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A prospective study of functional & radiological outcomes of subtrochanteric femur fractures treated by proximal femur nailing

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Abstract
Subtrochanteric fracture is a leading cause of hospital admissions in elderly people. The number of such admissions is on a raise because of increasing life span, sedentary habits, continuous, ongoing changes in people's life style, industrialization and urbanization and rapidly raising accidents. Conservative methods of treatment results in malunion with shortening and limitation of hip movement as well as complications of prolonged immobilization like bed sores, deep vein thrombosis and respiratory infections. This study is done to analyze the surgical management of Subtrochanteric fractures using Proximal Femoral Nail. This is a prospective study of 30 cases of fresh subtrochanteric fractures admitted to National Institute of Medical Sciences Hospital, between 01 – 01 -2015 to 31 – 06 – 2016. Excellent to good results are seen in 93.3% of cases of subtrochanteric fractures. From this study, we consider that PFN is an excellent implant for the treatment of Subtrochanteric fractures. The terms of successful outcome includes proper patient selection, a good understanding of fracture biomechanics, good preoperative planning, accurate instrumentation, good image intensifier and exactly performed osteosynthesis.

Keywords: PFN; Subtrochanteric, fractures

Introduction
Due to continuous, ongoing changes in life style of population, industrialization and urbanization, accidents are raising rapidly and this tendency will probably continue in near future which results in more & more accidents & trauma. Due to this many people are sustaining fractures. Subtrochanteric fracture of the femur occurs in the area that is 5 cm below the lesser trochanter [1] Proximal hip fractures are commonly seen in the adult population. Studies have shown that the incidence of proximal femur fractures is increasing with the increase in the life expectancy of the general population recently [1]. Subtrochanteric fractures are seen in 10 – 34% of all hip fractures which is equivalent to 10 -15% of proximal femur [1]. These fractures are also associated with osteoporosis. The mechanism of injury in elderly mainly constitute moderate or minimal trauma whereas in young individuals these are as a result of high energy trauma [1]. These fractures associated with high energy are associated with more complications as compared to the low velocity trauma. Subtrochanteric femoral fractures results due to high energy trauma. This was also common in contact sports to the tune that Ireland found that 2 out of 20 patients of subtrochanteric fractures were football players [2]. Every effort should be made to fix the fracture surgically as soon as possible. Surgery is treatment of choice in majority of cases. Patients expectations, our challenge & goal is to bring back early and prompt return to pre-functionality level. This also decreases the mortality and morbidity in such patients. The development of new and better implants due to improvements in the understanding of the biomechanics have improved the treatment outcome of subtrochanteric fractures, which have been historically difficult to treat [3-5]. The goals of surgical treatment of subtrochanteric fractures are anatomic alignment, stable internal fixation, rapid mobilization of the patient and early functional rehabilitation of the limb [6]. Historically, fractures of the proximal femur was treated

by side plates, IM devices, rods, screw bolts, static plates & Jewett nails etc. Among these, closed IM nailing has supplanted other forms of treatment, still complications & failures pose new challenges. Many internal fixation devices have been recommended for use in subtrochanteric fractures because of incidence of complications reported after surgical treatment [7]. Despite improved technology and internal fixation devices, malunion, implant failure, delayed union and infection occurs at a disturbing frequency [8]. Subtrochanteric femoral fractures are often associated with high rates implant failure and nonunion due to high stresses in this region. Selection of devices should be based on individual fracture anatomy and biomechanical research [7]. The proximal femoral intramedullary devices are proposed to treat intertrochanteric fractures, high subtrochanteric fractures and combination of these Fractures [9]. The proximal femoral intramedullary devices are useful for the treatment of isolated pathological lesions in the intertrochanteric/subtrochanteric region [9]. Biomechanically, the nail can withstand between 3to 5 times body weight [9]. Hence proximal femoral nail was introduced during 1997 & results are found better. We chose Proximal Femoral Nailing because it has a well proven design, additional anchoring, option for secondary dynamic locking, optimal stability, ease of insertion, prevention of fractures, etc. Proximal Femoral Nailing is an excellent implant for the management of unstable intertrochanteric and subtrochanteric femoral fractures.

