Femoral Neck Geometry and rationale of Placement of the Proximal Femoral Nail and its relation with fracture risk in the Indian Population

A Review of 120 Cases

A study conducted at Gulmohar Hospital, Ranchi ;

By Dr.Anchal Kumar

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Introduction

Proximal femur fractures are associated with substantial morbidity and mortality; approximately 15% to 20% of patients die within one year of fracture. Trochanteric fractures are more common in women than in men by a margin of 3 to 1.Hip fracture is among the most common injuries necessitating hospital admission and is among the most devastating injuries in the elderly.

Epidemiological studies have suggested that the incidence of fractures of proximal femur is increasing, not unexpectedly, since the general life expectancy of the population has increased significantly during past few decades. A trivial fall or a sudden twist can cause a trochanteric fracture in elderly while in younger patients it usually results from high energy trauma. Intertrochanteric fractures usually unite if reduction and fixation are adequate, and late complications are infrequent.

In India, currently about 1.21 billion people, approximately 6 million people are osteoporotic and 2.3 million people are being added to the list every year. One out of three women and one out of eight men are suffering from osteoporotic bone fracture. Nearly 75% of all hip fractures occur in women [3] and about 25% of hip fractures in people over 50 years occur in men. A 50 year old woman has a 2.8% risk of death related to hip fracture during her remaining lifetime, equivalent to her risk of death from breast cancer and 4 times higher than that from endometrial cancer. Approximately 1.6 million (0.024% of present population of the earth) hip fractures occur worldwide every year and by 2050 this number could reach between 4.5 million and 6.3 million

Operative treatment, which allows early rehabilitation and offers the patient the best chance for functional recovery, and is the treatment of choice for virtually all trochanteric fractures.

According to engineering principles, the strength of an object is a function of other properties besides the mass and density of the material present. Strength depends on (1) the mechanical properties of the materials (2) the object's geometry and shape, and (3) the loading conditions, in terms of magnitude rate, and direction, of force applied to the object. In proximal femur this principles are applicable to asses various aspect of fracture etiology, management, prognosis, risk assessment.

It is commonly accepted that the examination and statistical analysis of femoral anthropometry among different populations reveals a great amount of variation due to the fact that femoral anthropometric measurements from different countries are likely to be affected by racial variations in diet, heredity, climate and other geographical factors related to life style .Anatomical and anthropological studies on the dimensions of the head of the femur have failed to establish a universal norm for all human races .

In India, intramedullary proximal femoral nail (PFN) is a commonly used device for the fixation of proximal femoral fractures. But there are few technical issues that need to be addressed when using this implant.

First, being multi ethnic place there is quite variation in anthropometry of proximal femur. Generally, it was deemed smaller than that of the Caucasian population as the build of the local population is smaller as well. This may potentially lead to an increased difficulty in placement of femoral neck screws and anti-rotation pins.

Secondly, the need for fixation in certain prefixed angles as determined by the implant construct may alter the width of the neck that needs to be negotiated in order to insert the implant safely, thus making the working area narrower and increase the difficulty of the procedure. This may lead to an inadequate placement of the antirotation pin, the usage of an anti-rotation pin that is too short or even omitting the placement of an anti-rotation pin. Thus, the stability of the fracture fixation may be compromised.

Since the clinical outcome of osteoporosis is bone fracture, attention is now increasingly focused on the identification of patients at high risk of fracture rather than the identification of people with osteoporosis as defined by BMD alone.[2,9,31,42] Accurate assessment of fracture risk should ideally take into account other proven risk factors that add information to that provided by BMD. The risk of hip fracture can be predicted by other factors such as bone micro structure, direction and severity of the fall, femoral neck geometry, and family history or lifestyle factors.

The proximal femur in human is subjected to large variety and a magnitude of force during day to day activities. The basic purpose of this study is to accumulate data on people of developing countries like ours, who’s built, physique, habits, genetic makeup and personal life styles are different from western civilization. While data base regarding anthropometry of proximal femur is available for western population [2, 3] .The same cannot be said for native Indian population.

To minimize intraoperative and postoperative complications, the implants should be designed by taking in to account anthropometry and biomechanics data [22,27] .Thus the study conducted with aim to remove lacuna of information about proximal femoral geometry in Indian people and evaluate its impact on implant design

Geometrical variations between races of the femoral neck have been assumed to predict osteoporosis-related hip fractures. FNL (femur neck length) may represent only one dimension of hip geometry and [7] it is assumed that the neck dimension may add additional value to predict the risk of fracture. Hip axis length (which include pelvic brim), neck shaft angle, BMD (bone mineral density), cortical thickness has been reported to be independent predictor of hip fractures.

Intertrochanteric fractures:

Intertrochanteric fractures occur in the transitional bone between the femoral neck and the femoral shaft (Figure 1) [27] .These fractures may involve both the greater and the lesser trochanters. Transitional bone is composed of cortical and trabecular bone. These bone types form the calcar femorale posteromedially, which provides the strength to distribute the stresses of weight bearing. Consequently, the stability of intertrochanteric fractures depends on the preservation of the postero-medial cortical buttress [29] .Osteonecrosis is uncommon because these fractures usually do not disturb the femoral head blood supply. Moreover, because transitional bone is highly vascular, complications such as nonunions are uncommon as well [27].

Classification

The most often used classification system for intertrochanteric fractures is based on the stability of the fracture pattern and the ease in achieving a stable reduction. [27]This classification was introduced by Evans in 1949 and accurately differentiates stable fractures (standard oblique fracture pattern) from unstable fractures (reverse oblique fracture pattern) (Figure 2). The stability of intertrochanteric fractures depends on the integrity of the posteromedial cortex, and instability increases with Comminution of the fracture, extension of the fracture into the sub-trochanteric region, and the presence of a reverse oblique fracture pattern. [27]

Evans' classification of intertrochanteric fractures:

- Standard oblique fracture
- Stable and reverse
- Oblique fracture (unstable)

