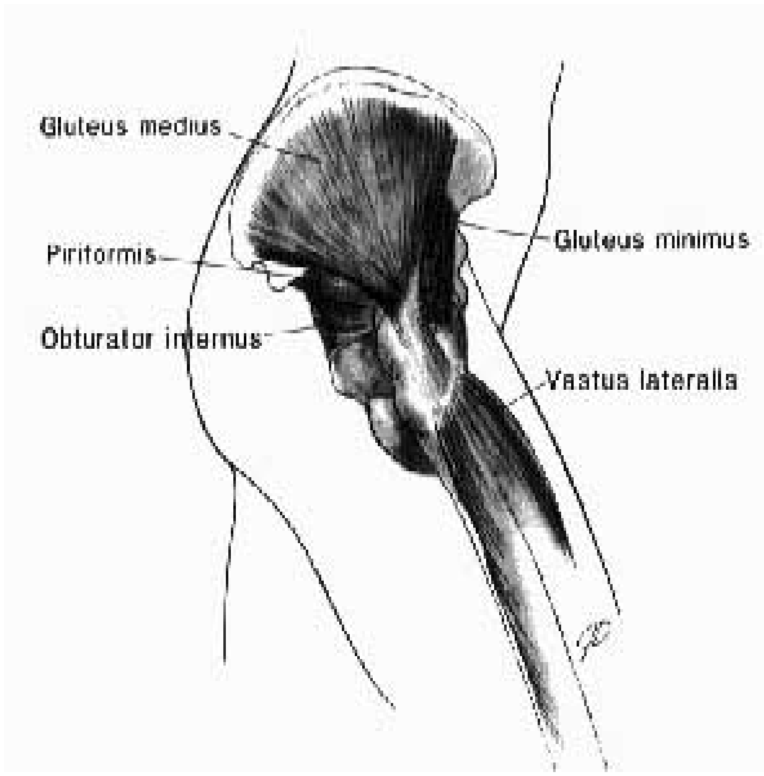
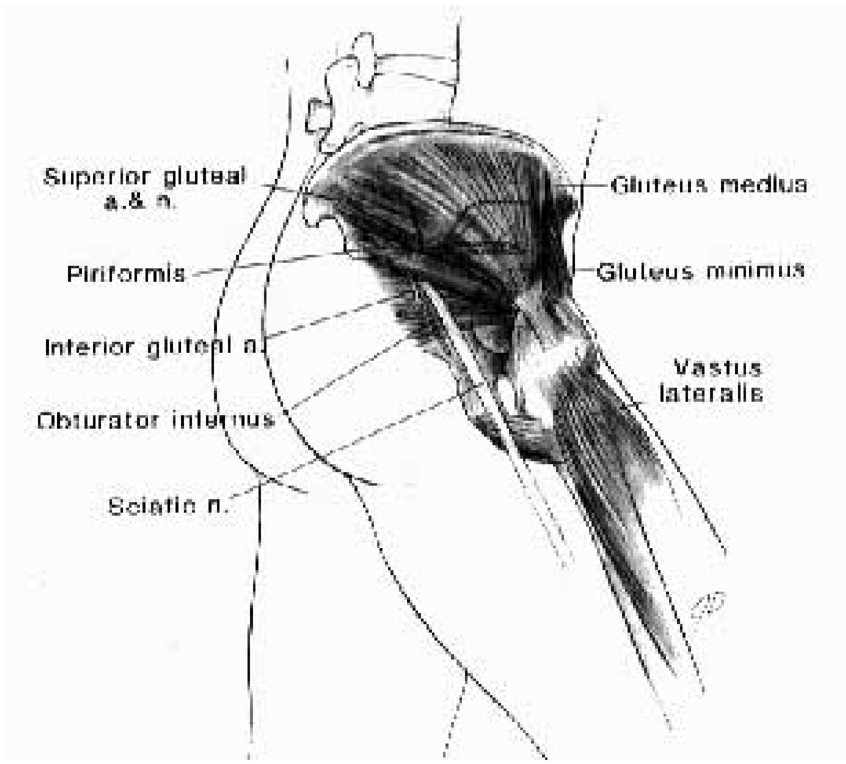


FIG 12 f



Superior gluteal a.& n.
Piriformis
Interior gluteal n.
Obturator internus
Sciatic n.
Gluteus medius
Gluteus minimus
Vastus lateralis

which originates from the wing of the ilium just below the crest. The origin for the gluteus medius extends across the whole breadth of the wing of the ilium, and the broad fan-shaped muscle narrows to a distal insertion on the lateral and anterior surfaces on the greater trochanter. The posterior margin of the gluteus medius is well defined by a thick tendon, which inserts into the tip of the trochanter just anterior to the pyriformis tendon insertion.

The gluteus medius is innervated by branches from the superior gluteal nerve. The next strongest abductor is the gluteus minimus, which originates from the wing of the ilium just beneath the gluteus medius. It, too, extends the full width of the wing of the ilium, in this case just anterior to the greater sciatic notch to the level of the bridge between the anterior-superior and anterior-inferior iliac spines. From this broad origin, it narrows sharply to insert onto the anterior-superior greater trochanter, deep and anterior to the insertion of the gluteus medius tendon.

External rotators: The flat muscle belly of the pyriformis lies almost parallel to the posterior margin of the gluteus medius. It arises from the lateral margin of the anterior surface of the sacrum and the margin of the greater sciatic foramen, passing out of the pelvis through the greater sciatic foramen to insert into the tip of the greater trochanter. It is frequently blended at its insertion with the common tendon of the obturator internus and gemelli. The sciatic nerve passes deep to the pyriformis. The pyriformis, in addition to being an abductor, it is also an external rotator. The obturator internus and gemelli form a common insertion just inside the tip of the trochanter and deep to the pyriformis tendon. The obturator internus originates from the inside of the obturator foramen, passing out of the pelvis through the lesser sciatic foramen and then passing horizontally across the posterior capsule of the hip, where it receives the attachments of the gemelli and is inserted into the aforementioned spot on the trochanter. Its innervation comes from a special nerve from the sacral plexus within the pelvis **(Fig 12 g).**

The obturator externus covers the outer surface of the anterior wall of the pelvis, arising from the margin of the medial side of the obturator foramen. The fibers end in a tendon that runs across the back of the neck of the femur and inserts into the trochanteric fossa. It is innervated from a branch of the obturator nerve. The last of the important short external rotators is the quadratus femoris, which arises from the upper part of the external border of the tuberosity of the ilium and inserts into the upper part of the linea quadrata extending downward from the intertrochanteric crest. Superior to the quadratus femoris is the gemellus inferior, and inferior to it is the adductor magnus. It is innervated from a branch from the sacral

FIG 12 g

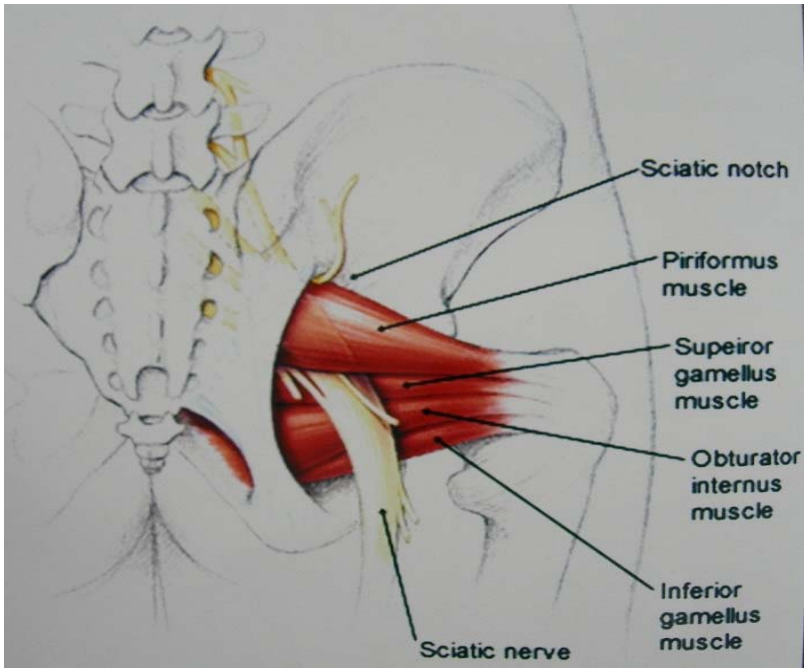


FIG 13

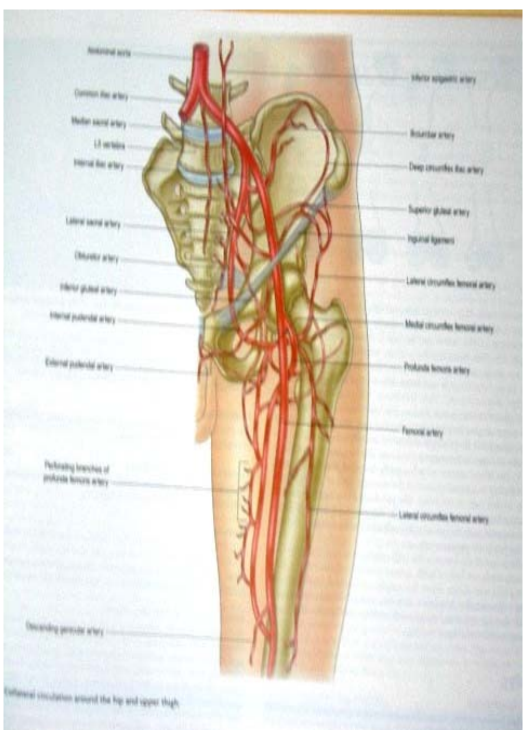
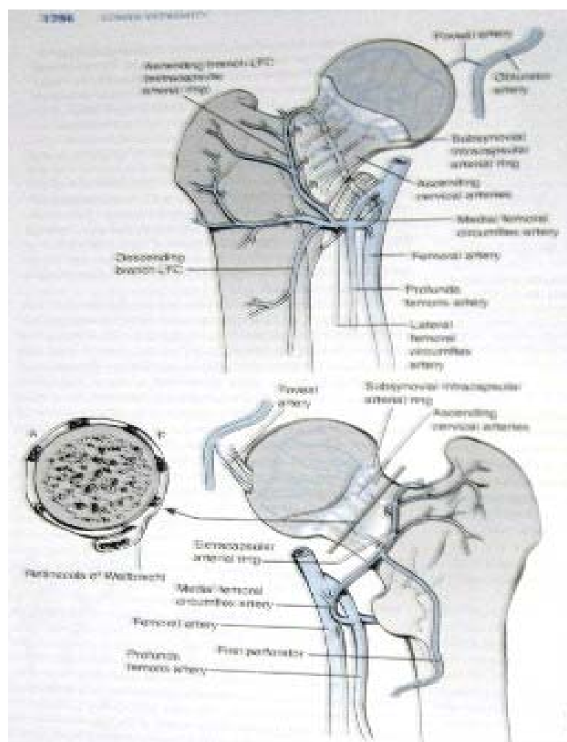


FIG 14



plexus. The quadratus femoris marks the inferior margin of the muscle release necessary for exposure of the hip through the posterior approach. The sciatic nerve lies deep to the pyriformis muscle but superficial to the rest of the external rotators.

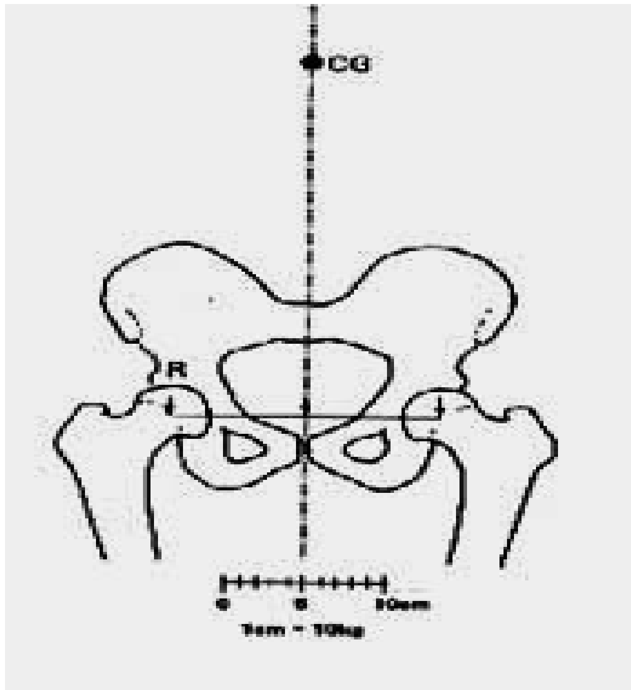
Flexors : The psoas tendon inserts into the lesser trochanter of the femur. The muscle fibers of the iliacus extend distal to the lesser trochanter to insert onto the body of the femur in front of and below the lesser trochanter. There is usually an indentation in the anterior lip of the acetabulum where the psoas crosses it. The psoas serves to reinforce the Y ligament of Bigelow as the hip is extended. The other flexors located in the anterior aspect of the thigh are sartorius, pectineus and rectus femoris ,the adductor muscles (longus, brevis & magnus) and gracilis are located in the medial aspect of thigh.

Vessels about the Hip

The common iliac artery and vein lie on the anterior surface of the wing of the ilium and cross the superior pubic ramus and pass medial to the femoral head. The medial femoral circumflex artery arises from the medial aspect of the profundus and passes between the pectineus and the psoas major. The acetabular branch from the medial femoral circumflex enters the hip joint beneath the transverse ligament and supplies blood to the fat in the bottom of the acetabular fossa. **(Fig 13 and 14).**

The lateral circumflex artery arises from the lateral side of the profunda and passes behind the rectus femoris, dividing into anterior, transverse, and descending branches. The terminal divisions of the transverse branch wind around the femur just below the greater trochanter and may be encountered when splitting the vastus lateralis fibers in carrying out the direct lateral approach. The superior gluteal artery passes out of the greater sciatic notch above the pyriformis in the company of the superior gluteal nerve and passes between the medius and minimus. The inferior gluteal artery comes out below the pyriformis and has arterial branches that overlie the short rotators.

FIG 15



BIOMECHANICS

The forces exerted on the hip have their biological expression in the form of the femur and acetabulum, particularly in the location and orientation of the trabecular pattern. When the weight of the body is being borne on both legs, the center of gravity is centered between the two hips and its force is exerted equally on both hips **(Fig 15).**

Under these loading conditions, the weight of the body minus the weight of both legs is supported equally on the femoral heads, and the resultant vectors are vertical. When the hips are viewed in the sagittal plane and if the center of gravity is directly over the centers of the femoral heads, no muscular forces are required to maintain the equilibrium position, although minimal muscle forces will be necessary to maintain balance. If the upper body is leaned slightly posteriorly so that the center of gravity comes to lie posterior to the centers of the femoral heads, the anterior hip capsule will become tight, so that stability will be produced by the Y ligament of Bigelow. Therefore, in symmetrical standing on both lower extremities, the compressive forces acting on each femoral head represent approximately one-third of body weight. In a single leg stance, the effective center of gravity moves distally and away from the supporting leg since the nonsupporting leg is now calculated as part of the body mass acting upon the weight-

FIG 16

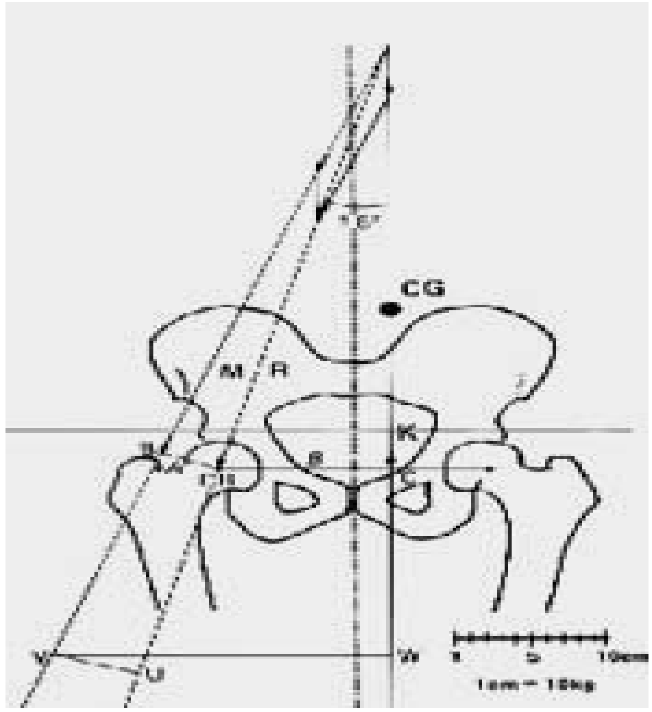


Fig 17

bearing hip. Since the pillar of support is eccentric to the line of action of the center of gravity, body weight will exert a turning motion around the center of the femoral head. This turning motion must be offset by the combined abductor forces inserted into the lateral femur. In the erect position, this muscle group includes the upper fibers of the gluteus maximus, the tensor fascia lata, the gluteus medius and minimus, and the pyriformis and obturator internus. The combined resultant vector of the abductor group can be represented by the line of action M **(Fig 16).** Since the effective lever arm of this resultant force (BO) is considerably shorter than the effective lever arm of body weight acting through the center of gravity (OC), the combined force of the abductors must be a multiple of body weight. The vectors of force K and force M produces a resultant compressive load on the femoral head that is oriented approximately 16° obliquely, laterally, and distally.