2. Materials and Methods

The study consisted of 30 patients having subtrochanteric femoral factures, treated with Proximal Femoral nail at National Institute of Medical Sciences, Jaipur in duration of 18 months from JAN 2015 to June 2016

Inclusion Criteria

- Patients with Closed Subtrochanteric femur fractures aged 21 years and above.
- Gustilo- Anderson type 1 subtrochanteric femur fractures

Exclusion Criteria

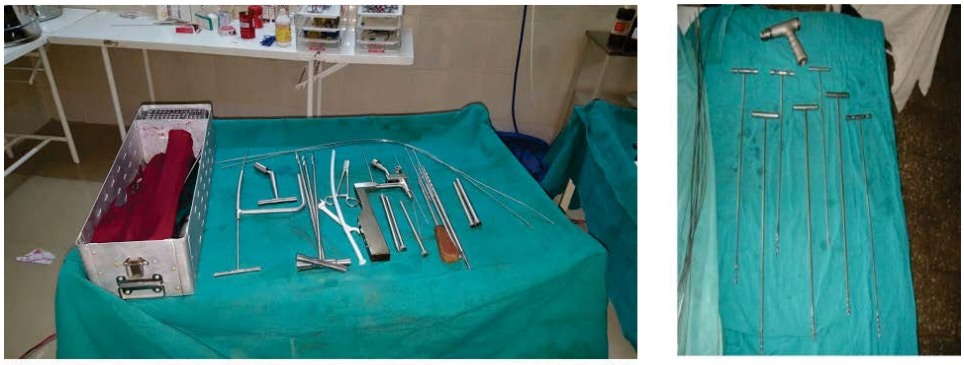
- Patients with Gustilo- Anderson type 2 and 3 subtrochanteric femur fractures.
- Children with subtrochanteric fractures whom growth plate is intact.
- Patients with pathological subtrochanteric fractures other than osteoporosis.
- Patients managed conservatively for other medical reasons.
- Subtrochanteric femur fractures with neurovascular deficit.

Management of patients

After admission patient with suspected subtrochanteric fracture, radiological examination of the pelvis with both hips was done and the patient was applied skin traction. The preoperative investigations were done for fitness.

Pre-Operative Planning

Nail Diameter, Neck shaft angle: Measure the unaffected side on AP x-ray and Length of nail: Measured between the tip of the greater trochanter and the upper pole of patella of the unaffected side.



1.1 A 1.1 B

Fig 1

Proximal femoral nail details

A proximal femoral nail, two proximal screws (1*8mm and 1*6.5mm), along with two 4.9mm with an end cap at distal locking bolts. Proximal femoral nail used.

1.1A – Tool box, jig, wrench, sliding hammer, sliding hammer rod, bone awl, screw drivers, guide wires, drill bits, hand reamer for reaming proximal femur.

1.1 B – Reamers of various sizes and gun for electrical drill.

Operative Techniques

A prophylactic antibiotic shot was given to the patient 1 hour before the surgery. All the cases in our study was operated under epidural and spinal anaesthesia.

3. Results

Age Distribution

Maximum age is 65 years. Minimum age 24 years and Mean age was 40.16 years I our study.

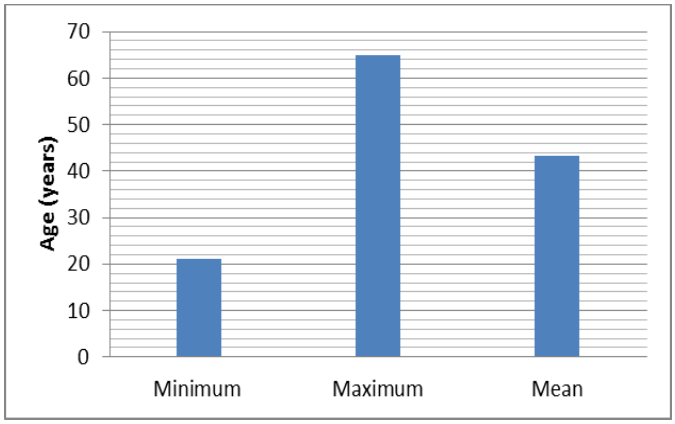


Fig 2: Showing minimum, mean and maximum age distribution.

Age Distribution

Table 1: Shows number and percentage of cases in various age groups.

Age group	Number of cases	Percentage
21-30	10	33.33%
31-40	4	13.33%
41-50	7	23.33%
51– 60	6	20.00%
61- 65	3	10.00%

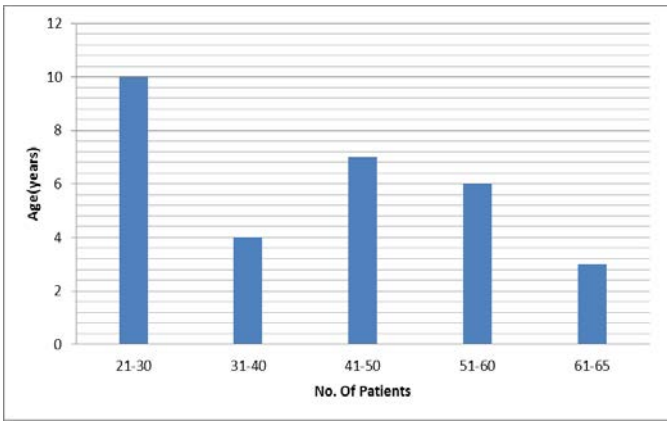


Fig 3: Shows number and percentage of cases in various age groups.