AO classification of inter-trochanteric fractures

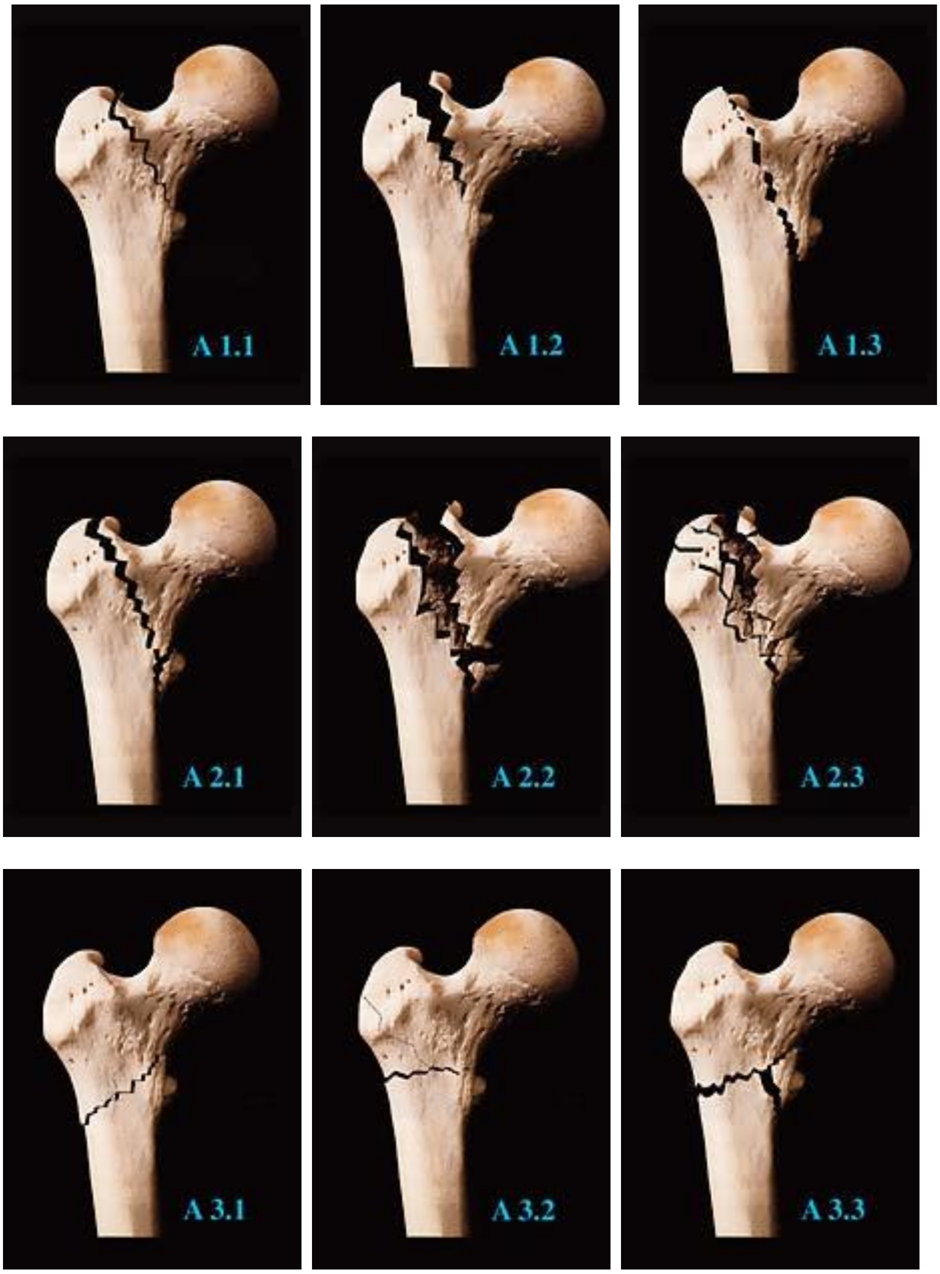


Figure 1. AO classification

A1: Simple (2-fragment) pertrochanteric area fractures

A1.1 Fractures along the intertrochanteric line

A1.2 Fractures through the greater trochanter

A1.3 Fractures below the lesser trochanter

A2: Multifragmentary pertrochanteric fractures

A2.1 With one intermediate fragment (lesser trochanter detachment)

A2.2 With 2 intermediate fragments

A2.3 With more than 2 intermediate fragments

A3: Intertrochanteric fractures

A3.1 Simple, oblique

A3.2 Simple, transverse

A3.3 With a medial fragment

Implant design

1. Intramedullary devices e.g. PFN

2. Extramedullary devices e.g. DHS

Dynamic hip screw (DHS) has been the major implant for fixation of these fractures in the last two decades, but it has its own problems of cutting through, screw giving away from shaft, implant failure and penetration of the joint by the screw and the rate of fixation failure can go as high as 20% .So intramedullary devices (Ender nail, Gamma nail PFN) with the main advantage of being near to the weight bearing axis have taken over as the modality for fixation of these fractures.

Intramedullary devices are fast becoming popular methods for fixation of intertrochanteric They are preferred to the conventional dynamic hip screw fixation as the latter requires a larger surgical wound exposure, more soft tissue handling and anatomical reduction, hence possibly causing an increase in morbidity due to blood loss and infection. Furthermore, intramedullary devices are biomechanically more superior.

Biomechanically, compared to a laterally fixed side-plate, an intramedullary device decreases the bending force of the hip joint on implants by 25 to 30%. This has advantages especially in elderly patients, in whom the primary treatment goal is immediate full–weight-bearing mobilization. The gamma nail fixation is recommended for pertrochanteric fractures, but serious complications such as cut-out of lag screws have been reported in 8 to 15% of cases. [1, 3, 5, 13, 16, 21, 24]

The proximal femoral nail (PFN) has an additional anti-rotational screw (hip pin) placed in the femoral neck to avoid rotation of the cervicocephalic fragments during weight bearing. [10, 15, 18, 29, 32]. The latest implant for management of intertrochanteric fracture is PFN. This implant is a cephalomedullary device and has many potential advantages like:

1. Being intramedullary, load transfer is more efficient.

2. Shorter lever arm results in less transfer of the stress & less implant failures.

3. Advantage of controlled impaction is maintained.

4. Sliding is limited by intramedullary location, so less shortening & deformity.

5. Shorter operative time, less soft tissue dissection and less blood loss.

The PFN was developed by AO/ASIF. It is available in two varieties, the standard and the long cannulated. The standard PFN consist of a 240 mm long nail. The distal part of the nail is available in 10, 11 or 12 mm diameter and its proximal part is 17mm in diameter. The angle between the two parts measures 6 degrees and is situated at 11 cm from the top of the nail. Two screws can be inserted through the proximal part, an 11 mm neck screw and a 6.5 mm anti-rotation screw. Distal locking can be static or dynamic. The tip of the nail is specially shaped to reduce stress concentration.

Modified PFN

Keeping in view the smaller diameters of the proximal femur in Indian population, and recalling from the complications of shattering of proximal femora associated with the Gamma nail as reported by Leung et al, Modified PFN to suit the smaller diameters of proximal femora of our population diameter of proximal part reduced from 17 mm to 14 mm; also the diameter of neck screw was decreased to 8mm from 11mm; rotational screw from 6.5mm to 6mm; length reduced to 18mm [35, 38].

Objective of study:

1. To evaluate the adequacy of femoral neck geometry for the placement of PFN in a contemporary Indian population located in Jharkhand state
2. To use the obtained data to estimate the rational of modified proximal femur nailing in such population.
3. To estimate the outcome of proximal femur nailing.
4. To evaluate femoral neck geometry for fracture risk in such population

MATERIALS AND METHODS

A retrospective, observational study was conducted at the Department of Orthopedic Surgery, Gulmohar Hospital Ranchi, and Jharkhand. One hundred and twenty consecutive patients aged 20 years old and above, who were evaluated at the department of orthopedics from January 2008 to August 2010, had proximal femoral fracture and had an anterior-posterior (AP) pelvic radiographs performed at Gulmohar hospital were recruited. Only cases with adequate AP radiographs were included. Adequate AP pelvic radiographs were defined as, pelvic projection films that visualized the entire pelvis in true AP position including the 5th lumbar vertebra, sacrum and coccyx, as well as the proximal femurs, including the both trochanters which were demonstrated along the medial borders of the femurs. The X-ray technician trained to take all X-rays in similar explained standard technique. Contralateral hip was evaluated for all measurements.

The following data were collected: patient’s age, gender, menopausal status, mechanism of injury, related injuries, pre-injury ambulatory status, and pre-existing local and systemic conditions that may affect recovery. Full clinical examination was done to assess the general condition of the patient, condition of the neighboring joints, and any associated injuries. Personality and type of fracture was studied in detail according to AO classification by examining the X-rays of the hip to be operated. Laboratory investigations were done as per requirement. Each patient was operated upon as early as possible (within two weeks) after getting fitness for anesthesia.

Anthropometry measurements

Neck shaft angle (NSA), narrowest femoral neck width at NSA (NW), narrowest femoral neck width at 130° with the femoral axis (NW130) and narrowest femoral neck width at 135° with the femoral axis (NW135) was evaluated for each patient[33]. The NW130° and 135° are the common preset PFN implant angle between the nail and the lag screw used in this center. Femur neck length was also evaluated at the same time for assessment of fracture risk. The measurements were carried out with radiographic imaging software (AGFA) NX Precision Tools 2.0 Belgium).