The orientation of this resultant vector is exactly parallel to the orientation of the trabecular pattern in the femoral head and neck **(Fig 17).** The effect of this combined loading of body weight and the abductor muscle response required for equilibrium results in the loading of the femoral head to approximately 4 times body weight during the single leg stance phase of gait. This means that in normal walking the hip is subjected to wide swings of compressive loading from one-third of body weight in the double support phase of gait to 4 times body weight during the single leg support phase. The factors influencing both the magnitude and the direction of the compressive forces acting on the femoral head are 1) the position of the center of gravity; 2) the abductor lever arm, which is a function of the neck-shaft angle; and 3) the magnitude of body weight. Shortening of the abductor lever arm through coxa valga or excessive femoral ante version will result in increased abductor demand and therefore increased joint loading.

If the lever arm is so shortened that the muscles are overpowered, then either a gluteus minus lurch (the center of gravity is brought laterally over the supporting hip) or a pelvic tilt (Trendelenburg gait) will occur. Since the loading of the hip in the single leg stance phase of gait is a multiple of body weight, increases in body weight will have a particularly deleterious effect on the total compressive forces applied to the joint. The effective loading of the joint can be significantly reduced by bringing the center of gravity closer to the center of the femoral head **(Fig 18).** Sideways limping however, requires acceleration of the body mass laterally, its deceleration during the stance phase of gait, and then its acceleration back to the midline or even to the other side as the single leg stance phase changes to the opposite extremity. This requires considerable energy consumption and is a much less efficient means of ambulation than the normal situation

Fig 18

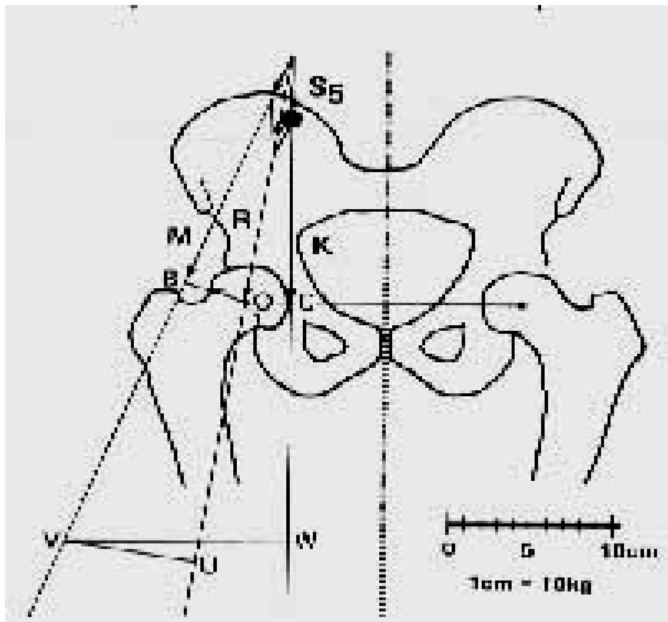
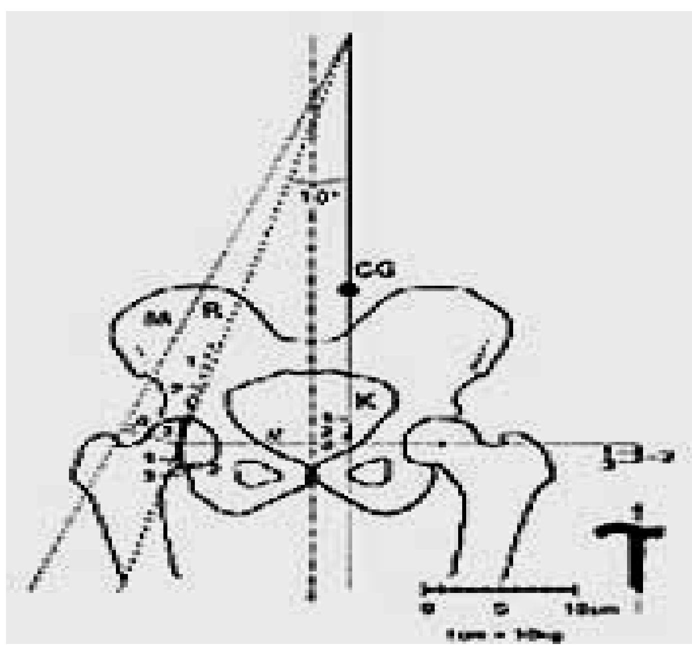


FIG 19



in which the hip is subjected to these considerable forces. Another effect of sideways limping is that the resultant vector becomes more vertical because the center of gravity is acting in a more vertical direction, and therefore the bending moment the femoral neck is increased.

Another mechanism for reducing the resultant load on the femoral head is the use of a walking stick in the opposite hand. Since some of its force is transferred to the walking stick through the hand, the effective load of body weight is thus reduced in two ways: 1) the effective load of body weight is reduced; 2) since the turning moment around the femoral head is reduced, the abductor demand is also reduced **(Fig 19).**

Pauwels has calculated both the total compressive load on the femoral head and the angle of inclination of the vertical compressive loads for different forces applied to the walking stick. It can be that only 9 kg of force applied to a cane in the opposite hand reduces the load on the femoral head by nearly 40%. The same effect could also be achieved by a 40% reduction in body weight. Also the angle of inclination with this degree of unloading is not significantly different from normal, so that using a stick to unload the femoral head produces lower bending forces around the femoral neck than sideways limping. Therefore, in the rehabilitation of patients after hip surgeries the use of a stick to prevent sideways limping is always preferable. The form of the femur and the orientation of the trabecular pattern in the proximal femoral metaphysis and epiphysis would support the conclusion that the principal loading of the femoral head is in the coronal plane. When an individual rises from the seated position or climbs stairs, the forces of body weight are applied to the anterior surface of the femoral head. The femur itself is prevented from rotating in response to this applied load by the stabilization of the posterior femoral condyles against the tibial plateaus. In addition the psoas tendon inserting into the lesser trochanter prevents this applied load from rotating the femur internally. This anteriorly applied force therefore produces a twisting strain on the proximal femur. This aspect of loading of the proximal femur takes on particular importance for femoral stem design since anteriorly applied loads will produce a twisting strain on the stem within the medullary canal. Vertical loading of the femoral component will produce compressive load on the medial side of the femoral stem and tension loads on the lateral side of the stem, whereas anterior loading will produce shear stresses.

MECHANISM OF INJURY

Peritrochanteric fractures in young adults are the results of high energy trauma like road traffic accidents or fall from height and account for only 10%.   In contrast 90% of fractures occurring in elderly are due to a simple fall. The tendency to fall increases with age and is exacerbated by several factors like poor vision, decreased blood pressure, poor reflexes, decreased muscle power, vascular disease and co-existing musculo skeletal pathology .

Cummins and Nevitt identified four factors they determined whether a particular fall results in a fracture of the hip.

1. The fall must be oriented so that the person lands on or near the hip.
2. Inadequate protective reflexes that do not reduce the energy of fall below a certain critical threshold.
3. Deficient local shock absorbers (muscle and fat around the hip)
4. Insufficient bone strength at the hip.

FIG 20

FIG 21

SIGNS AND SYMPTOMS

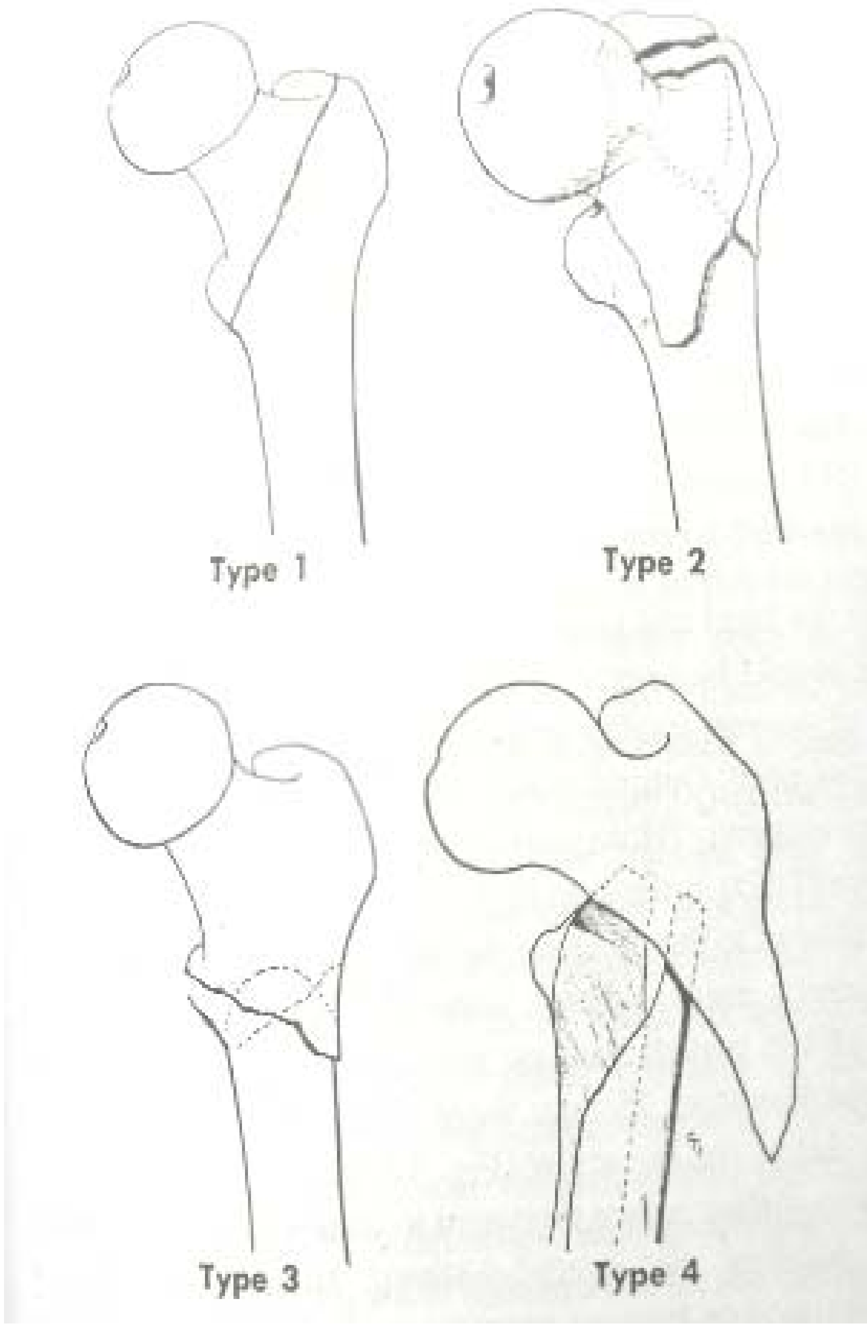
Fractures may be undisplaced or impacted and, such patients may present with minimal pain at the hip or may present with thigh pain. They may be ambulant, were as patients with displaced fractures are clearly symptomatic and usually cannot stand, much less ambulant. Patients with undisplaced fracture may present with virtual absence of clinical deformity, where as those with displaced fractures exhibit the classic presentation of shortened and externally rotated extremity. There may be tenderness to palpation in the area of the greater trochanter. Ecchymosis may be present and should be noted.

RADIOGRAPHIC AND OTHER IMAGING STUDIES

Standard radiographic examination includes AP of the pelvis and an AP and cross table Lateral view of the proximal femur. The lateral radiograph can help to assess the posterior comminution of the proximal femur. An internal rotation view of the injured hip may be helpful to identify non displaced fractures. Internally rotating the involved femur 10 to 15° offsets the ante version of the femoral neck and provides a true AP of the proximal femur. A second AP of the contra lateral side can be used for pre operative planning.

When hip fracture is suspected but not apparent on standard radiographs a technetium bone scan or a MRI scan should be obtained **(Fig 20 & 21).** Two or three days may be required before a bone scan becomes positive, but MRI can reveal occult fractures within 24 hours of injury.3d CT scans can be useful to determine the extent and severity of comminution so that pre-operative planning and implant selection can be decided.

Fig 22



CLASSIFICATION

The commonly used classification is the Boyd & Griffin classification.

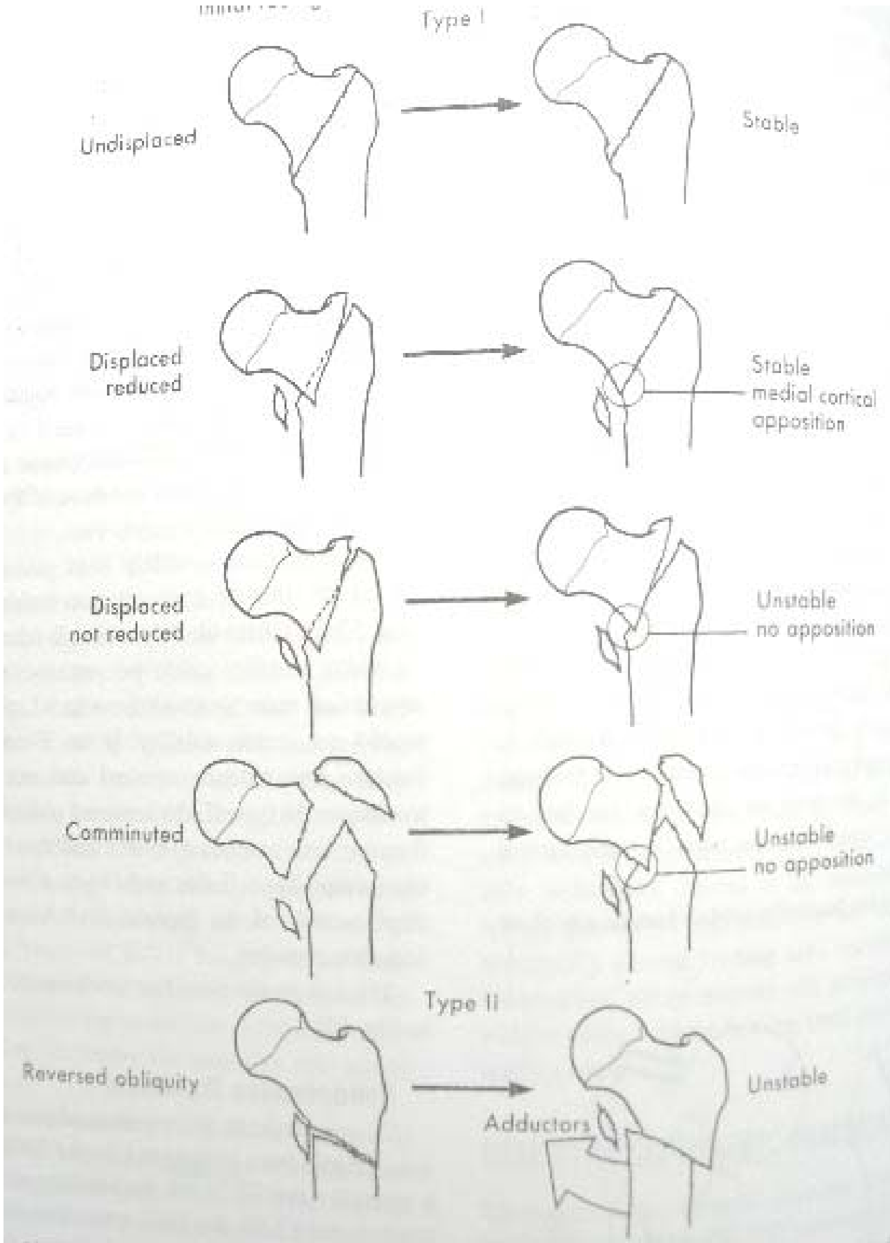
Boyd & Griffin classification (1949) included all fractures from the extra capsular part of neck to a point 5cm distal to the lesser trochanter **(Fig 22).**

Type I: Fractures that extend along the intertrochanteric line from the greater to the lesser trochanter .reduction is usually simple and maintained with little difficulty. Results are generally satisfactory.