Neck shaft angle (NSA): The angle between axis of the femoral neck and the axis of the shaft of the femur. Neck width (NW): The shortest distance within the femoral neck perpendicular to the femoral neck axis. Neck width at 130° (NW130): The shortest distance within the femoral neck perpendicular to the line 130° from the femoral shaft axis. Neck width at 135° (NW135): The shortest distance within the femoral neck perpendicular to the 135° from the femoral shaft axis. Femur neck length (FNL): = Length between the lateral border of the base of the greater trochanter and the femoral head

Table 1

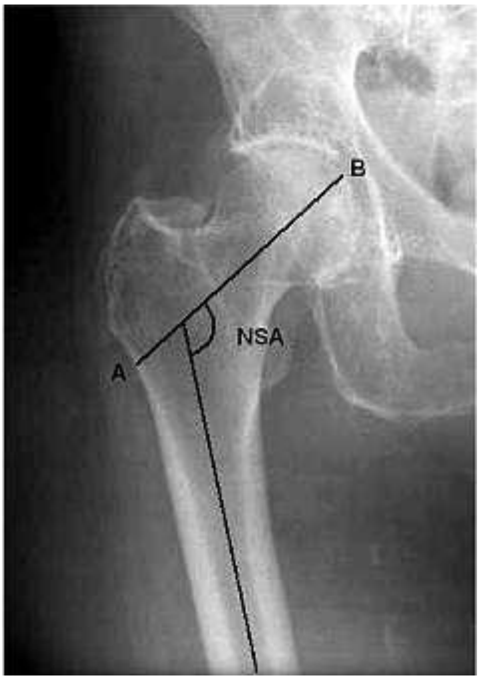


Figure 1

Geometrical parameters of the proximal femur.
AB = FNL (Femoral Neck Length) = Length between the lateral
Border of the base of the greater trochanter and the femoral
Head.
NSA (Neck Shaft Angle) = Angle between the femoral neck and the femur shaft

In this study, true AP pelvic radiographs were chosen to provide the measurements of NSA, NW, NW130 and NW135. Pelvic radiographs are taken in patients with proximal femoral fractures. Preoperative planning is commonly done using plain radiographs including the pelvic film. Moreover, preoperative templating is usually done on plain pelvic radiographs. Error in measurements due to anteversion or retroversion of the femur can be minimized by the inclusion of only true AP pelvic projections. Thus, the assessment of the true AP pelvic radiographs can be both practical and reasonably accurate.

Statistical analysis:

The data collected was tabulated and analyzed using statistical software, SPSS version 17 for Windows (Chicago, Illinois). The statistical tests used were independent t-test, one-way ANOVA, and repeated measures ANOVA.

General treatment considerations: The goal of treatment is to limit pain and to help the patient return to the level of activity, he or she had prior to sustaining the fracture. Patients, who sometimes have cardiac, pulmonary, and psychiatric co-morbidities, an immediate surgical procedure may initially carry too high a risk for substantial morbidity and mortality. Prior to surgery, elderly patients need to be medically evaluated to minimize any potential risks of surgery. Medical work-up usually involves evaluating the patient for hypertension, heart disease (including coronary artery disease, dysrhythmias, and congestive heart failure), diabetes mellitus, chronic obstructive pulmonary disease, cerebral vascular disease, and urinary tract infection. Till the time of operation the patient was put on a skin/skeletal traction as needed.

The time needed to perform a complete medical evaluation and treat or manage co-morbidities in elderly patients can delay surgery for at least 12 to 12days. Although there is conflicting evidence about the mortality rate if surgery is delayed for 24 hours or less, there is substantial evidence suggesting that if surgery is postponed for more than 3 days, the mortality rate within the first year after this treatment doubles Furthermore, prolonging the time before surgery increases the risk of skin breakdown, urinary tract infection, deep vein thrombosis (DVT), and pulmonary complications.

Moreover, if a patient, regardless of age, is receiving anticoagulation, for other reasons, reversal of this therapy may be appropriate before the surgical procedure is performed. To help with the discomfort of a displaced fracture, 5 lb of longitudinal (Buck’s) skin traction can be used, although pillow support alone has been shown to be just as effective .If surgery is delayed for a considerable amount of time, DVT prophylaxis is indicated and can include compression stockings, calf, thigh, or ankle pumps exercises, and low-molecular-weight heparin.

Operative procedure: The patient was positioned supine on the fracture table under spinal or general anesthesia as the condition of the patient permitted. The fracture was reduced by longitudinal traction and the limb was placed in neutral or slight adduction to facilitate nail insertion through the greater trochanter. A straight lateral incision was made from tip of the greater trochanter, extending 3-5 cm proximally; the gluteus Maximus muscle was dissected in line with its fibers. Where open reduction was required we extended the incision distally, incising the iliotibial band in line with the skin incision. The entry portal for the PFN was made at the tip of the greater trochanter, halfway between its anterior and posterior extent. A Kirschner (K) wire was inserted at the tip of the greater trochanter under C-arm control. The K-wire is advanced into the femoral shaft in such a way that it is located in the middle of the shaft in both directions. In cases where modified PFN was used, we manually reamed the proximal part of the femur if required. After mounting the appropriate sized nail on the insertion device the nail was introduced manually into the femoral shaft. Via the aiming arm, which was attached to the insertion device, first the guide wire for the neck screw was introduced into the femoral neck in such a way that the screw was placed in lower half of the neck on the antero-posterior view and centrally on the lateral view. Thereafter, the guide pin for the antirotational hip pin was introduced. The hip pin was introduced first with the tip just about 25 mm medial to the fracture line, and then the neck screw of appropriate size was inserted. Afterwards depending on the type of fracture, distal interlocking either statically or dynamically was achieved via the same aiming arm in sta. The stability of the construct was assessed and wounds were closed in layers over negative suction drain. Antiseptic dressing was done. Per-operatively one dose of antibiotic was also administered. Prophylactic intravenous antibiotics were administered.

Evaluation of reduction according to Baumgartner criteria modified by Fogagnolo et al.

Alignment	Antero-posterior view angle	Normal cervico-diaphyseal or slight valgus
	Lateral view	< 20° of angulation
Displacement		more than 80%overlapping in both planes Less than 5mm of overlapping
Good	Both criteria met	
Acceptable	Only one criterion met	
Poor	Neither criterion met	

Table 2

Post operative

Patients were allowed to mobilize on postoperative day 2, and partial weight-bearing walking was initiated on day 3 or 4 as tolerated. Gradually supervised rehabilitation starts as per patient condition.

Follow up assessments done with help of mobility score by Parker and Palmer and final clinical outcome assessed with Kyle et al criteria9(25)

Mobility score parker and palmer (0-9)

Mobility	**No difficulty**	**With aid**	**With help from another person**	**Not at all**
Able to get about home	3	2	1	0
Able to go out of home	3	2	1	0
Able to go shopping	3	2	1	0

Table 3

Clinical Outcome (Kyle et al)

	Pain	Limp	ROM*
Excellent	No	No-minimal	Full
Good	Mild Occasional	Mild	Full
Fair	Moderate (using two sticks)	Up to moderate	Limited
Poor	Pain on any position	Wheelchair bound	Non-ambulatory

*Range of motion

Table 4

OUTCOMES

AGE RANGE (years)	NUMBER OF PATIENTS	PERCENTAGE
20 – 35	40	33.33%
36 – 50	20	16.67%
51 – 65	25	20.83%
66 – 80	25	20.83%
81 – 95	10	8.33%

Table – 5 (Age distribution)

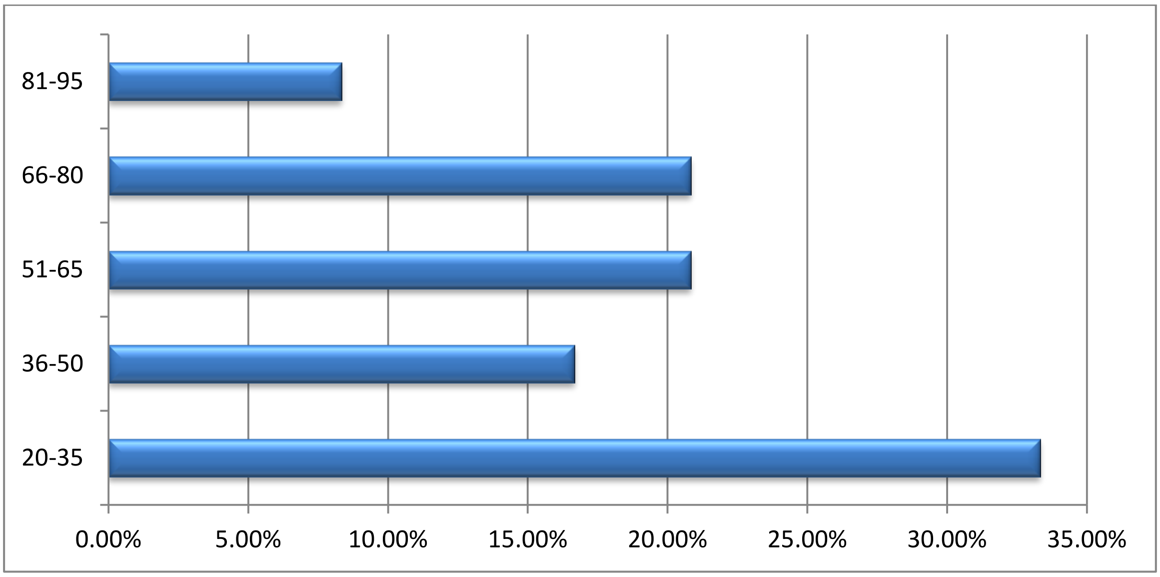


Figure 2 (Age distribution)

SEX	NUMBER OF PATIENTS	PERCENTAGE
MALE	48	40%
FEMALE	72	60%

Table – 6 (Sex distribution)

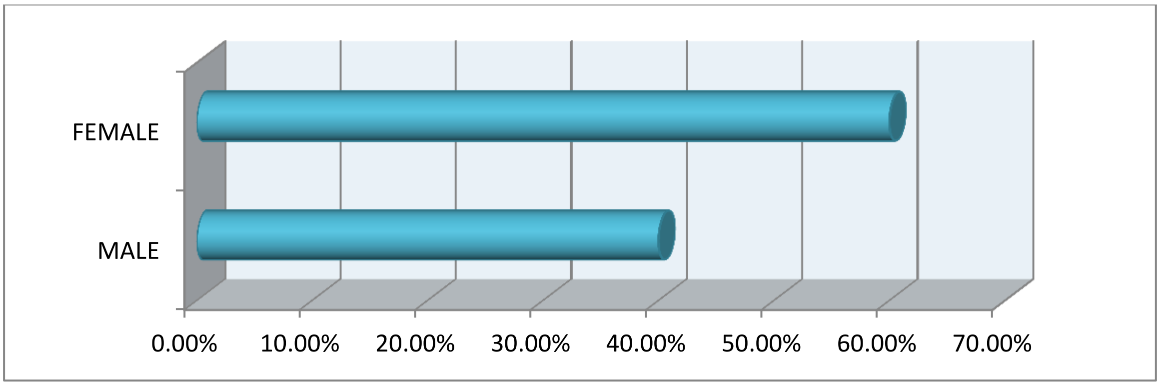


Figure 3. (Sex distribution)

Etiology	**Number of patients**	**Percentage**
Slip and fall	75	62.5%
Fall from height	20	16.67%
RTA	15	12.50%
Direct blunt trauma	10	8.33%

Table – 7 (Fracture etiology)

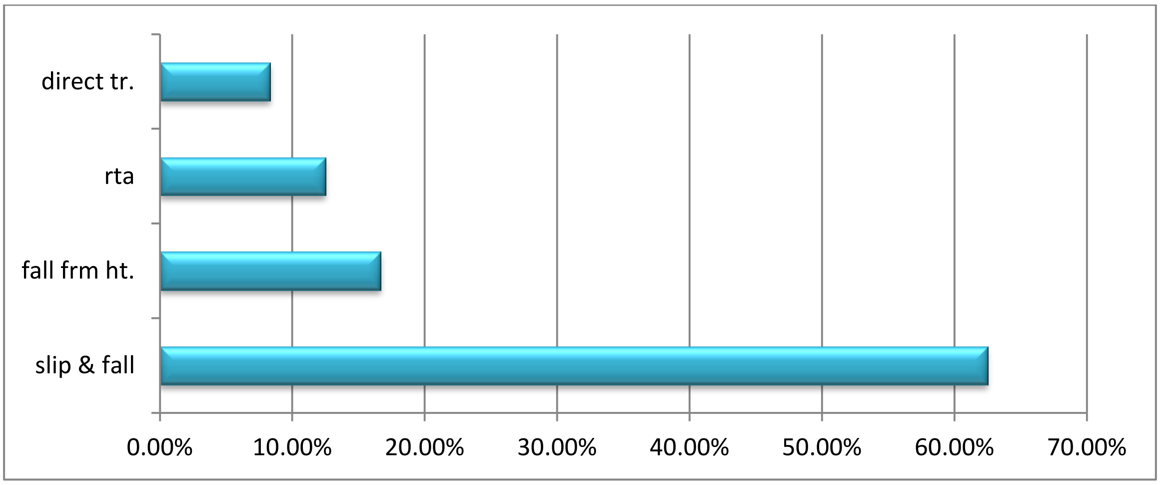


Figure 4. (Etiology of fracture)

SIDE AFFECTED	NUMBER	PERCENTAGE
RIGHT side affected	**78**	**65%**
LEFT side affected	42	35%

Table 8 (Fracture side in study)

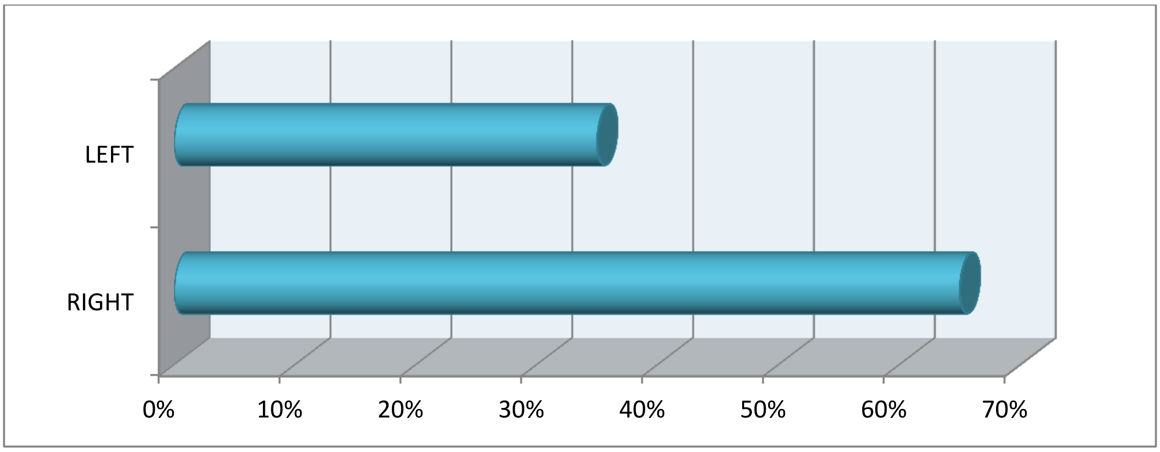


Figure 5 (Side affected)

TYPE OF FRACTURE	NUMBER OF CASES	PERCENTAGE
A1	42	35%
A2	59	49.16%
A3	19	15.84%

Table 9 (Type of fracture in study population)

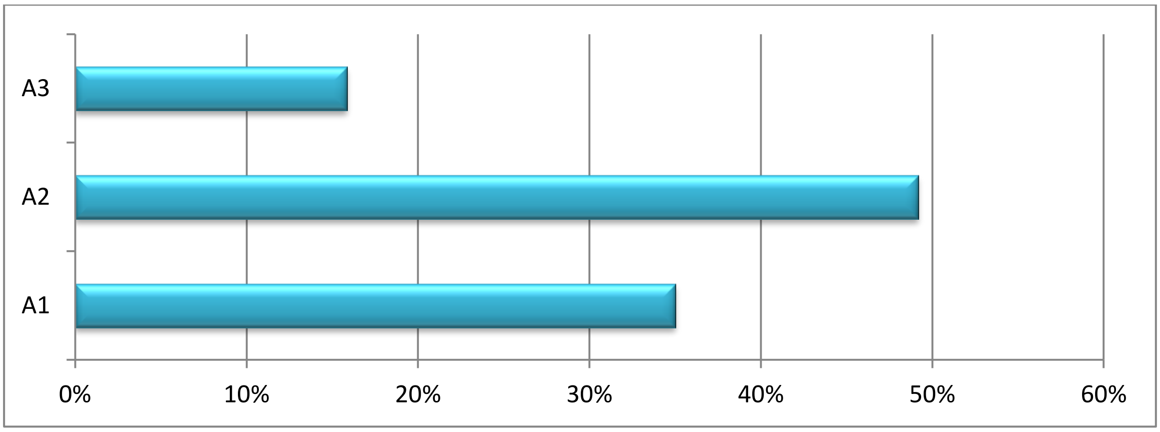


Figure 6. (Type of fractures in study)

Pairwise comparison between NW, NW130 and NW135

WIDTH (I) (mm)	WIDTH (J) (mm)	Mean difference (I-J) mm	Standard error of mean	Significance
NW	NW 130	0.03	0.01	0.0299
	NW 135	-0.11	0.006	0.1099
NW 130	NW	-0.03	0.01	0.0299
	NW 135	-0.14	0.003	0.1399
NW 135	NW	0.11	0.006	0.1099
	NW130	0.14	0.003	0.1399

Table – 10

Neck - width pattern in present study.