Type II: Comminuted fractures, the main fracture being along the intertrochanteric line but with multiple fractures in the cortex. Reduction of these fractures are more difficult because the comminution can vary from slight to extreme. A particularly deceptive form of the fracture is one where in there is an antero – posterior linear intertrochanteric fracture occurs a s in type I but with an additional fracture in the coronal plane.

Type III: Fractures that are basically sub trochanteric with at least one fracture passing across the proximal end of the shaft just distal to or at the lesser trochanter. Varying degrees of comminution are associated. These fractures are usually more difficult to reduce and

FIG 23



result in more complications, both during operation and during convalescence.

Type IV: Fractures of the trochanteric region and the proximal shaft, with fracture in at least two planes, one of which is the sagittal plane and may be difficult to see in the routine AP radiograph. If open reduction & internal fixation are used two plane fixation is required because of the spiral, oblique or butterfly fracture of the shaft.

Evans classification (1949)

Evans devised a widely used classification system based on the division of fractures into stable and unstable groups. He divided the unstable fractures further into those in which stability could be restored by anatomical or near anatomical reduction and those in which anatomical reduction would not create stability **(Fig 23).**

Type I: Fracture line extends upwards and outwards from the lesser trochanter.

Type II: Reverse obliquity fracture – the major fracture line extends outward and downward from the lesser trochanter. These fractures have a tendency towards medial displacement of the femoral shaft because of the pull of adductor muscles.

Fig 24

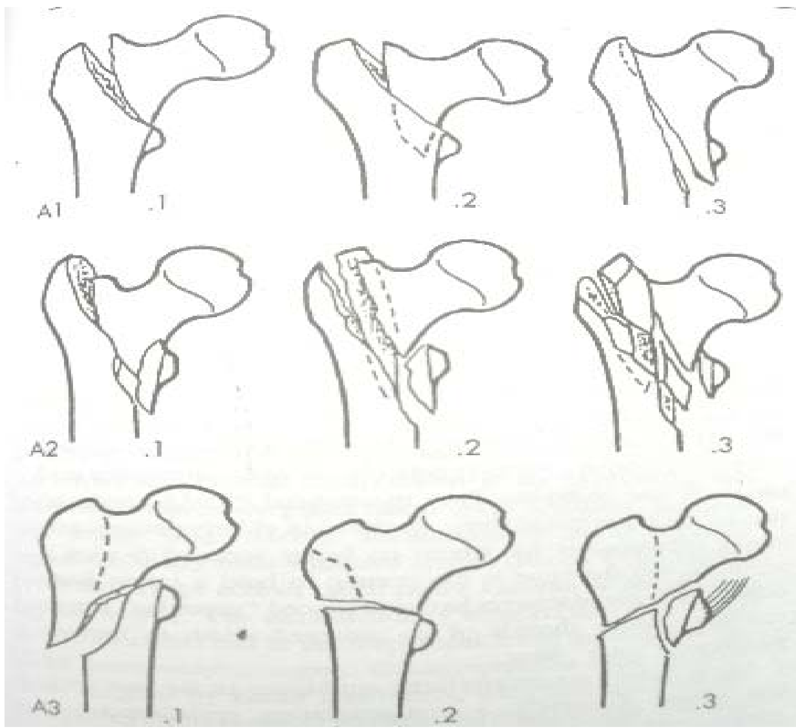
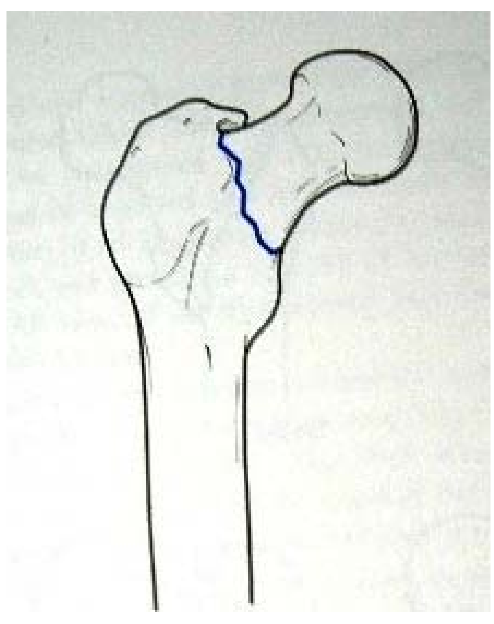


Fig 25



OTA classification

In orthopedic trauma association alpha – numeric fracture classification intertrochanteric fractures are typed 31A **(Fig 24).**

Group I: Simple two part fractures.

Group II: Comminuted fractures with a postero medial fragment, the lateral cortex of the Greater trochanter however remains intact.

Group III: Fractures in which the fracture line extends across both the medial & lateral cortices. This group includes the reverse obliquity pattern.

Unusual Fracture Patterns

Basicervical neck fractures are located just proximal to or along the inter trochanteric line. Though Basicervical fractures are considered extra capsular this may not always be the case. Basicervical fractures are thus at greater risk of osteonecrosis than the more distal intertrochanteric fractures. Further more Basicervical fractures lack the cancellous inter digitations seen with fractures through the intertrochanteric region and are more likely to sustain rotation of the femoral head during implant insertion **(Fig 25).**

The intertrochanteric region of the hip consisting of the area between the greater and lesser trochanters representing a zone of transition from femoral neck to the femoral shaft. The greater and lesser trochanters are the sites of insertion of the major muscles of the gluteal region, the short external rotators, the abductors and the iliopsoas. The calcar femorale extending from the posteromedial aspect of the femoral shaft to the posterior part of the femoral neck forms an internal trabecular strut within the inferior portion of the femoral neck and the intertrochanteric region and act as a strong conduit for stress transfer.

HISTORICAL REVIEW

1564 - Ambrose Pare′ initially described fractures of the proximal femur.

1882 - Sir Jacob Astley Cooper was the first to distinguish between intra and extra capsular fractures. In those times therapeutic options were few and patients were treated with bed rest.

19th century – Concept of traction was introduced with the goal of minimizing limb. Shortening and deformity from the middle of this century. But prolonged bed rest in traction until fracture healing occurred (usually 10 to 12 weeks) followed by a lengthy programme of ambulation training was associated with high complication rates especially with elderly like decubitus ulcers, UTI, joint contractures, pneumonia and thrombo embolic complications resulting in high mortality rate. In addition fracture healing was generally accompanied by varus deformity and shortening because of inability of traction to effectively counteract the deforming muscular forces.

1960's – Operative management consisting of fracture reduction and stabilization which permits early patient mobilization and minimizes many of the complications of prolonged bed rest became the treatment of choice.

Non-operative management: Nevertheless there remain situation where surgery cannot be performed like

1. An elderly person whose medical condition carries an excessively high risk of mortality from anesthesia and surgery

2. Non ambulatory patient who has minimal discomfort following fracture

Non-operative protocols took one of two different approaches:

- **a.** Early mobilization within the limits of patients discomfort and acceptance of deformity. Patient was allowed out of bed and in a chair within a few days of injury but ambulation was delayed.
- **b.** Attempt to establish and maintain a reasonable reduction via skeletal traction until fracture union occurred.

When non operative management is required in elderly the first approach is better because it avoids complications of prolonged bed rest, which is important than attempting often unsuccessful task of maintaining a reduction in traction like in the second approach.

Fig 26

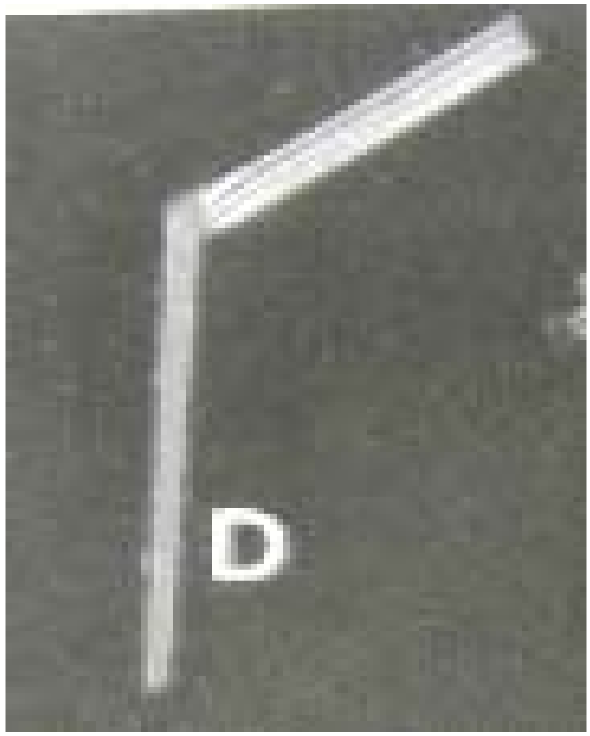
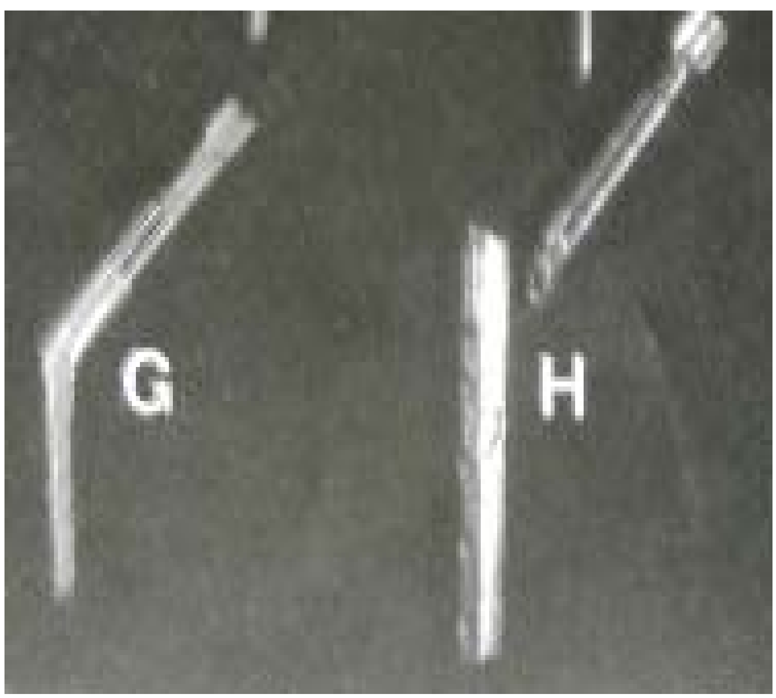


FIG 27



Operative management - The first successful implants were

Fixed - angle nail plate devices :

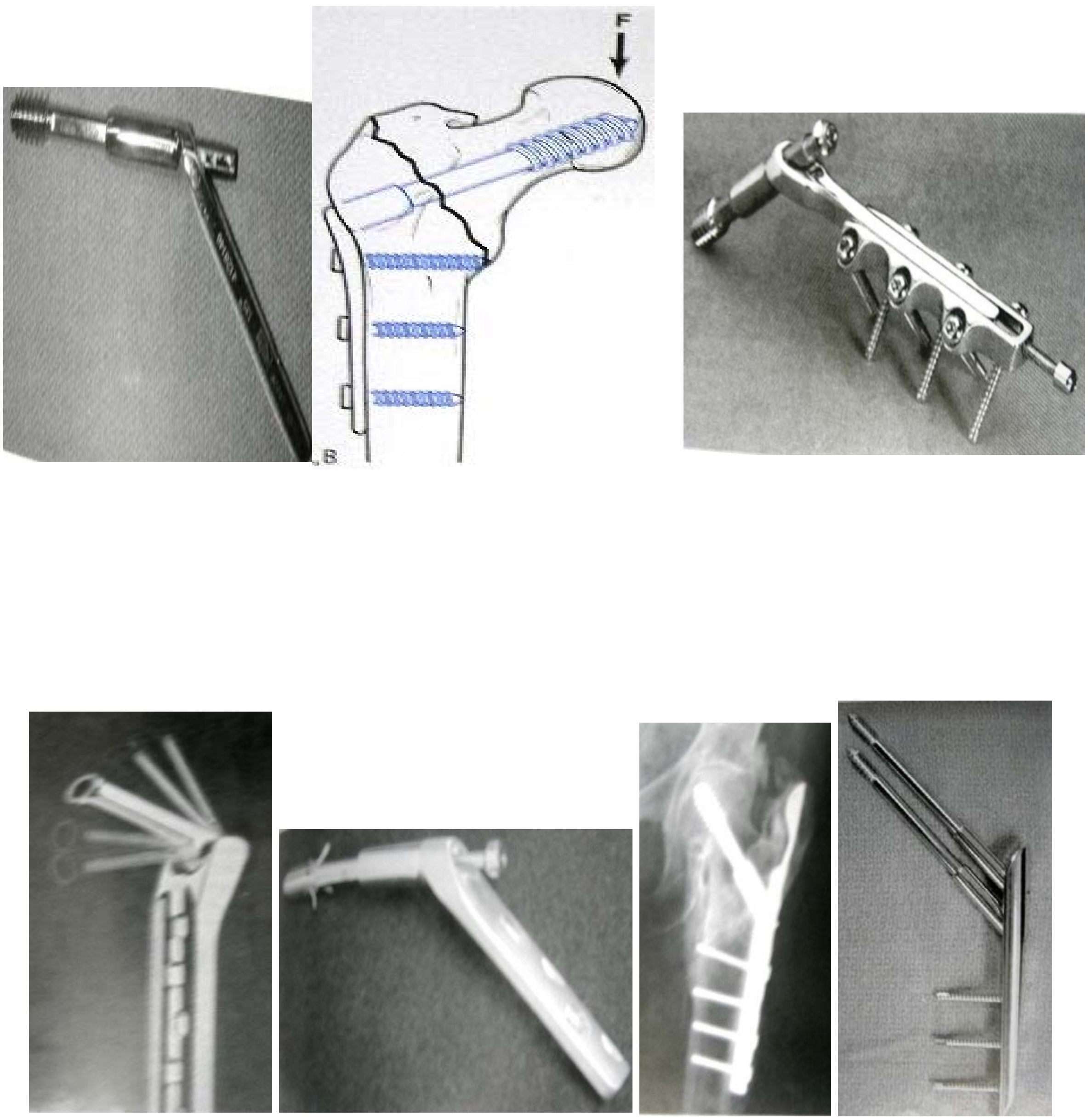
Jewett nail, Holt nail consisting of a tri-flanged nail fixed to a plate at an angle of 130 to 150◦ **(Fig 26).**

While these devices provided stabilization of femoral head and neck fragment to the femoral shaft, they did not provide controlled fracture impaction. If significant impaction of the fracture site occurred the implant would either penetrate into the hip joint or cutout through the superior portion of the femoral portion and neck. On the other hand if no impaction occurred lack of bony contact would result in either plate breakage or separation of the plate and screws from the femoral shaft. These complications occurred more frequently in cases of unstable fractures. So experiences with these indicated the need for a device that allows controlled fracture impaction. This gave rise to,

Sliding – nail plate devices:

Massie nail ,Ken-Pugh nail (Fig 27) consisting of a nail that provided proximal fragment fixation and a side plate that allowed the nail to **"telescope"** within a barrel allowing bone on bone contact which promoted fracture union and decrease the stresses on implant, thereby lowering the risk of implant failure.

FIG 28



Kyle et al reported a lower incidence of nail breakage and fewer cases of nail penetration with a Massie sliding nail than with a fixed – angle Jewett nail for the treatment of unstable trochanteric fractures.

Sliding hip screw devices:

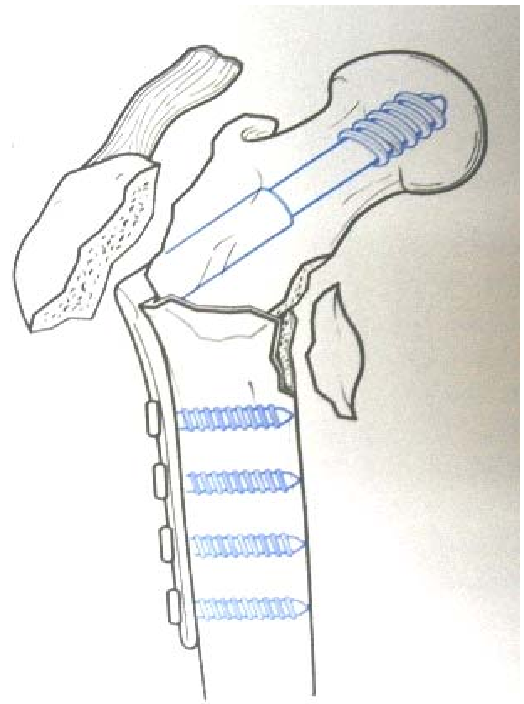
In these devices the nail portion was replaced by a blunt ended screw with a large outside thread diameter. Theoretically these alterations would result in improved proximal fragment fixation and decrease the risk of screw cutout by eliminating the sharp edges found on tri-flanged nails. Numerous series have reported excellent results and became the most widely used devices.

Bi-directional sliding:

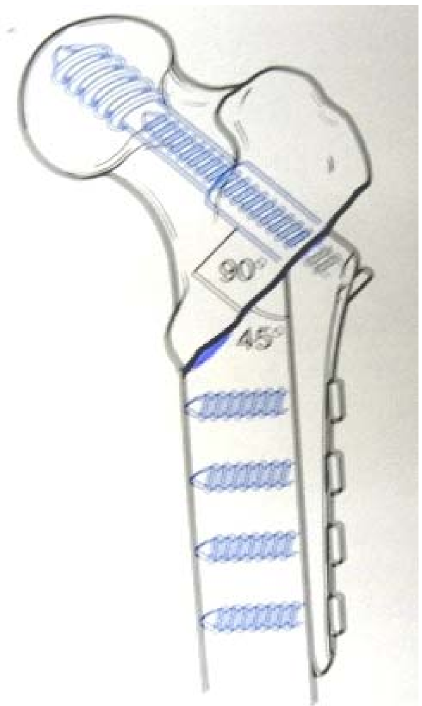
One early modification to the sliding hip screw maximized fracture impaction by allowing the proximal lag screw to telescope within the barrel and the plate to slide axially along the femoral shaft creating the bi-directional sliding by replacing the rounded screw holes with slotted screw holes, e.g. **Egger's plate (Fig 28 a,b, c, d, e, f& g).**

More recently a 2 component plate device was introduced, e.g. **Medoff plate** in which a central vertical channel constraints an internal sliding component. Both devices have been successfully used for the treatment of stable and unstable trochanteric fractures.

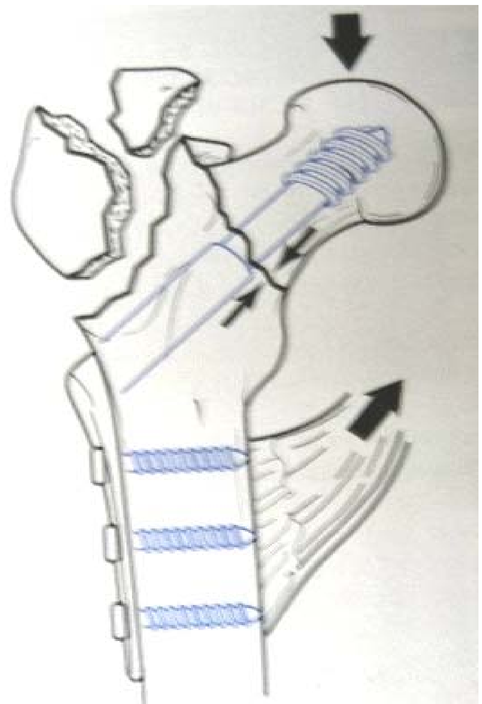
Fig 29



(a)



(b)



(c)

The Alta expandable dome plunger (How medica):

It is a modified sliding hip screw designed to improve fixation of the proximal fragment with facilitating cement intrusion into the femoral head. Cement is kept away from the plate barrel so that the device's sliding potential is maintained. Although this device is demonstrably superior to the standard sliding hip screw system in laboratory testing, improved efficacy has not been shown in clinical trials.

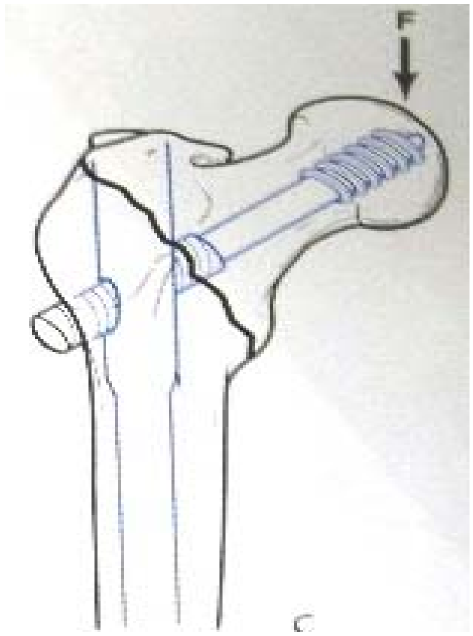
Intertrochanteric osteotomies:

Emphasizing that restoration of medial continuity is essential for successful internal fixation of three and four part intertrochanteric fractures, in the absence of stable medial buttress the following methods were subsequently developed to achieve stable medial cortical apposition.

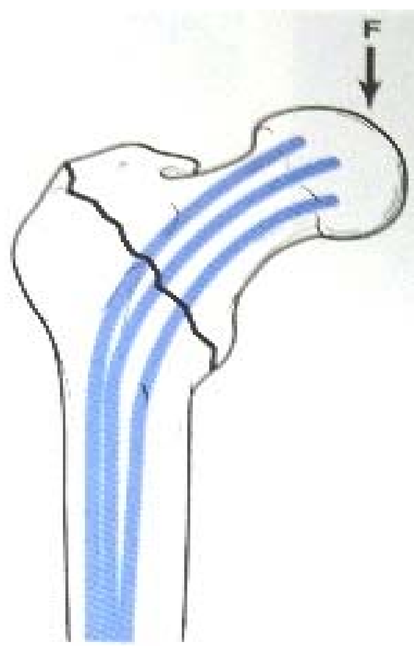
1. **Dimon-Hughston** medial displacement osteotomy **(Fig 29 a)**
2. **Sarmiento** valgus osteotomy **(Fig 29 b)**
3. **Wayne County** lateral displacement osteotomy **(Fig 29 c)**

These methods provide stable but non – anatomic alignment. Since the advent of sliding hip screw devices there has been renewed

FIG 30



(a)



(b)

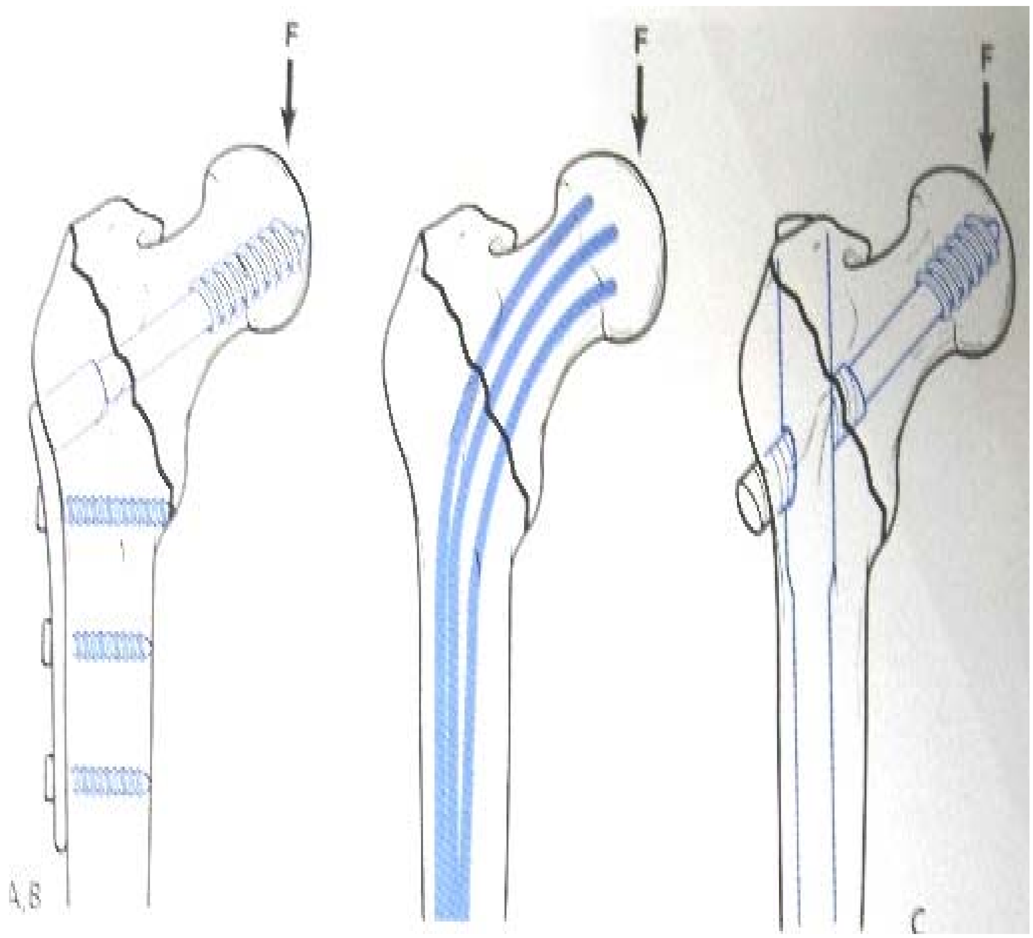
interest in anatomic alignment. Anatomic alignment differs from anatomic fracture reduction in that its goal is simply to align the head and neck fragment with shaft rather than reduce and stabilize all fracture fragments.

Because a sliding hip screw allows controlled fracture collapse anatomically aligned unstable fractures that are stabilized with a properly inserted sliding hip screw usually move spontaneously to a stable medially displaced position as reported by Hopkins et al. Knowledge of these techniques is still occasionally useful in some extremely comminuted fractures where anatomic reduction is not possible.

Intramedullary devices:

Further progression lead to the development of intra medullary devices **(Fig 30 a),** which are subjected to lesser bending movements than plate and screw devices because they are positioned closer to the mechanical axis of femur. The longest experience has been the use of flexible intra medullary nails e.g. **Ender's nail (Fig 30 b),** inserted under image intensifier in retrograde fashion through portals in the distal femur through fracture sire into the femoral head.

FIG 31



While the advantages of this procedure were supposed include –

- Closed fracture reduction and fixation where fracture hematoma is not disturbed
- Decreased blood loss
- Reduced anesthetic and operating time
- Reduced mortality

But in practice their use has been associated with a significant incidence of complications like rotational deformity, supra condylar femur fracture, proximal migration of nail through femoral head and back out of the nails with resultant knee pain and stiffness.

Cephalo – medullary nails:

Recently renewed interest is being given to cephalo – medullary fixation devices because of several potential advantages **(Fig 31),**

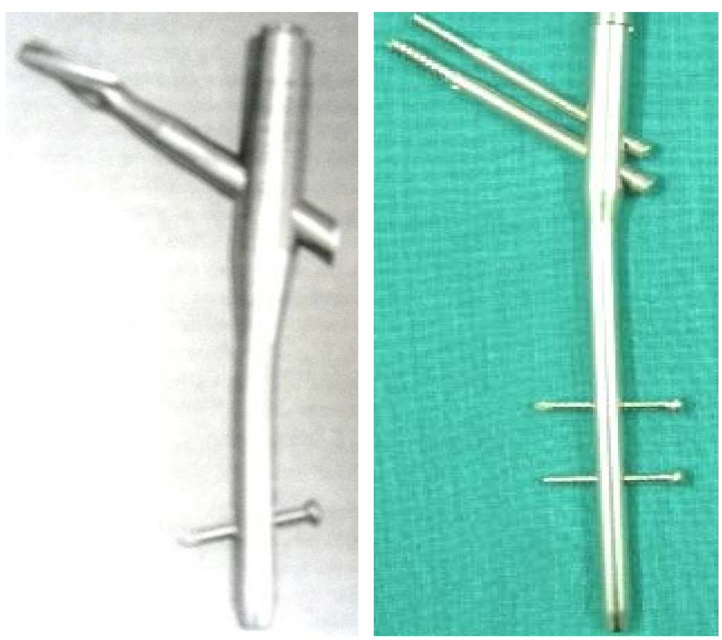
1. An intra medullary fixation device because of its location theoretically provides more efficient load transfer than a sliding hip screw.

2. The shorter lever arm of the IM device can be expected to decrease tensile strain thereby decreasing the risk of implant failure.

3. Because it incorporates sliding mechanism with the hip screw the advantage of controlled impaction is maintained.

FIG 32

(a) (b) (c)



(d) (e)

4. Insertion of an IM device theoretically requires shorter operative time and less soft tissue dissection than a sliding hip screw – plate devices thereby potentially resulting in decreased overall morbidity.

Examples :- IMHS (intra medullary hip screw – Fig 32 a)

- **Gamma nail** (Fig 32 b)
- **Russel – Taylor** reconstruction nail (Fig 32 c)
- **ATN** (Ante grade trochanteric nail)
- **TFN** (Trochanter fixation nail - Fig 32 d) and
- **PFN** (Proximal femoral nail – Fig 32 e)

These devices are Centro - medullary nails which couple, an intra medullary hip screw (for proximal fixation into the femoral head and neck Fragment) **+** a distally locked intra medullary nail

The gamma nail, IMHS, ATN and TFN began as shorter nails than reconstruction nails with a tip ending within the diaphysis of the femur. However they have the disadvantage of increased risk of femoral shaft fractures at the nail tip and the insertion sites of the distal locking screws. Severe deformities of the femoral canal or excessive anterior bowing may preclude the use of an intra medullary device.

To prevent the occurrence of femoral shaft fractures modification of these nails by tapering the distal diameters lead to the introduction of proximal femoral nail.

Proximal femoral nail:

PFN is considered to be the second generation nail, was introduced during **1997** by Synthes company in **Czech Republic** for treatment of unstable peritrochanteric fractures. PFN is **240 mm** in length is made of **316 LVM** stainless steel or **titanium. 2 proximal screws** can be inserted into the femoral neck through the proximal part of the nail. The **load bearing neck screw** is **11 mm** and the tip of it should be placed subchondrally into the distal half of femoral head. The other screw is a **6 mm derotation – proximal pin** and should be placed through the upper part of the nail into the proximal half of the femoral neck to prevent rotation of the head and neck fragment. 2 distal interlocking bolts of **4.9 mm** size is inserted through the distal part of the nail connecting the lateral and the medial cortex of the shaft. It has both **dynamic** and **static locking** . The proximal end of PFN is **17.5 mm** in diameter.

A randomized study conducted by **Pajarinen .J et al 2005** comparing peritrochanteric fractures treated with a DHS and PFN reported that patients treated with PFN had regained their pre – injury working ability significantly faster compared to patients treated with DHS. Secondly there was shortening of both the femoral neck (loss of hip offset) and femoral shaft (loss of leg length). In the patients treated with DHS. The difference in shortening of femoral neck was **5 mm** and was statistically significant.

Banan.H et al in **2002** from Essex, UK after stabilizing 60 consecutive femoral neck fractures with PFN suggested the use of PFN for unstable trochanteric fractures is very encouraging but a large randomized trial with DHS would be helpful to clarify the relative risks and benefits.

Al – Yassari .G et al in **2002** from Middlesex, UK treated 76 patients with unstable trochanteric fractures with PFN and reported it as a relatively easy procedure and a biomechanically stable construct allowing early weight bearing, but femoral neck screw positioning as critical.

Pavelka .T et al in **2003** from Czechoslovakia did a 4 year study and reported PFN as an excellent implant for the treatment of unstable fractures of proximal femur and the successful outcome includes a good understanding of fracture biomechanics, correct indication and exactly performed osteosynthesis.

K.J.Simmermacher et al in **1999** from Netherlands after 1 year study of 191 cases in four European clinics reported that PFN compare favorably to the other currently available IM devices like

Gamma nail used for the treatment of unstable peritrochanteric fractures.

Schipper I.B. et al in **2002** from Netherlands after studying biomechanical behavior of PFN suggested slotted hole for the derotational hip pin to decrease the excessive weight loading of the hip pin thereby preventing its cutout, which is the most serious complication encountered.

Klinger H.M. et al in **2005** from Germany after 3 years period of study comparing DHS versus PFN fixation in 173 patients with unstable trochanteric fractures reported considerably shorter operating time, shorter in-patient stay, immediate full weight bearing and decreased incidence of complications with PFN .

Although several authors reported in favor of PFN for unstable trochanteric fractures regarding easy surgical procedure, reduced blood loss, reduced operating time, better biomechanical stability and early mobilization the role of intra medullary devices like PFN in favor of DHS for unstable trochanteric fractures require precise surgical technique and expertise, adequate learning curve, accurate placement of lag screw in femoral head and good selection of cases. However a longer duration of study comparing the performance of DHS vs PFN is needed to conclude the advantages.

POST OPERATIVE CARE

The mobilization of hip fracture patients out of bed and ambulation training be initiated on post operative day 1. Further more, any patient who has been surgically treated for an intertrochanteric fracture should be allowed to bear weight as tolerated. Restricted weight bearing after hip fracture has little biomechanical justification, since activities such as moving around in bed and use of a bed pan generate forces across the hip approaching those resulting from unsupported ambulation. Even foot and ankle range of motion exercises performed in bed produce substantial loads on the femoral head secondary to muscle contraction.