Width	≤22.5mm	>22.5 to ≤25mm	>25 to ≤27.5mm	>27.5 to≤30mm
NW				
Male (%)	0	0	2.08%	0
Female (%)	2.77%	27.77%	36.11%	34.72%
Total (%)	1.67%	16.67%	22.5%	20.83%
NW130				
Male (%)	0	0	2.08%	0
Female (%)	2.77%	26.38%	40.27%	31.94%
Total (%)	1.67%	15.83%	25%	19.16%
NW135				
Male (%)	0	0	2.08%	0
Female (%)	2.77%	27.77%	36.11%	31.94%
Total (%)	1.67%	16.67%	22.5%	19.16%

Table 11.

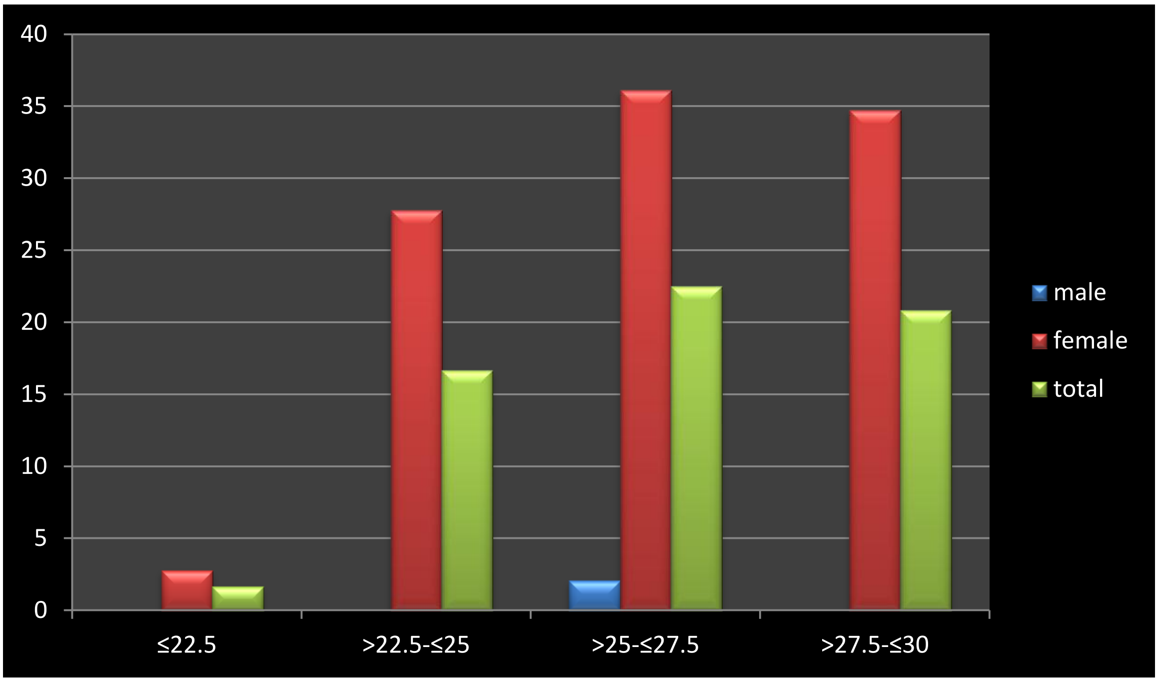


Figure 7. (Neck width pattern in study population)

Risk factors for fracture proximal femur.

VARIABLES	**MALE**	MALE	**FEMALE**	FEMALE	**TOTAL**	TOTAL
	MEAN ± SD	**RANGE**	MEAN ± SD	**RANGE**	MEAN ± SD	**RANGE**
AGE (years)	38.2±24	20-80	65.2±23.6	50-95	58.5±25.41	20-95
NECK SHAFT ANGLE (degree)	134.31± 3.48	125-151	130.55± 4.26	122-146	133.13± 12.94	122-151
NECK WIDTH (mm)	35.56± 2.87	28-40.5	26.22± 1.81	22.2-35.6	29.95± 5.13	22.2-40.5
NW 130	35.38± 2.89	27-42.2	26.28± 1.78	23.5-36.2	29.92± 5.02	23.5-42.2
NW 135	35.44± 2.90	28-41.6	26.48± 2.18	22.6-36	30.06± 5.06	22.6-41.6
FNL	92.3	105.7-87.8	88.2	98.2-78.6	89.1	105.7-78.6

Table – 12 (Variables for risk scoring)

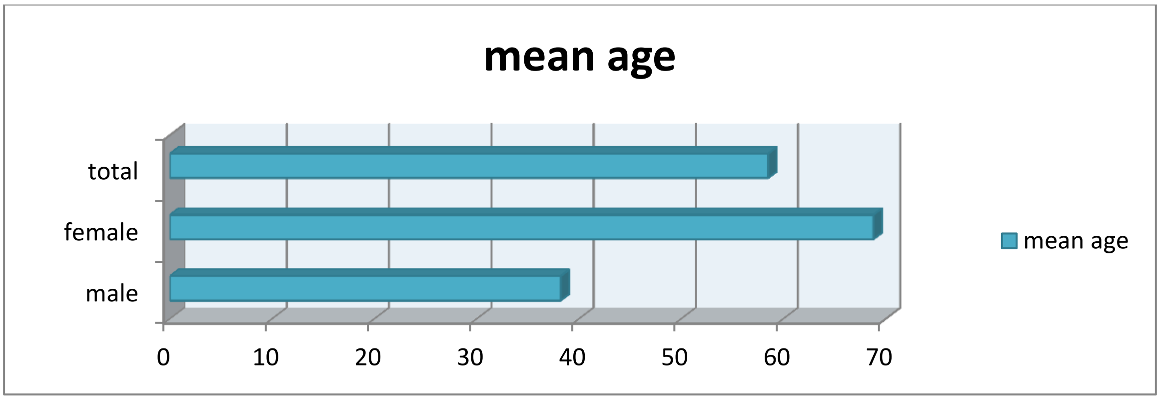


Figure 8(Age of study population)

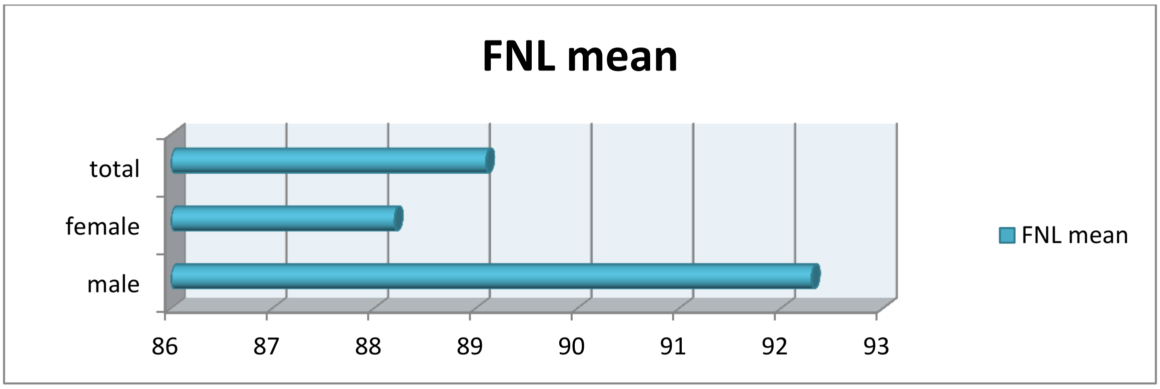
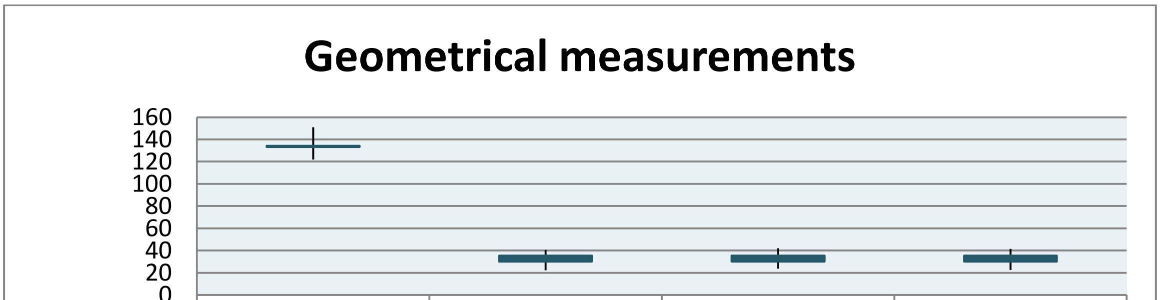