Since the goal in all trochanteric fractures is to provide early mobilization and the best chance for functional recovery, the role of immediate restricted and unrestricted weight bearing depends upon the type of fracture (stable or unstable) and the ability of the patient to support them with their upper extremity. Although literature studied show immediate unrestricted weight bearing with support does not increase complication rate (Ecker et al) there is still 2.5 to 5 % of requirement of revision surgery, more prevalent in unstable trochanteric fractures as high as 20 % and they attribute it to poor surgical technique.

If the fracture pattern is stable, the internal fixation rigid and the device is biomechanically superior unrestricted immediate weight bearing can be allowed. On the other hand if the fracture pattern is unstable it is wise to allow restricted weight bearing with support.

COMPLICATIONS

Loss of fixation:

Fixation failure with either a sliding hip screw or an Intramedullary device is most commonly characterised by varus collapse of the proximal fragment with cutout of the lag screw from the femoral head. The incidence of fixation failure is reported to be as high as 20% in unstable fracture patterns. Lag screw cut out from the femoral head generally occurs within 3 months of surgery and is usually due to

a. Eccentric placement of the lag screw within the femoral head

b. Improper reaming that creates a second channel

c. Inability to obtain a stable reduction

d. Excessive fracture collapse such that the sliding capacity of the device is exceeded

e. Inadequate screw – barrel engagement which prevents sliding

f. Severe osteopenia which precludes secure fixation .

Achieving a stable reduction with proper insertion of a sliding hip screw is the best way of preventing post operative loss of fixation rarely, fixation failure results from loss of fixation of the plate holding screws. When fixation failure occurs, management choices include:

a. Acceptance of the deformity

b. Revision ORIF, which may require methylmethacrylate

c. Conversion to prosthetic replacement

Acceptance of the deformity should be considered in marginal ambulators who are a poor surgical risk. Revision ORIF is indicated in younger patients. While conversion to prosthetic replacement (unipolar, bipolar or total hip replacement) is performed in the elderly patient with osteopenic bone.

Non union

Non union following surgical treatment of intertrochanteric fractures occurs in < 2 % of patients. Its rare occurrence is largely due to the fact that the fracture occurs through well – vascularized cancellous bone. The incidence of non union is highest in unstable fracture patterns. **Mariani and Rand et al** in 1987 reported on 20 nonunion, 19 of which (95%) occurred in fracture with loss of posteromedial support. Most intertrochanteric nonunion following unsuccessful operative stabilization with subsequent varus collapse and screw cutout through the femoral head. Another possible etiology for intertrochanteric non union is an osseous gap secondary to inadequate fracture impaction. This can occur as a result of jamming of the lag crew within the plate barrel or mismatch of the lag screw and plate barrel length leading to the loss of available screw barrel slide. Both problems can be avoided with proper attention to the details of device insertion.

Intertrochanteric non union should be suspected in patients with persistent hip pain that have radiographs revealing a persistent radioluscency at the fracture site 4 to 7 months after fracture fixation. Progressive loss of alignment strongly suggests non union, although union may occur after an initial change in alignment particularly if fragments contact improves. Abundant callus formation may be present, making the diagnosis of non union difficult to confirm. Tomography evaluation may help to confirm the diagnosis. Otherwise the diagnosis may not be possible until the time of surgical exploration. As with any non union, the possibility if an occult infection must be considered, however in most elderly individuals conversion to a calcar replacement prosthesis is preferred.

Malrotation Deformity

The usual cause of malrotation deformity after intertrochanteric fracture fixation is internal rotation of the distal fragment at surgery. In unstable fracture patterns, the proximal and distal fragments may move independently. In such cases the distal fragment should be placed in neutral to slight external rotation during fixation of the plate to the shaft. When malrotation is severe and interferes with ambulation, revision surgery with rotational osteotomy of the femoral shaft should be considered.

Other Complications

Osteonecrosis of the femoral head is rare following intertrochanteric fracture. No association has been established between location of the implant within the femoral head and development of osteonecrosis, although one should avoid the postero superior aspect of the femoral head because of the proximity to the lateral epiphyseal arterial system.

Various case reports have documented unusual complications relating to lag screw back out and migration into the pelvis. Most cases of lag screw migration into the pelvis occur in unstable fractures and are associated with improper reaming and violation of the hip joint or the presence of inadequate screw – barrel engagement. **"Z" effect** noted in PFN with reversal of derotation – proximal pin and penetration of the lag screw into the hip joint can be avoided by creating a slotted hole for proximal pin and accurate placing of the lag screw (within 5mm of subchondral bone), so that weight bearing occurs through the lag screw into the Intramedullary nail and also allows the proximal pin to yield during weight transmission .

Laceration of the superficial femoral artery by a displaced lesser trochanter fragment has been reported as well as binding of the guide pin within the reamer, resulting in guide pin advancement and subsequent intra articular or intra pelvic penetration.

MATERIALS AND METHODS

At our institution we selected 21 cases of peritrochanteric fractures for this prospective study. All 21 cases were treated with proximal femoral nail (indigenous) of which 20 patients came for regular follow up and they were included in the study. The age group varied from a minimum of 32 years to a maximum of 72 years and average age was 52.7 years. The duration of the study was from June 2004 to June 2006. The mean follow up was 10.75 months. Of the 20 patients 14 were males and 6 were females. Right side was involved in 7 patients and in 13 patients the left side was involved. 13 patients were sedentary workers and 7 patients were manual laborers.

All the fractures were classified according to the Boyd and Griffin classification for peritrochanteric fractures.

11 patients were classified as type II

4 patients were classified as type III

5 patients were classified as type IV

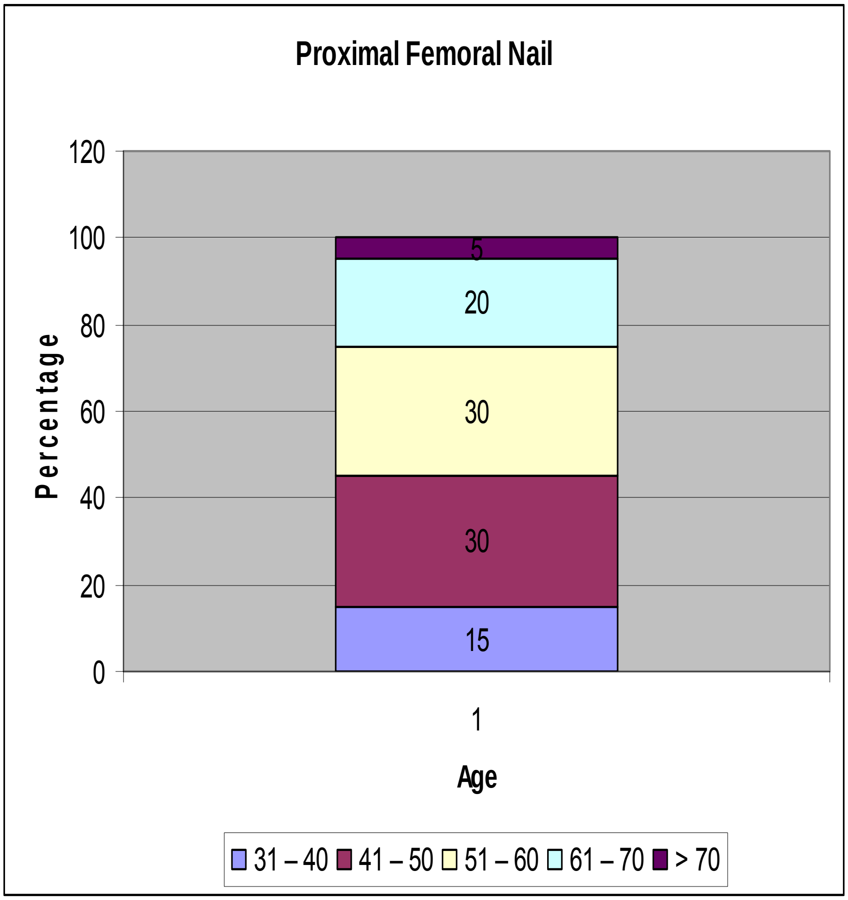
All of them are unstable trochanteric fractures

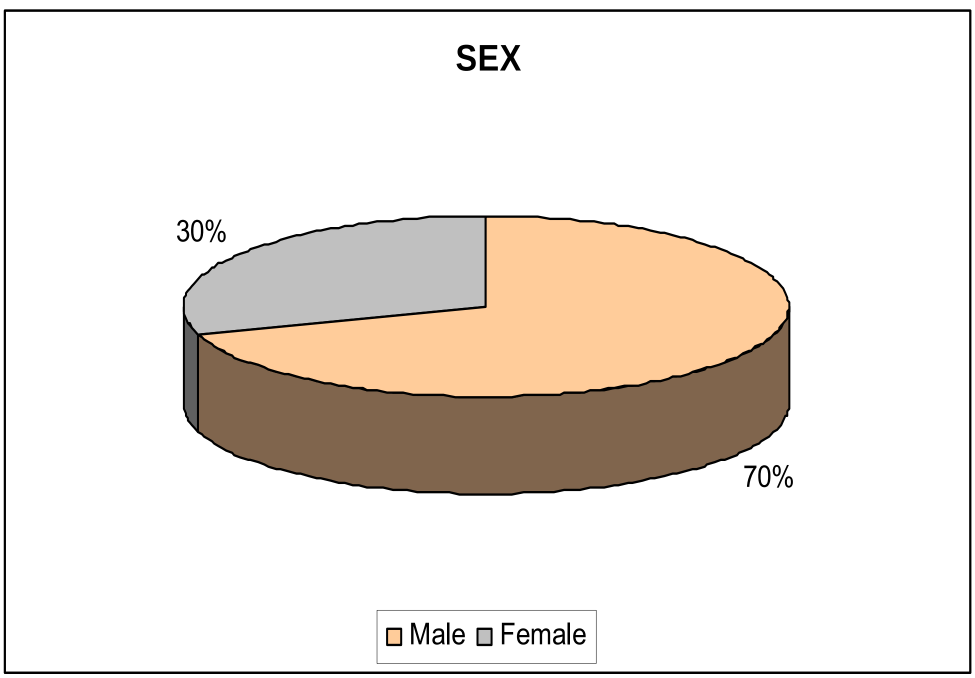
AGE

Age Group (Years)	Proximal Femoral Nail	
	No.	**%**
31 – 40	3	15.0
41 – 50	6	30.0
51 – 60	6	30.0
61 – 70	4	20.0
> 70	1	5.0
Total	20	100
Mean	52.7	

SEX

Sex	Proximal Femoral Nail	
	No.	**%**
Male	14	70.0
Female	6	30.0


Proximal Femoral Nail
120
100
80
60
40
20
0
Percentage
5
20
30
30
15
1
Age
31 – 40
41 – 50
51 – 60
61 – 70
> 70


SEX
30%
70%
Male
Female

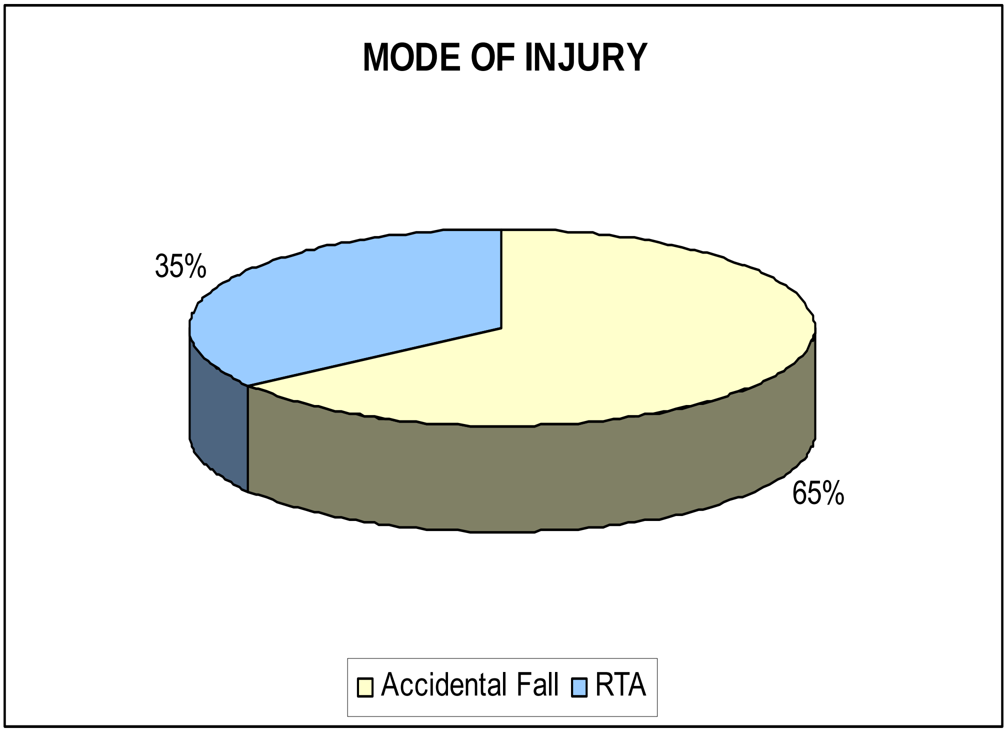
MODE OF INJURY

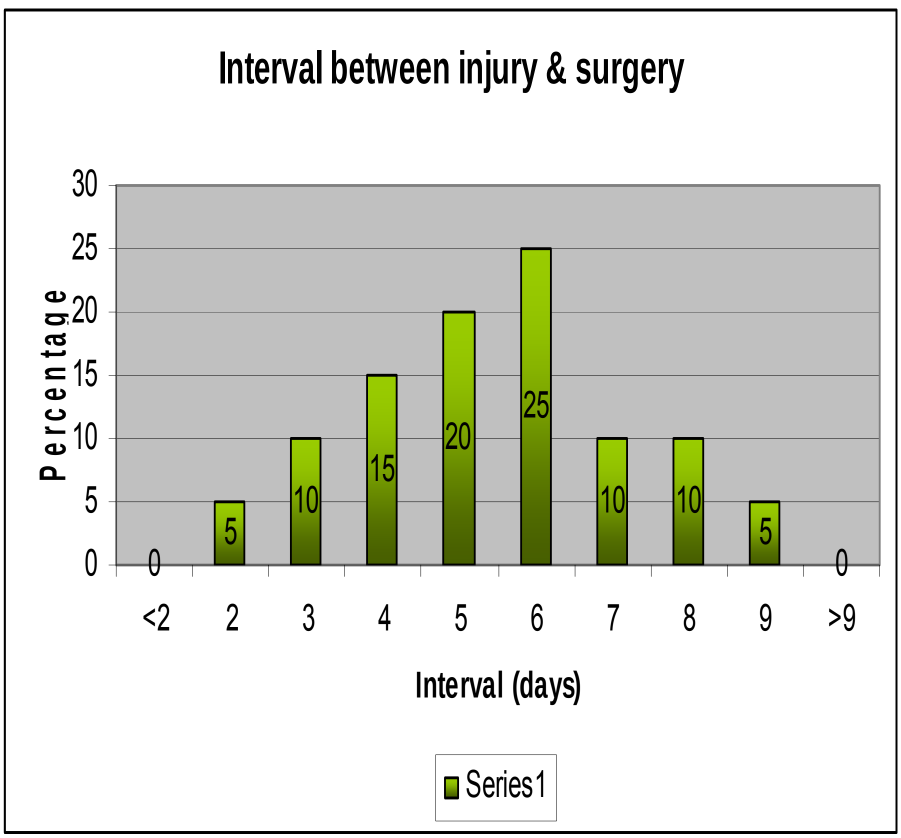
Accidental fall was the most common followed by RTA

Mode of Injury	Proximal Femoral Nail	
	No.	%
Accidental Fall	13	65.0
RTA	7	35.0

INTERVAL BETWEEN INJURY & SURGERY

Intervals (Days)	Proximal Femoral Nail	
	No.	%
<2	-	-
2	1	5.0
3	2	10.0
4	3	15.0
5	4	20.0
6	5	25.0
7	2	10.0
8	2	10.0
9	1	5.0
>9	-	-
Total	20	100
Mean	5.0 days	


MODE OF INJURY
35%
65%
Accidental Fall
RTA


Interval between injury & surgery
30
25
20
15
10
5
0
Percentage
0
5
10
15
20
25
10
10
5
0
<2
2
3
4
5
6
7
8
9
>9
Interval (days)
Series1

CLASSIFICATION

Classification (Boyd & Griffin)	Proximal Femoral Nail	
	No.	**%**
I	-	-
II	11	55.0
III	4	20.0
IV	5	25.0
Total	20	100