Figure 9 (FNL of study population)



	NSA	NW	NW130	NW135
male mn	134.31	35.56	35.38	35.44
lowest	122	22.2	23.5	22.6
highest	151	40.5	42.2	41.6
femae mn	130.55	26.22	26.28	26.48
total mn	133.13	29.95	29.92	30.06

Figure10 (Box plot of proximal femur geometric measurements for risk assessment)

INTRAOPERATVE VARIABLES	RANGE	MEAN ± SD
BLOOD LOSS(ml)	100-500	252.5±75.5
RADIOGRAPHIC EXPOSURE(times)	20-75	34.5±8.75
DURATION OF SURGERY(min)	25-90	42.5±25.65

Table – 13 (Intraoperative variables)

INTRAOPERATIVE COMPLICATIONS	NUMBER	PERCENTAGE
Varus angulation	2	1.66%
Drill bit breakage	3	2.5%
Fracture displacement by nail insertion	3	2.5%
Failure to put derotation screw	2	1.66%
Failure to lock distally	0	0
Jamming of nail	1	0.8%
infection	6(superficial)	5%
Guide wire breakage	5	4.16%
Open reduction	7	5.83%
Iatrogenic fracture femur	2	1.66%

Table 14 (Intraoperative complications)

Post operative assessments

VARIABLES	Number	Percentage
HIP stiffness	3	2.5%
Knee stiffness	6	5%
Non union	0	0
Shortening more than 1 cm	2	1.66%
Varus	2	1.66%
Screw cut out	0	0
Implant failure	1	0.8%
Pulmonary embolism non fatal	1	0.8%

Table –15 (Post operative complications)

Lag screw slide:

Type of fracture	Mean (mm)±SD	Range (mm)
A1	2.5±1.7	0-10mm
A2	3.6±2.25	0-15mm
A3	4.1±3.9	0-15mm

Table – 16 (Lag screw slide in A1, A2 and A3)

HOSPITAL STAY	MEAN (DAYS)±SD	RANGE (DAYS)
A1	5.8±0.6	5-8 days
A2	7.9±1.2	5-20 days
A3	10.3±2.3	7-20days

Table – 17 (Duration of hospital stay)

FULL WEIGHT BEARING	MEAN (WEEKS)±SD	RANGE(WEEKS)
A1	9.4±2.3	6-20 wks
A2	12.6±4.6	6-20wks
A3	14.4±3.7	10-24wks

Table – 18 (Time taken for full weight bearing)

MOBILITY AFTER SURGERY	NUMBER	PERCENTAGE
INDEPENDENT	82	68.33%
AIDED	26	21.67%
NON-AMBULATORY	12	10%

Table – 19 (Mobility after surgery)

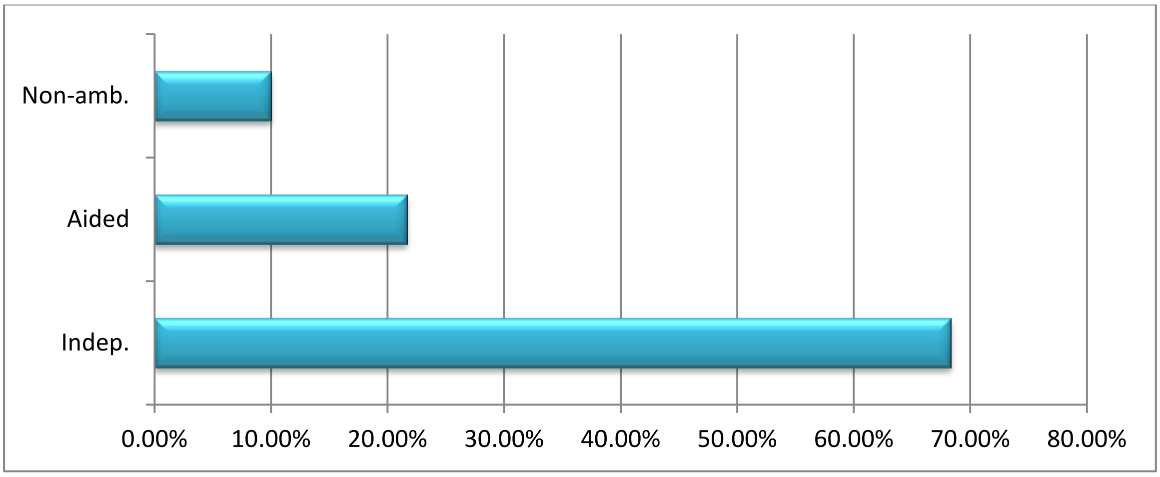


Figure 11(Mobility after surgery)

Mean mobility score	initial	1year follow up
A1	7.2.	6.5
A2	8.5	7.6
A3	9.0	7.5

Table – 20 (Mean mobility score comparison at follow-up)

FUNCTIONAL RESULTS	NUMBER	PERCENTAGE
EXCELLENT	88	73.33%
GOOD	20	16.67%
FAIR	12	10%

Table – 21(Functional results)

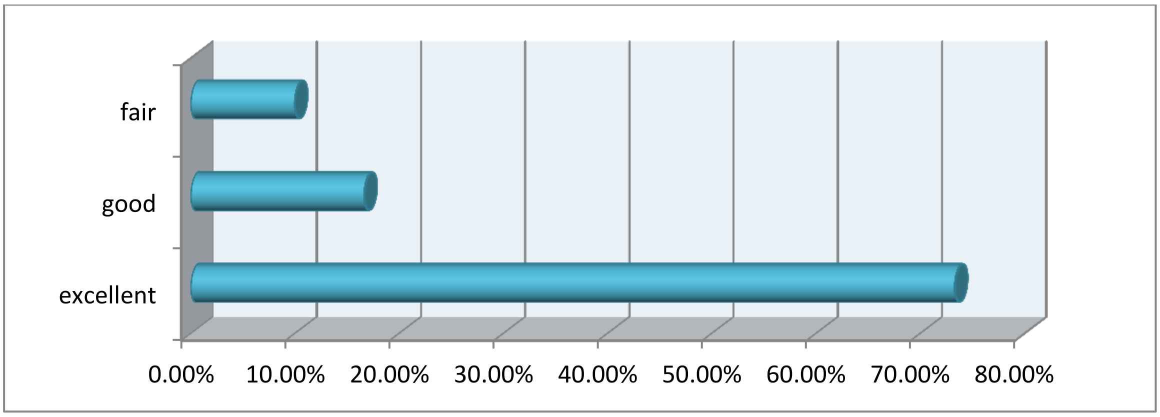


Figure 12(Functional results)

ANALYSIS

The following observations were made from the data collected during the study of 120 cases of intertrochanteric fractures treated by modified proximal femoral nail in department of Orthopaedic in Gulmohar Hospital Ranchi January 2008 – August 2010. Between January 2008 to August 2010, 48 men and 72 women aged 20 to 95 (mean 58.5 ± 15.41) years with trochanteric femoral fractures underwent modified PFN fixation and were followed up to12 months. All patients were followed up until clinical and radiological consolidation. In our study maximum age was 95 years and minimum age was 22 years. Most of the patients were between 50-80years. Mean age was 58.5 ± 15.41 (Table 5) Figure 2.In our study female were 60% (72 patients) and male 40% (48 patients).Figure 3

Patients had different etiological factors for proximal femur fractures, 75 patients had history of slip and fall (62.50%), road traffic accident contributed 15 cases (12.50%) (Table7) Figure 4. 65% (78) patients had right side affected (table 8).Figure 5

One patient had opposite side tibia fracture ipsilateral radius fracture, 5 patients had simple head injuries, 5 patients had bilateral radius fracture and 1 patient had associated ipsilateral calcaneum fracture. Fracture was classified with AO system. A1 type was 35% (42), A2 type 49.16 %(59) and A3 type 15.84 %(19) (table 9).Figure 6.