Associated Injuries

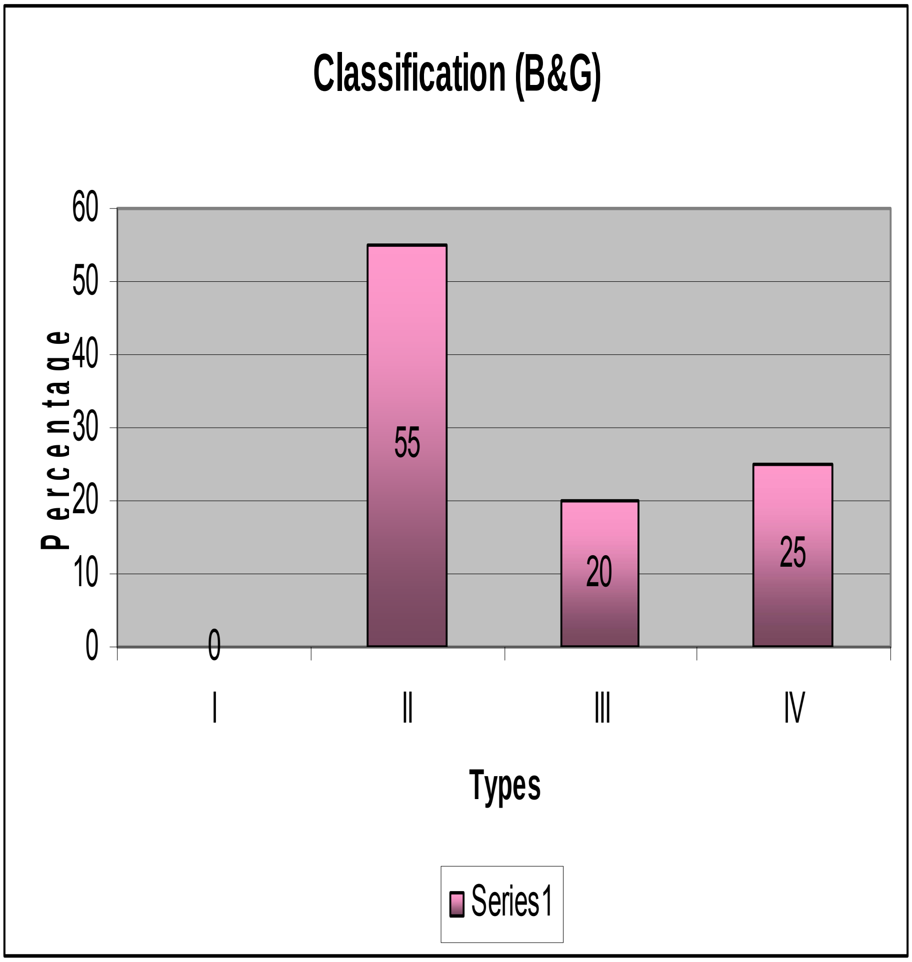
Colle's fracture - 1 case

Fracture shaft of humerus - 1 case

The average interval from injury to the time of surgery was 5 days. All the patients were managed initially with skin traction before taking up for surgery. Patient with Colle's fracture and fracture shaft of humerus were treated with CMR with POP immobilization for Colle's fracture on the day of admission and ORIF of fracture shaft of humerus after internal fixation of the trochanteric fracture.

Preoperative Planning

Preoperative templating with AP X-ray of the pelvis was done in the uninjured femur in internal rotation and the nail diameter and the lag screw length was measured.



Classification (B&G)
Percentage
0
10
20
30
40
50
60
0
55
20
25
I
II
III
IV
Types
Series1

IMPLANTS AND INSTRUMENTATIONS

The indigenous proximal femoral nail is an Indian version of the original European PFN (Synthes)

- which has a proximal diameter of 17.5 mm
- load bearing femoral neck screw of 11.0 mm

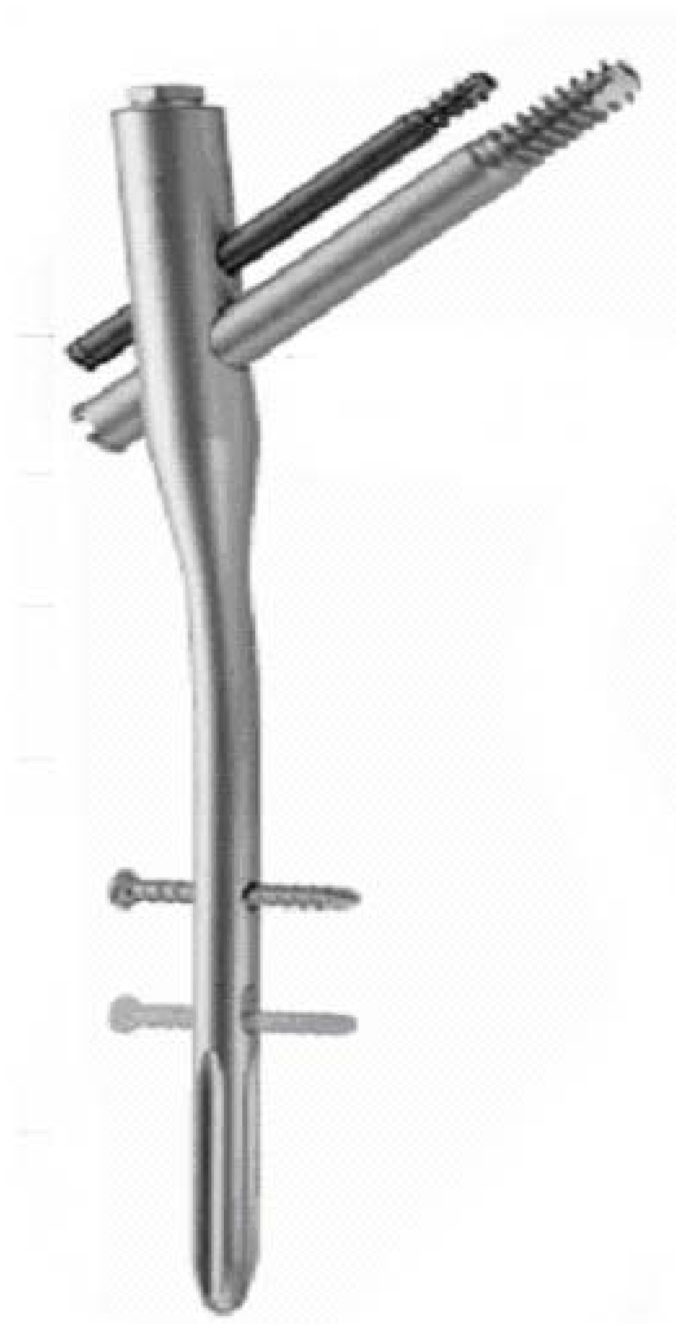
It was modified to **15.o mm** for proximal diameter and **8.0 mm** for load bearing femoral neck screw to suit the proximal femora of Indian patients **(Fig 33).**

Implant

- Length of indigenous PFN - 240 mm
- Proximal diameter - 15.0 mm
- Distal diameters - 9 , 10 , 11 & 12 mm
- Self tapping derotation – hip pin - 6.0 mm (50, 55, 60 to 110 mm size)
- Self tapping load bearing femoral Neck screw (lag) - 8.0 mm (50, 55, 60 to 110 mm size)
- Distal locking bolts (2 nos.) - 4.9 mm

- 135 ◦ angled proximal holes for cervical screws

FIG 33



INSTRUMENTATION (Fig 34 &35)

- JIG with proximal & distal targeting guide
- Bone awl
- Tissue protector
- Guide wire (2 × 450 mm)
- Cannulated proximal reamer
- Cannulated distal reamers (graded)
- Cervical guide pins (2 nos.)
- Cervical cannulated drill (for 8.0 mm & 6.0 mm screws)
- Cervical guide wire & drill sleeves (2 nos.)
- Cannulated screw drivers (2 nos.) for cervical screws
- Distal locking - drill sleeves
- 4.0 mm drill bit for distal locking bolts
- Fracture table
- Image intensifier

FIG 34

FIG 35

SURGICAL TECHNIQUE

Anaesthesia

Spinal anaesthesia	-	16 cases
General anaesthesia	-	2 cases

Position

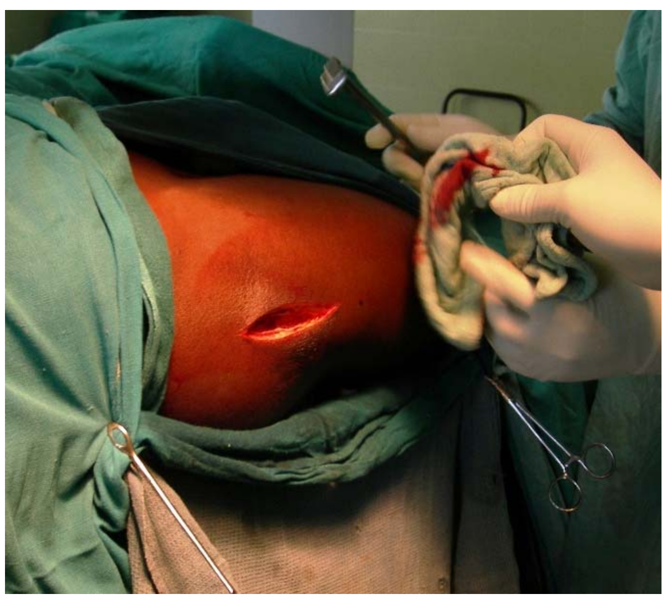
Supine in a standard fracture table. Rest both feet in a padded foot holder and use a padded perineal post. The pelvis must lie in the horizontal position. Adduct the affected femur to allow access to trochanteric region **(Fig 36).** Abduct the unaffected limb while adducting the trunk and affected extremity. Tilt the trunk away from the fracture and strap the arm on the same side across the chest of the e patient. Place the uninjured side flexed and abducted to allow unimpeded access of the image intensifier between the legs.

All the fractures were reduced with initial closed reduction by slight internal rotation of the femur with traction. The alignment of the medial cortex in AP view and reduction of the proximal fragment and shaft fragment in lateral view is checked.

Preparation from just above iliac crest to knee and from beyond the midline anteriorly to the midline posteriorly.

FIG 36

FIG 37



Incision

Lateral linear incision of 5 to 6 cm size extending proximally from the tip of greater trochanter **(Fig 37),** followed by splitting of aponeurosis of the gluteus maximus in line with its fibres and careful splitting of gluteus medius in the line of its fibres.

Entry Point

The point of entry is made just medial to the tip of trochanter at the junction of its anterior one - third and posterior one - third with a curved bone awl **(Fig 38).**

Guide Wire Insertion and Reaming

The guide wire is inserted using a tissue protector and a guide pin – centering sleeve well beyond the subtrochanteric region. The position of guide wire is checked in AP and lateral views **(Fig 39).** The 15 mm cannulated proximal femoral reamer is used to ream the proximal femur for up to 7 cm . Distal reaming of the femoral canal is done with graded cannulated reamers up to more than 1 size of the distal diameter of the nail.

Nail Insertion and Proximal Targeting

The nail with jig before insertion is checked for the alignment of the proximal targeting guide and distal targeting guide to the corresponding holes in the nail along with the drill sleeves. Then the nail is inserted with the help of the jig over the guide wire by hand by gentle twisting movements and the progress of the nail is done under image intensifier control. Excessive force or hammering is totally avoided. Once the nail is positioned appropriately, guide wire is removed and drill sleeves are inserted into the proximal targeting guide. Through a stab incision over the lateral thigh the drill sleeve is pushed upto the lateral cortex of femur with the help of a trocar. The cervical guide pins for the load bearing cervical lag screw (8.0 mm)and for the derotation – hip pin were passed into the head and neck using the guide pin sleeves under fluoroscopic control in the desired position **(Fig 40 a & b).**

The guide pin is advanced to 5 mm from the articular surface of the femoral head and reaming is done using cannulated drill with a guide wire in situ. The load bearing cervical lag screw of adequate length is inserted into the sub chondral bone upto 5mm from the articular surface with the screw driver under image control, followed by the insertion of derotation – hip pin of adequate length into the upper half of neck.

FIG 38

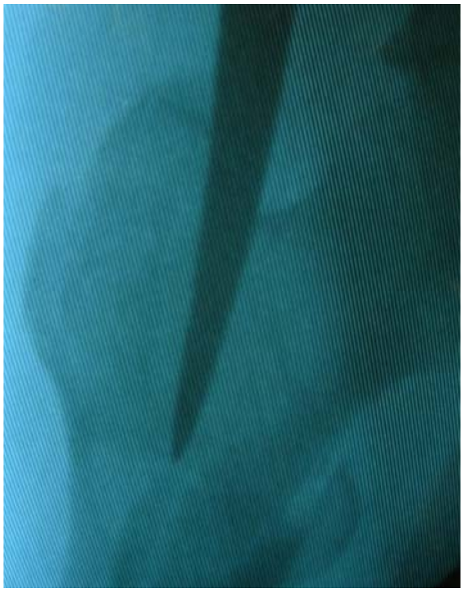


FIG 39

FIG 40

(a)

(b)

Distal Targeting

Distal locking also is done with the aid of distal targeting guide and drill sleeves using 4.0 mm drill bit **(Fig 41).**

Holes were made in the lateral and medial cortex of the femoral shaft through the distal holes of the nail and locking done by two 4.9 mm locking bolts and the position of the screws were confirmed with the C-arm.

Closure

After removal of the jig, proximal wound is closed over a suction drain after approximating the gluteus medius fibres and the aponeurosis of gluteus maximus. The distal wounds were closed with skin sutures **(Fig 42).**

FIG 41

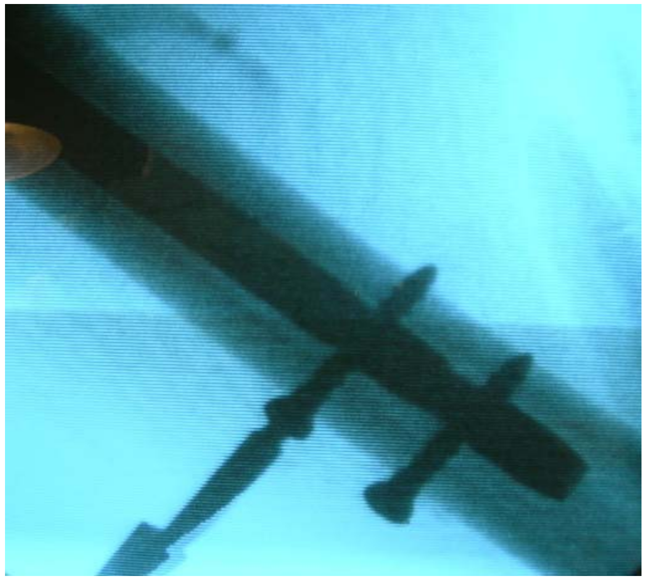


Fig 42

RESULTS

The operating time was calculated from the start of surgical incision to wound closure. In the initial cases our operating time was on the higher range, with experience the operating time reduced. Operating time varied from 58 to 84 minutes. The blood loss was calculated from the number of surgical mops that were used, each corresponding to 50 ml blood. Blood loss varied from 150 to 350 ml. The average blood loss was 230 ml. The duration of image intensifier usage was calculated in seconds.

Complications encountered intra operatively were

- breakage of drill bit while drilling for distal locking in 3 cases and drill bit was removed immediately.

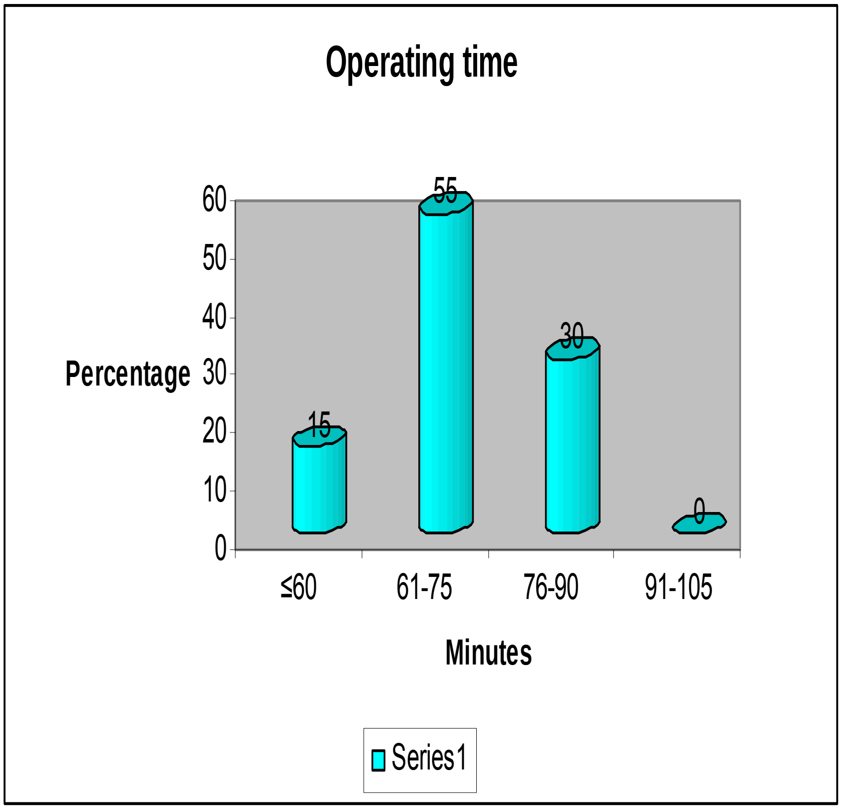
- in 1 case because of smaller diameter of the femoral neck the position of the proximal derotation pin was found far superior and the patient was left only with the load bearing cervical lag screw.

OPERATING TIME

Operating Time (Minutes)	Proximal Femoral Nail	
	No.	%
≤60	3	15.0
61-75	11	55.0
76-90	6	30.0
91-105	0	0
Total	20	100
Mean	71.5 mts	

BLOOD LOSS

Blood Loss (ml)	Proximal Femoral Nail	
	No.	%
<150	0	0
150	2	10.0
200	9	45.0
250	5	25.0
300	2	10.0
350	2	10.0
>350	0	0
Total	20	100
Mean	232.5 ml	


Operating time
Percentage
60
50
40
30
20
10
0
15
55
30
0
≤60
61-75
76-90
91-105
Minutes
Series1

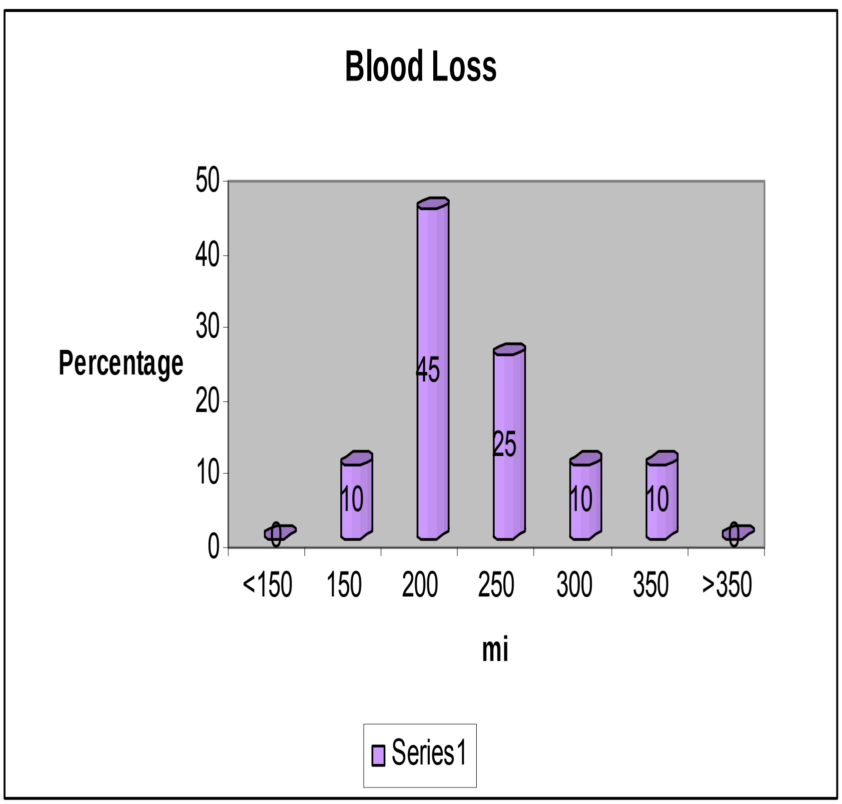

Blood Loss
Percentage
50
40
30
20
10
0
0
10
45
25
10
10
0
<150
150
200
250
300
350
>350
ml
Series1

IMAGE INTENSIFIER EXPOSURE

Image Intensifier Exposure (sec)	**Proximal Femoral Nail**	
	No.	**%**
≤100	0	0
101-110	3	15.0
111-120	7	35.0
121-130	8	40.0
131-140	2	10.0
>140	0	0
Total	20	100
Mean	120.10 Sec	

Post Operative Protocol

Patients were mobilized with physiotherapy on the first post operative day. Patients were allowed partial weight bearing with bilateral elbow crutches as tolerated. Sutures were removed on the 12th post operative day. After the 3rd post operative week weight bearing was gradually increased. Patients were evaluated clinically and radiologically at 3 weeks for the first 3 months and thereafter monthly for the next 3 months and bi-monthly for the next 6 months. Clinical union was observed as the absence of tenderness or pain with full weight bearing. During follow up the Harris hip score was evaluated at 3 months and 6 months post operatively. Various parameters like pain, limp, use of support, distance walked, sitting, stair climbing, absence of deformity, range of motion were evaluated using the Harris hip score.

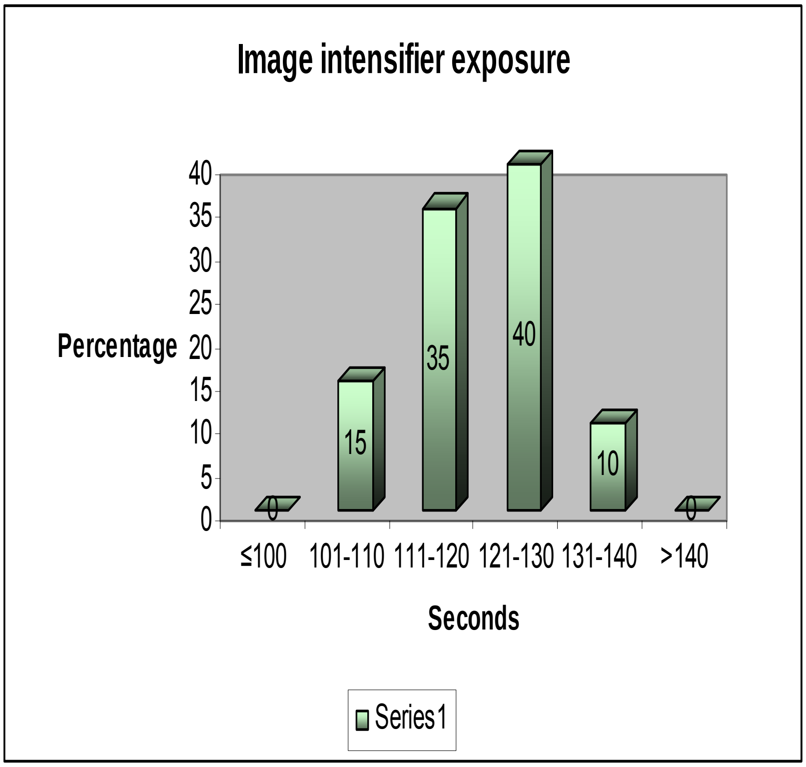


Image intensifier exposure
Percentage
40
35
30
25
20
15
10
5
0
0
15
35
40
10
0
≤100
101-110
111-120
121-130
131-140
>140
Seconds
Series1

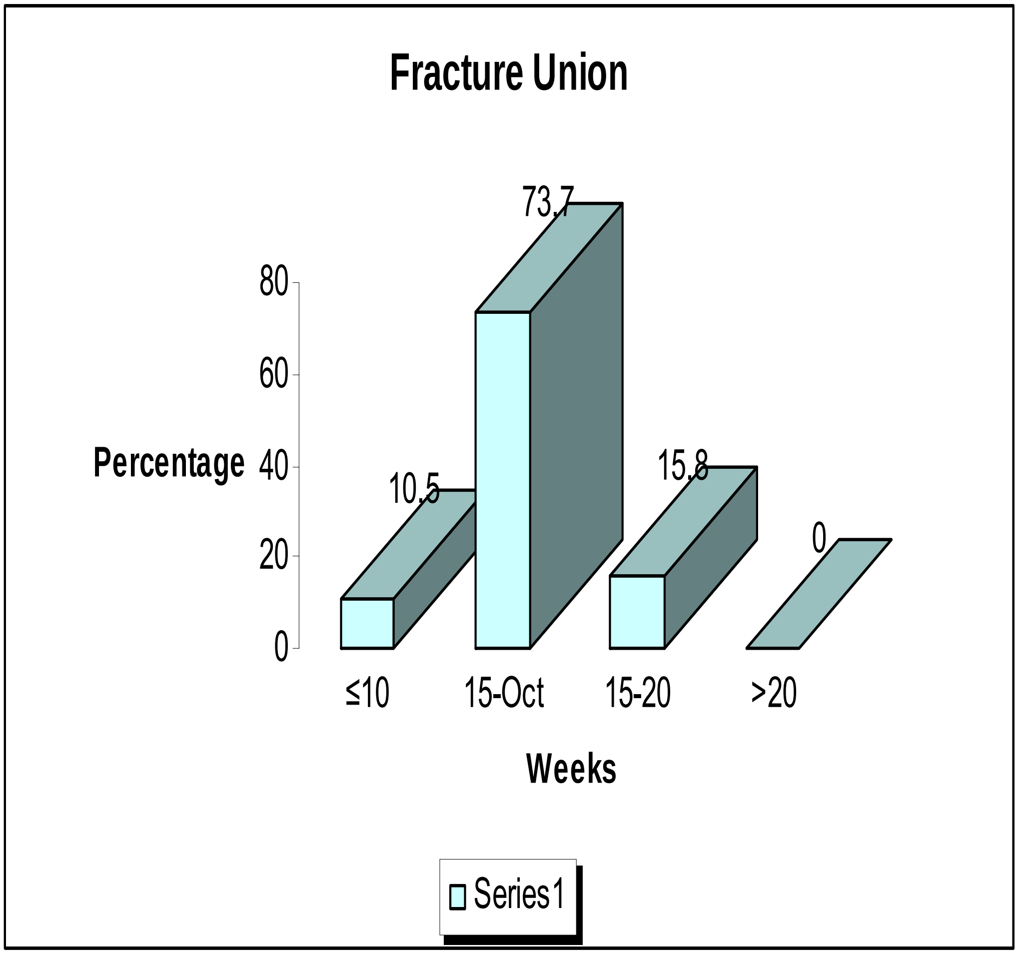
FRACTURE UNION

Fracture Union (weeks)	Proximal Femoral Nail	
	No.	%
≤10	2	10.5
10-15	14	73.7
15-20	3	15.8
>20	0	0
Total	19	100
Mean	12.6 Weeks	

RESULTS

Results	Proximal Femoral Nail	
	Mean	
Operating Time	71.5 min	
Blood Loss	230 ml	
Image intensifier Exposure	120 sec	
Fracture Union	12.6 weeks	
Harris Hip Score at 6 months	85.05	
	No.	%
Superior cut out of lag screw With re-operation	1	5.0
Varus Deformity	2	10.0
Abductor Lurch	3	15.0

All the patients were ambulated as early as 3 weeks with aids and at the end of 6 weeks all patients were allowed full weight bearing. The mean Harris hip score at the end of 3 months was 78.65 and at end of 6 months was 85.05.



Fracture Union
Percentage
80
60
40
20
0
73.7
10.5
15.8
0
≤10
15-Oct
15-20
>20
Weeks
Series1

One patient had cutout of the cervical screws leading to collapse and severe varus deformity. He was re-operated at 6 weeks with calcar replacing cemented bipolar hemiarthroplasty.

Another patient with a single load bearing cervical lag screw developed varus deformity of 8°. The fracture united and patient was comfortable with deformity, so left alone. All the other patients went back to their pre injury occupation. 3 patients developed abductor lurch which improved with time Superficial wound infection occurred in 1 case and it settled down with antibiotics. There was no case of deep infection.

CASE ILLUSTRATIONS

CASE 1

Name: Srinivasan **Age:** 62 **Sex:** M **I.P. No.:** 827542

Mode of Injury: Accidental Fall **Side:** Right **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type III

DOA: 09/02/05 **DOS:** 15/02/05

Associated injuries: Nil

Nail size: 10 X 240 mm

Operating time: 65 min

Blood loss: 200 ml

C-arm Exposure: 116 sec

Time for # Union: 10.5 weeks

Harris hip score at 6 mths: 88

Follow up (months): 18

Complications: Nil

CASE 1

(PRE-OP) (POST OP - AP) (POST OP – LAT)

(3 MONTHS POST OP) (6 MTHS) (6 MTHS)

CASE - 2

Name: Saravanan **Age:** 36 **Sex:** M **I.P. No.:** 845429

Mode of Injury: RTA **Side:** Left **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type IV

DOA: 10/03/05 **DOS:** 14/03/05

Associated injuries: Nil

Nail size: 11 X 240 mm

Operating time: 58 min

Blood loss: 350 ml

C-arm Exposure: 106 sec

Time for # Union: 10 weeks

Harris hip score at 6 mths: 91

Follow up (months): 17

Complications: Nil

CASE 2


(PRE-OP)


(POST OP - AP)


(POST OP – LAT)


(3 MONTHS POST OP)


(6 MTHS)


(6 MTHS)

CASE - 3

Name: Jeya velu **Age:** 48 **Sex:** M **I.P. No.:** 859864

Mode of Injury: RTA **Side:** Right **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type II

DOA: 06/04/06 **DOS:** 09/04/06

Associated injuries: Nil

Nail size: 11 X 240 mm

Operating time: 60 min

Blood loss: 300 ml

C-arm Exposure: 108 sec

Time for # Union: 12 weeks

Harris hip score at 6 mths: 90

Follow up (months): 6

Complications: Nil

CASE 3

(PRE-OP)

- AP)

(POST OP – LAT)

(3 MONTHS POST OP)

(3 MTHS)

(3 MTHS)

CASE - 4

Name: Govindaswamy **Age:** 52 **Sex:** M **I.P. No.:** 864275

Mode of Injury: Accidental Fall **Side:** Left **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type II

DOA: 02/02/06 **DOS:** 10/02/06

Associated injuries: Nil

Nail size: 10 X 240 mm

Operating time: 75 min

Blood loss: 250 ml

C-arm Exposure: 126 sec

Time for # Union: 14 weeks

Harris hip score at 6 mths: 83

Follow up (months): 8

Complications: Nil

CASE 4


(PRE-OP)


(POST OP)


(3 MONTHS POST OP)


(6 MTHS)


(6 MTHS)


(6 MTHS)

CASE - 5

Name: Nixon **Age:** 32 **Sex:** M **I.P. No.:** 840651

Mode of Injury: RTA **Side:** Left **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type II

DOA: 07/08/05 **DOS:** 11/08/05

Associated injuries: Nil

Nail size: 11 X 240 mm

Operating time: 58 min

Blood loss: 300 ml

C-arm Exposure: 102 sec

Time for # Union: 11 weeks

Harris hip score at 6 mths: 92

Follow up (months): 14

Complications: Nil

CASE 5

(PRE-OP) (POST OP) (3 MONTHS POST OP)

(3 MTHS) (3 MTHS)

CASE - 6

Name: Kanniyappan **Age:** 38 **Sex:** M **I.P. No.:** 835926

Mode of Injury: RTA **Side:** Left **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type II

DOA: 08/06/05 **DOS:** 13/06/05

Associated injuries: Ipsi-lateral fracture shaft of humerus, treated with ORIF – plate osteosynthesis after internal fixation of trochanteric fracture.

Nail size: 11 X 240 mm

Operating time: 84 min

Blood loss: 200 ml

C-arm Exposure: 130 sec

Time for # Union: 11 weeks

Harris hip score at 6 mths: 81

Follow up (months): 16

Complications: Nil

CASE 6

(PRE-OP)

(POST OP)

(3 MONTHS POST OP)

(6 MTHS)

(6 MTHS)

(6 MTHS)

CASE - 7

Name: Mahalingam **Age:** 53 **Sex:** M **I.P. No.:** 852392

Mode of Injury: RTA **Side:** Right **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type IV

DOA: 12/10/05 **DOS:** 19/10/05

Associated injuries: Nil

Nail size: 11 X 240 mm

Operating time: 68 min

Blood loss: 250 ml

C-arm Exposure: 122 sec

Time for # Union: 14 weeks

Harris hip score at 6 mths: 86

Follow up (months): 12

Complications: Nil

CASE 7

(PRE-OP)

(POST OP)

(3 MONTHS POST OP)

(3 MTHS)

CASE - 8

Name: Pandurangan **Age:** 55 **Sex:** M **I.P. No.:** 838752

Mode of Injury: Accidental Fall **Side:** Left **Unit:** II

Ward: Male Ortho **Classification (B&G):** Type II

DOA: 05/07/05 **DOS:** 14/07/05

Associated injuries: Nil

Nail size: 10 X 240 mm

Operating time: 88 min

Blood loss: 250 ml

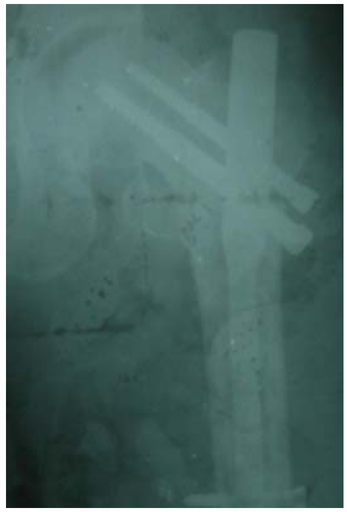
C-arm Exposure: 134 sec

Complications: Developed proximal screw cut out with severe varus deformity at 6 weeks, so implant removal done and calcar replacing bipolar cemented hemi arthroplasty done.