The mean NSA, NW, NW130 and NW135 and FNL are tabulated in Table 12. The NW was statistically wider in males than in females (35.56 ± 2.87 mm vs. 26.22 ± 1.81 mm; $P<0.001$). Present study also showed difference in neck shaft angle in gender, though the result not significant (male vs. female 134.31 ± 3.484 vs. 130.55 ± 4.26, $p>0.01$) (table 12) Figure 10.Indian patients generally had narrower NW (mean = 29.95±5.13 mm).

Looking into the box plot of NW, NW130 and NW135, all of these factors had approximately normal distribution and almost similar variability. The error bar showed that there was considerable overlap in the 95% confidence interval between all factors. This suggested little difference between them. We used the repeated measures ANOVA to analyze the relationship between NW, NW130, and NW135 for the patients. There was no significance difference between the measurements of width in NW, NW130 and NW135 ($P>0.01$) Table 10.

As shown in table 11, figure 7, Two female patient (2.77% of the sample population) had NW narrower than 22.5 mm and twenty female patients (27.7% of the sample population) had NW narrower than 25 mm. Twenty seven patients including both male and female of the sample population had NW 25mm to 27.5mm.twenty patient including both male and female patient had NW between 27.5 to 30 mm.Two of the patients had NW130 narrower than 22.5 mm(2.77%),nineteen females (26.38% of the sample population) had NW130 between 22.5 to 25 mm. 25% of the sample population had NW130 between 25 to 27.5.19.16% of the sample population had NW130 between 27.5mm to 30mm two female patient (2.77%of the sample population) had NW135 narrower than 22.5 mm, twenty females had NW135 between 22.5mm to

25mm .22.5% of the sample population had NW135 between 25 mm to 27.5mmn. 19.16% of sample population between 27.5 mm to 30mm. All male patients had NW, NW130 and NW135 more than 30 mm except one patient (2.08 %of male patient) table 11.Mean FNL for the total sample 89.1mm, for female 88.2, and for male 92.3. Range of FNL 105.7-78.6

All the cases included in our study group were fresh fractures that underwent surgery at the earliest possible in our setup. The delay was due to associated injuries and medical condition of the patient. All the patients were operated at interval between 2-12 days. The mean operating time was 42.5 (range, 25 – 90) minutes and mean blood loss was 252.5 (range, 100–500) ml. The mean duration of radiographic exposure was 34.5 times (range, 20-75times). (Table 13)

Intraoperative complications were very few. Varus angulation was seen in two (1.66%) male patients, drill bit breakage was encountered in three (2.5%) patients.
Fracture displacement by nail insertion happened in three (2.5%), guide wire breakage in five (4.16%), failure to put derotation screw in two (1.66%) and jamming of nail in one (0.8%). In no patient there was difficulty to lock distally. Iatrogenic fracture of lateral cortex happened in two (1.66%) patients, whereas seven (5.83%) required open reduction. Superficial infection developed in six (5%) patients. (Table 14)

In AP radiographs, 100% of lag screws appeared to be placed in the inferior part of the femoral head. In lateral radiographs, 90% of lag screws appeared to be placed centrally, 8% anteriorly, and 2% posteriorly. The optimal position—inferior on AP view and central on lateral view—was achieved in 90% patients.
There was no cut-out of lag screws, not even a knife or Z-effect. Hip stiffness occurred in three (2.5%), knee stiffness in six (5%) and Varus deformity in two (1.66%). No case of non union and shortening of >1cm seen in two (1.66%) patient. There was one case of implant failure (0.8%). One patient (0.8%) had non- fatal pulmonary embolism. (Table 15)

The overall mean lateral slide of the lag screw was 3.9 (range, 0–15) mm; it was 2.5 (range, 0–15) mm in A1, 3.6 (range, 0–15) mm in A2, 4.1 (range, 0–15) mm in A3 fractures. The mean lateral slide in A1 fractures was significantly less than that in A2 fractures ($p<0.01$). (Table16)

The mean duration of hospitalization was 6.7 (range, 5–20) days. For A1 fractures 5.8 (range, 5–8) days. For A2 fractures 7.9(range 5-20days), and 10.3 (range, 7–20) days for A3 fractures; the corresponding differences were not significant ($p>0.01$). (Table 17)

Time for full weight bearing was 9.4(6-20) weeks for A1, 12.6(6-20) weeks for A2 and 14.4 (10-24) weeks for A3. (Table 14) Eighty two (68.33%) could walk independently at six weeks, 26(21.67%) walked aided, whereas just twelve (10%) were non ambulatory (Table 18). One year postoperatively, the mean mobility scores of all fracture types decreased (A1: 7.2 to 6.5; A2: 8.5 to 7.6; A3: 9.0 to 7.5) but not significantly $p>0.01$. (Table 19) Final functional analysis showed excellent result in 88(73.33%), good in 20(16.67%) and fair result in 12(10%). (Table20)
Mobility assessed in all patients, 68.33% had independent mobility,21.67%had aided mobility ,and 10%where not able to ambulate (figure 11).A1 type of fracture had mean mobility score of 6.5, A2 type 7.6 and A3 7.5.(table 20). In all cases there was reduction in mobility score, but it was not very significant considering the number old age patients in sample population

Functional results was excellent in 73.33%, good in 16.67% and fair in 10% patient of sample, there was no poor result .(table 21, figure 12)

Follow-up

All patients were followed up at 2 weeks interval till fracture union, at 12 weeks & at 6 months post operatively. At each follow up radiographs of upper femur and hip were taken for assessment. (Table15). No major delayed complication seen.

DISCUSSION

Numerous implants are available both intramedullary and extramedullary and excellent results have been reported with all. One of the implants used for fixation of trochanteric fractures is proximal femoral nail. It provides stable internal fixation with biomechanical advantage of a shorter lever arm, which is more stable under loading. The anti-rotation screw prevents the rotational element of the proximal fracture fragment; the distal locking bolts more proximal than in other devices avoided the abrupt changes in stiffness of the construct thus decreasing the incidences of distal femoral fractures reported with the use of other similar devices. [18, 21, 3, 16]

The optimum outcome of treatment of any fracture depends upon: (1) Anatomical reduction. (2) Stable internal fixation. (3) Preservation of the blood supply to the bone fragments and the soft tissues by means of atraumatic surgical technique. (4) Early active pain free mobilization of muscles and joints (5) Good wound healing.

PFN fulfills most of the above mentioned criteria's.

It is clear from the above study that proximal femoral nailing have very low complication rate. If all precaution taken care preoperative, intraoperative and post-operative good results are expected. Very low infection rate as it avoids the long incision necessary for a long plate hip screw device, provides excellent functional results, early mobility and weight bearing allowing the old patients out of bed early thus preventing the complications of recumbancy, has low incidence of femoral shaft fracture at the tip of the implant as compared to other intramedullary implants, low nonunion / delayed union rates.

We conclude that proximal femoral nail is an attractive implant for proximal femur fractures and its use in unstable trochanteric fractures is very encouraging. This study has shown that this device can be safely used by the average surgeon in the average hospital to treat common and sometimes difficult fractures.

Proximal femoral geometry indeed influenced the risk of hip fracture [2, 19, 20, 26, and 31]. For this purpose, various parameters, including the neck-shaft angle (NSA) and femoral neck width (NW), femur neck length (FNL) were assessed. Evidence has shown that NSA, FNL, NW can be used together with bone marrow density measurement to predict the risk of hip fractures [6, 7]. Others had found that NW can also influence the prediction for the occurrence of fracture [8, 14].

Measurement of NSA, NW, NW130 and NW135 in Europe, Africa and Asia showed somewhat variable NSA (121.0°-132.1°) and NW (33.1-38.0mm) measurement. Some had shown that the femoral geometry differed in gender indicating that the female population had a narrower femoral neck and smaller NSA. Cadaveric studies had attempted to compare Asian proximal femoral geometry with the Caucasian population. Two studies had described and reported that femoral neck width for Asians (Hong Kong Chinese and Thai) were comparatively smaller than that of a Caucasian.

Most of these implants were initially designed based on measurements in Caucasian population. These implants are being used for the Asian population. This posed a possible problem of mismatch in the sizes of implant for the Asian population [35, 30, 40, and 41].

There are a few different types of intramedullary proximal femoral nail systems available for fixation of intertrochanteric. Most systems consist of an intramedullary femoral nail, a femoral neck screw or lag screw and distal femoral shaft locking screws. PFN employ an anti-rotational pin or hip pin fixation into the femoral neck adjacent to the femoral neck screw to give additional rotational stability. This configuration of fixation had shown to give better biomechanical stability in certain types of intertrochanteric fracture especially the reverse obliquity variant.

We found that the femoral neck width in our sample population was adequate for placement of femoral neck screw and anti-rotation pin using the modified PFN implant for Indian population. (Mean NW = 29.95±5.13mm,) Except for few cases(2 female),where neck width was less than 22.5mm, so putting anti-rotation screw was not possible with modified PFN implants. Even though the female population had smaller neck width (mean = 26.28±1.78mm) than males, it was still within an acceptable size for a femoral neck screw and an anti-rotation pin placement. The distance between the upper border of the anti-rotation pin and the lower border of the femoral neck screw is approximately 16.5 mm. In our experience, the margin of safety for placement of both the femoral neck screw and anti-rotational pin is approximately 5mm (3mm cranially and 3mm caudally).Thus, placement of both the screw and pin will be difficult in those with femoral neck width less than22.5mm, in this two female patients putting anti rotational screw was not possible. In this study, all the male patients had NW, NW130 and NW 135 more than 25mm

In respect to the changes in neck width working area in relation to the implant neck screw angle (130° and 135°), there was no significant difference. There was no difference between femoral neck width working area for both the 130° and 135° angle implants in our sample population. (Table 10)

Therefore, femoral neck screws and hip pins can be inserted at these prefix implant angles without any worry to the variance of the femoral neck width. The discrepancies in mean age noted between genders (Table 11, 12) can be explained by inferring to the etiology of the fracture .Male presented at younger age compared to female, as they came with motor vehicle accident or direct trauma. Female had more of osteoporosis related advance age fracture.

PFN fixed with 2 screws; the larger (lag) screw is designed to carry most of the load, and the smaller screw (the hip pin) is to provide rotational stability. If the hip pin is longer than the lag screw, vertical forces would increase on the hip pin and start to induce cutout, a knife effect or Z-effect. This might force the hip pin to migrate into the joint and the lag screw to slide laterally. The cut-out rate with a PFN is reportedly 0.6 to 8%. [28]

Although complication rates remain low, cut-out of either screw is a serious complication, which can lead to revision surgery and related morbidity. When the hip pin was 10 mm shorter than the lag screw, the percentage of the total load carried by the hip pin ranged from 8 to 39% (mean, 21%) no cut-out of the femoral head and no unacceptable implant or fracture displacement were observed. In our study, the hip pin was 10 to 15 mm shorter than the lag screw, and this may have prevented overloading the hip pin and cut-out in all cases. Unstable A2 fractures should be initially reduced to a slightly valgus position during PFN surgery, because the neck-shaft angle would decrease during the first 6 postoperative weeks .The lag screw should be inserted into the femoral head subchondral and inferior in AP view, central in LATERAL view. Anatomic and biomechanical studies have shown that the super medial quadrant of the femoral head is the weakest part for the implant, and therefore proper positioning of the screw is emphasized [21] .Cutout is usually resulted from poor positioning of the proximal screw in the femoral head, particularly in the osteoporotic bone.

In our study, the lag screw was inserted close to the subchondral bone, and the hip pin superior to the femoral head. This resulted in 90% of the lag screws being inserted at the optimal site (inferior to the centre of the femoral head) and to an optimal depth, thereby achieving rigid fixation. Lateral slide may occur more often in patients with a PFN, because of impaction of the fracture, rather than migration of the screws. cut-out of lag screws did not occur regardless of the extent of slide. Therefore, free sliding of a PFN may provide better impaction for unstable A2 fractures. The presence of an additional anti-rotational screw and the free sliding mechanism of the lag screw may increase rotational stability of cervico-cephalic fragments and decrease overload on the femoral head. Most of the patients were operated between 5-8-days after injury. Closed reduction was tried in all cases and achieved in all, except 7 cases. Modified Standard PFN was used in all cases. Nail of diameter 9mm was used in 41 cases which indicate that the canal diameter in Indian patients is quite low. Due to smaller diameter of neck of Indian femora we were not able to pass antirotational hip pin in2 patients. The average time required for surgery was 42.5min ±, 25.65mins with a range between 25-90 minutes. In 8 cases one unit of blood was transfused. The average hospital stay was 6.7days. Patients, with other associated injuries started weight bearing late. Unprotected full weight bearing was started when radiological evidence of union was seen; average time for radiological union was 13.9 weeks. 88 patients achieved full painless movements at hip and knee 20 had some restriction in movements at the time of final follow up. 12 patients had slight pain on activities

Various studies has been done to evaluate fracture risk using various anthropometry indicators as an independent or combined factors influencing risk for fracture.in our study mean FNL was 89.1, male mean 92.3 and female 88.2. Evaluating this data with NW and NSA, patients had smaller neck width; longer neck shaft angle with FNL can be used as indicator for fracture risk and can be alternative for BMD. Our results are in congruence with other studies done in Asian, western condition [3, 4, 11, 35, 41]

Critical analysis of the results of this series of proximal femoral nailing was done criteria laid by Kyle et al, Parker and Palmer the most common complication in our study was poor placement of screws which occurred in 3 cases. These were the cases done in the beginning of the study and once the learning curve was achieved this complication did not occur. The other complications encountered were as shown in table 14.

CONCLUSIONS AND RECOMMENDATIONS

Every trochanteric fracture must be assessed individually and it will be irrational to establish fixed routines of treatment. Numerous difficulties may arise in the management of unstable intertrochanteric fractures because (1) Proximal femoral fractures tend to occur in very elderly and debilitated, resulting in a relatively high rate of complications. (2) Degree of osteoporosis. (3) Complex geometry of proximal femur fracture (4) Comminution on the medial side / stability of the fracture. (5) The occasional limitation of movements at hip or knee due to stiffness (6) Neck geometry (7) Selection of proper implants.

These difficulties that have given rise to so much controversy among surgeons as to the best method of managing proximal femoral fractures. Various modalities of treatment exist. The conservative mode has gone into disrepute due to the complications associated with it, leaving only few indications for its use, like an elderly patient whose medical condition carries an excessively high risk of mortality from anesthesia and surgery, or non-ambulatory patient who has minimal discomfort following fracture. Operative management consisting of fracture reduction and stabilization, which permits early patient mobilization and minimizes many of complications of bed rest, has consequently become the treatment of choice for trochanteric fractures. [1, 2, 9, 10-12]

In conclusion, the femoral neck width is important factor in deciding choice of PFN implant variety in Indian population with shorter neck width as placement of femoral neck lag screws and anti-rotation pin in proximal femoral nailing.

However, case to case evaluation is still needed to exclude cases with extremely narrow femoral neck width, where an implant with a hip pin and lag screw is associated with difficult positioning of screw. Good reduction of the fracture, and optimal positioning and length of the hip pin and lag screws are crucial for the PFN procedure and reported to yield excellent outcomes.

Our results therefore suggest that a modified PFN is useful for the treatment of all types of trochanteric femoral fractures in Indian population.

FNL, NW,NSA was evaluated for fracture risk assessment, this can be used as independent predictor of fracture risk and can be alternative or supportive to BMD Although it need age matched control study to come to conclusion It need further study. All this data can be useful for future studies

If the geometry of the hip is related to fracture risk, geometric measurements might be used together with densitometry measurements for a better assessment of hip fracture risk than might be obtained from just a density measurement alone.

Summary

Femur neck geometry for placing modified PFN in contemporary Indian population is adequate. As neck width is small in Indian population so it is recommended to evaluate every patient separately

Anthropometry data obtained in present study, suggest modified PFN as treatment of choice for fracture of proximal femur

Outcome of modified PFN in present study shows excellent outcome in majority of cases

In femur neck geometry FNL, NW, NSA can be used as independent indicator for fracture risk assessment for proximal femur

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