Harris hip score at 6 mths: 78

Follow up (months): 15

CASE 8


(PRE-OP) (POST OP) (4 WKS – SCREW CUT OUT)


(6 WKS – "Z" EFFECT & VARUS COLLAPSE) (CEMENTED BIPOLAR HEMI – ARTHAOPLASTY)

DISCUSSION

Several fixation devices have been developed to overcome the difficulties encountered in the treatment of unstable trochanteric fractures. Until recently most of these fractures were treated by sliding hip screw. Since these devices performed less well in unstable trochanteric fractures with high rates of failure, intra medullary devices have become increasingly popular. The proximal femoral nail is an effective load bearing device that incorporates the principles and theoretical advantages of all the intra medullary devices and considered to be the second generation nail (Schipper I.B. et al 2004). Biomechanically the PFN is more stiff, it has a shorter movement arm (i.e. from the tip of the lag screw to the centre of the femoral canal) whereas the DHS has a longer movement arm (i.e. from the tip of the lag screw to the lateral cortex). The DHS with a longer movement arm undergoes significant stress on weight bearing and hence higher incidence of lag screw cutout and varus malunion (Rosenblum et al 1992).

The larger proximal diameter of PFN imparts additional stiffness to the nail. It also combines the advantages of closed Intramedullary nailing, a dynamic femoral neck screw, minimal blood loss, shorter operative time and early weight bearing than DHS (Leung et al 1992).

The gamma nail and IMHS was the first intra medullary devices available from 1988 specifically designed for the treatment of these fractures. Follow up studies showed serious implant related complications like fracture of femoral shaft upto 17 % , failure of fixation upto 7 % and complications of distal locking in 10 % (Schipper I.B. et al 2004), because of these well described and persistent problems the PFN was developed to improve the rotational stability of the proximal fracture fragment and the tip of the nail was re-designed with reduction of the distal diameter of the nail to decrease the risk of intra and post – operative fractures of the femoral shaft by a significant reduction in bone stress. Since its introduction in 1997 several clinical studies have shown good results with few intra operative problems and a low rate of complications.

In this current study the union rate was 95.0 % with one case of varus malunion (5.0 %). 1 case of re-surgery with calcar replacing cemented bipolar hemiarthroplasty (5.0 %). There was no case of perioperative and post operative femoral shaft fractures.

The average blood loss in patients treated with PFN was 232.5 ml. The results were comparable with Schipper I.B. et al 2004, Wilhelmina H.G. Ekstrom et al 2003 , Pajarinen J. et al 2005.

Average Blood Loss	Wilhelmia. H.G. Ekstrom et al – 2003	Schipper.I.B et al – 2004	Pajarinen. J et al – 2005	Our series
	200 ml	220 ml	330 ml	230 ml

Average operating time in our series was 71.5 minutes. In our initial cases operating time was in a higher range (90 mts.). With experience the operating time reduced (58 mts.). Results were comparable to the series of Dousa et al 2002,Pavelka t. Et al 2003 , Pajarinen j. Et al 2005.

Average Operating Time	Dousa et al – 2002	Pavelka. T et al – 2003	Pajarinan. J et al – 2005	Our series
	61 min	56 min	55 min	71.5 min

The usage time for image intensifier was 120.10 seconds. Results were comparable to the series of Dousa et al 2002, Kostal .R et al 2003 , Pavelka .T et al 2003.

Image Intensifier Exposure	Dousa et al – 2002	Kostal. R et al – 2003	Pavelka. T et al – 2003	Our series
	170 sec	80 sec	60 sec	120 sec

In comparison mechanical failure of DHS occurs in 10 to 20 % cases primarily due to cutting out of the lag screw superiorly (Wolfgang, Bryant & O'Neill et al 1982). The operative blood loss in patients treated with DHS using Medoff plate is higher – 350 ml compared to PFN – 200 ml (Wilhelmina H.G. Ekstrom et al 2003). Full weight bearing is delayed inpatients treated with DHS (Leung et al 1992). Restoration of walking ability is gained more significantly faster in patients treated with PFN than DHS (Pajarinen J. et al 2005). Despite the short lever arm screw cutout and shaft fractures have been more commonly reported in patients treated with Gamma nail (Herrera .A et al 2002) than PFN. Pilot studies has shown good outcome with few complications after treatment with PFN when compared to Gamma nail (Schipper I.B. et al 2004).

Multiple factors have been implicated like implant design, fracture stability, operative technique, surgeon skills & learning curve in the outcome of good results. Optimal reduction of the fracture, conformation of reduction in both AP and lateral views and accurate positioning of the nail and screws remain of crucial importance and should be obtained at all times to prevent the important complication of screw cutout. Reduction in distal nail diameter, pre-reaming of femoral canal one size bigger than the implant and meticulous placement of the distal locking screws without creating additional stress risers decrease the complication rate of femoral shaft fractures.

Patients with narrow femoral canal and abnormal curvature of the proximal femur are the relative contra indications to intra medullary fixation with PFN. We have followed these recommendations in this series. We have not encountered any per operative or post operative femoral shaft fractures. A larger cohort of patients is necessary to document the incidence of shaft fractures which is a limitation to our study.

In our series we had 1 case of superior cut out of lag screw with severe varus deformity that lead to re-operation (5.0%) and varus deformity in another 1 case (5.0 %) which is less than 10° and he was comfortable, so no intervention was done. Total varus deformity 2 cases (10.0%). We had 3 cases of abductor lurch in the post operative period (15.0%) which improved with progression of time . Gluteus medius tendon injury has been reported in 27 % patients treated with IM devices (Mc Connell et al 2003). The abductor lurch may improve in many number of these patients and may also remain static in some patients

In short, the PFN with distinct advantages over DHS can be proved as a better implant with adequate surgical technique. The requirement and follow up based changes in design of PFN from the pioneer Gamma mail will certainly decrease the complication rates and increases all the postulated advantages of Intramedullary devices used in the treatment of trochanteric fractures.

CONCLUSION

Intra medullary nailing with PFN as claimed has distinct advantages over DHS like reduced operating time, less blood loss, rigid fixation and positive effect on the speed of restoration of walking. It also has advantage over Gamma nail in rotational stability of proximal fragment and reduction in the complication rate of femoral shaft fractures.

By decreasing the proximal diameter of the original PFN (17.5 mm) to 15 mm and the diameter of load bearing cervical lag screw (11.0 mm) to 8.0 mm, it becomes a suitable alternative for DHS in Indian patients. Early mobilization and weight bearing is obtained in patients with PFN thereby decreasing the incidence of decubitus ulcer, UTI, hypostatic pneumonia, thrombo – embolic complications related to prolonged recumbency.

The incidence of per operative and post operative femoral shaft fractures can be reduced by pre-reaming the shaft one size more than the diameter of the nail and by distal locking meticulously without creating additional stress risers. The incidence of cutout of cervical lag screw can be reduced by optimal reduction of the fracture and accurate positioning of cervical lag screws and nail.

Finally, we conclude that the PFN is a significant advancement in the treatment of unstable peritrochanteric fractures which has the unique advantages of closed reduction, preservation of fracture hematoma, less tissue damage, early rehabilitation and early return to work.

ANNEXURE

PROFORMA

NAME: AGE: SEX: IP.No:

ADDRESS: UNIT: DOA: DOS:

WARD:

MODE OF INJURY: SIDE OF INJURY: R/L

ASSOCIATED INJURIES: HEAD/ABDOMEN/PELVIS/OTHER LIMB INJURIES

BOYD & GRIFFIN CLASSIFICATION:

INVESTIGATION:

*PLAIN XRAY PELVIS AP & CROSS TABLE LATERAL VIEW

*PLAIN XRAY AP & LAT VIEW OF INJURED FEMUR

*URINE ALB./SUGAR

*BLOOD Hb/PCV/BT/CT/UREA/SUGAR/GROUPING & TYPING

*CXR

*ECG

INITIAL MANAGEMENT:

*IMPROVEMENT OF GENERAL CONDITION

*CLOSED REDUCTION / SKIN TRACTION

*DETAILS OF OTHER TREATMENT PARTICULARS

SURGERY

*INTERVAL BETWEEN INJURY AND SURGERY

*PATIENT POSITIONING

*OPERATING TIME

*ENTRY POINT

*METHOD OF FRACTURE REDUCTION

*TYPE OF IMPLANT

*LENGTH & DIAMETER OF NAIL

*LENGTH OF LAG SCREW

*DETAILS OF PROXIMAL & DISTAL LOCKING

*AMOUNT OF BLOOD LOSS / BLOOD TRANSFUSION

*FLOUROSCOPIC EXPOSURE (IN SECONDS)

COMPLICATIONS

*IMPROPER PLACEMENT OF NAIL / SPLITTING OF ENTRY SITE

*VARUS POSITIONING

*PEROPERATIVE FEMORAL SHAFT FRACTURES

*FAILURE OF DISTAL LOCKING

*EARLY POST OPERATIVE INFECTION

*ABDUCTOR LURCH

*CERVICAL LAG SCREW CUTOUT

CLINICAL & RADIOLOGICAL ASSESMENT DURING FOLLOWUP PERIOD

*FRACTURE UNION IN – WEEKS

*HARRIS HIP SCORE AT - 3 MONTHS

- 6MONTHS

HARRIS HIP SCORE (Modified)

PAIN

- ❑ None or ignores it (44)
- ❑ Slight, occasional, no compromise in activities (40)
- ❑ Mild pain, no effect on average activities, rarely moderate pain with unusual activity; may take aspirin (30)
- ❑ Moderate pain, tolerable but makes concessions to pain; some limitation of ordinary activity or work; may require occasional analgesics stronger than aspirin (20)
- ❑ Market pain, series limitation of activities (10)
- ❑ Totally disabled, crippled, pain in bed, bedridden (0)

LIMP

- ❑ None (11)
- ❑ Slight (8)
- ❑ Moderate (5)
- ❑ Severe (0)

SUPPORT

- ❑ None (11)
- ❑ Cane for long walks (7)
- ❑ Cane most of the times (5)
- ❑ One crutch (3)

- ❑ Two canes (2)
- ❑ Two crutches (0)
- ❑ Not able to walk (0)

DISTANCE WALKED

- ❑ Unlimited (11)
- ❑ Six blocks (8)
- ❑ Two or three blocks (5)
- ❑ Indoors only (2)
- ❑ Bed and chair (0)

STAIRS

- ❑ Normally without using a railing (4)
- ❑ Normally using a railing (2)
- ❑ In any manner (1)
- ❑ Unable to do stares climbing (0)

PUT ON SHOES AND SOCKS

- ❑ With ease (4)
- ❑ With difficulty (2)
- ❑ Unable (0)

SITTING

- ❑ Comfortably in ordinary chair I hour (5)
- ❑ On a high chair one – half hour (3)
- ❑ Unable to sit comfortably in any chair (0)

ENTER PUBLIC TRANSPORTATION (1) : □ Yes □ No

FLEXION CONTRACTURE: ________________(degrees)

LEG LENGTH DISCREPANCY: ________________(cm)

ABSENCE OF DEFORMITY (ALL Yes = 4; Less than 4 = 0)

Less than 30◦ fixed flexion contracture □ Yes □ No

Less than 10◦ fixed adduction: □ Yes □ No

Less than 10◦ fixed internal rotation in extension □ Yes □ No

Limb length discrepancy less than 3.2 cm: □ Yes □ No

RANGE OF MOTION (* Normal)

Total degree measurements, then check range to obtain score

Flexion (*140◦): _______ External Rotation (*40◦): _______

Abduction (*40◦): _______ Internal Rotation (*40◦): _______

Adduction (*40◦): _______

RANGE OF MOTION – SCALE

211◦ - 300◦ (5)	61◦ - 100◦ (2)
161◦ - 210◦ (4)	31◦ - 60◦ (1)
101◦ - 160◦ (3)	0◦ - 30◦ (0)

RANGE OF MOTION – SCORE: ________________

TOTAL HARRIS HIP SCORE : ________________

READMISSION TO HOSPITAL: □ Yes □ No

DATE OF READMISSION : ____/____/_____

IMPLANT REMOVAL DATE : ____/____/_____

COMMENTS: _________________________________

DATE: ____/____/_____ **INVESTIGATOR SIGNATURE:**

____/______/____ (dd/mm/yy)

MASTER CHART

S.No	Name	Age	Sex	I.P. No.	Mode of injury	Classi fication (B&G)	Side	Associated injury	Interval between inj. & surg. (days)	Redu ction	Nail size	Opera ting time (mts)	Blood loss (ml)	C-arm Expo sure (sec)	Compli cations	Time for union (weeks)	Harris hip score (3 mths)	Harris hip score (6mths)	Follow up (mths)
1	Srinivasan	62	M	827542	Acc. Fall	III	R		5	CR	10	65	200	116		10.5	81	88	18
2	Saravanan	36	M	845429	RTA	IV	L		3	CR	11	58	350	106		10	85	91	17
3	Kanniyappan	38	M	835926	RTA	II	L	# Shaft of Humerus	4	CR	11	84	200	130		11	74	81	16
4	Muniammal	58	F	839646	Acc. Fall	III	L		6	CR	9	80	200	128		14	75	82	15
5	Ramaswamy	45	M	836492	RTA	II	R		5	CR	10	64	200	114		10.5	82	88	16
6	Pandurangan	55	M	838752	Acc. Fall	II	L		7	CR	10	88	250	134	Screw cutout with varus deformity with abductor lurch		71	78	15
7	Kuppammal	65	F	839895	Acc. Fall	IV	L	Colle's #	6	CR	9	78	200	125		15	76	82	14
8	Dessappan	50	M	837049	Acc. Fall	II	L		4	CR	10	90	250	136	varus deformity with abductor lurch	16	71	80	13
9	Renukadevi	46	F	841279	Acc. Fall	III	R		5	CR	11	62	250	112		12	83	89	12
10	Nixon	32	M	840651	RTA	II	L		3	CR	11	58	300	102		11	86	92	14
11	Saraswathi	64	F	841728	Acc. Fall	II	L		6	CR	10	70	150	122		14	79	84	10
12	Mahalingam	53	M	852392	RTA	IV	R		4	CR	11	68	250	122		14	80	86	12
13	Mariswamy	56	M	852764	Acc. Fall	IV	R		8	CR	11	66	200	118		12	81	87	12
14	Veeraiah	72	M	852962	Acc. Fall	II	L		6	CR	10	86	150	126	varus deformity with abductor	18	72	79	11

MASTER CHART

S.No	Name	Age	Sex	I.P. No.	Mode of injury	Classi fication (B&G)	Side	Associated injury	Interval between inj. & surg. (days)	Redu ction	Nail size	Opera ting time (mts)	Blood loss (ml)	C-arm Expo sure (sec)	Compli cations	Time for union (weeks)	Harris hip score (3 mths)	Harris hip score (6mths)	Follow up (mths)
															lurch				
15	Parameshwaran	67	M	853428	Acc. Fall	III	R		6	CR	10	74	200	118		10	78	84	10
16	Rajeshwari	44	F	854652	RTA	IV	L		5	CR	9	72	350	124		11	78	84	10
17	Kothandaraman	42	M	859624	Acc. Fall	II	L		9	CR	10	68	200	120		12	80	86	9
18	Jeya velu	48	M	859864	RTA	II	R		2	CR	11	60	300	108		12	84	90	6
19	Sivakami	57	F	862754	Acc. Fall	II	L		7	CR	9	64	200	115		13	80	87	8
20	Govinda swamy	52	M	864275	Acc. Fall	II	L		8	CR	10	75	250	126		14	77	83	8
Average		52.7							5			71.5	232.5	120.10		12.6	78.65	85.05	10.75

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