Sex Distribution

Majority of the patients are found males in this study i.e. out of 30 patients, 25 patients are males (83.33%) and 5 patients are females (16.66%).

Table 2: Shows number and percentage in each sex groups.

Sex	Number of cases	Percentage
Male	25	83.33 %
Female	5	16.66 %

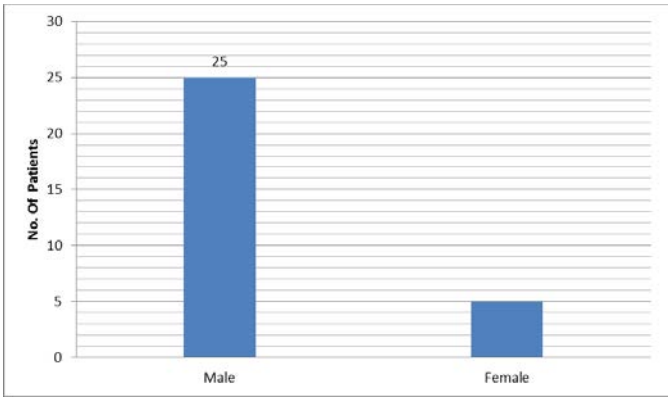


Fig 4: Showing Number of patients in sex group

Nature of Violence

In our study majority of the cases are RTAs and Self fall (46.6% and 26.6% each) and minority of the cases fall into fall from height and others group (16.6% and 10% each) - Table 3 and Fig 4 and 5.

Table 3: Showing various types of nature of violence.

Nature of violence	Number of patients	Percentage
Self-Fall	8	26.6
Road Traffic Accidents	14	46.6
Fall from height	5	16.6
Others	3	10.0

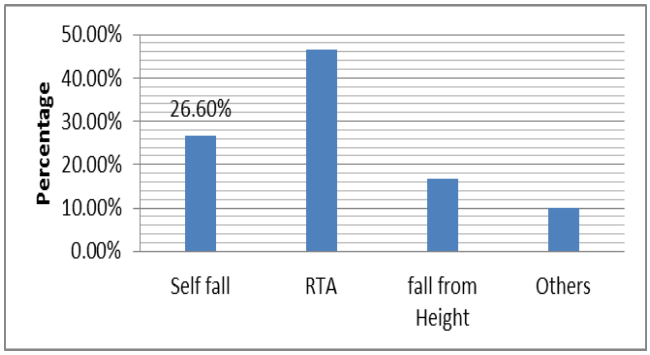


Fig 5: Showing no. of cases of various types of nature of violence.

Side Affected

In our study 19 patients were injured on right side (63.33%) and 11 patients were injured on left side (36.6%)

Table 4: Showing number and percentage of cases of right and left sides affected.

Side Affected	No. of Patients	Percentage
Right	19	63.3
Left	11	36.6

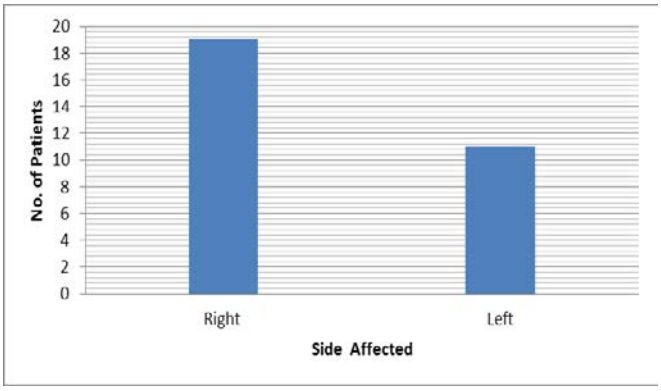


Fig 6: Showing Number of patients of right and left sides affected.

Associated Injuries

In this study one patient had fracture at the junction of upper and middle third ulna of right forearm. One patient had fractures of upper third of both bones of Right leg. One patient had undisplaced fracture of base of middle phalange of right middle finger.

Table 5: Showing number and percentage of cases with associated injuries affecting right and left sides.

	No. of Patients	Percentage
Cases without associated Injury.	27	90
Cases with associated Injury.	03	10

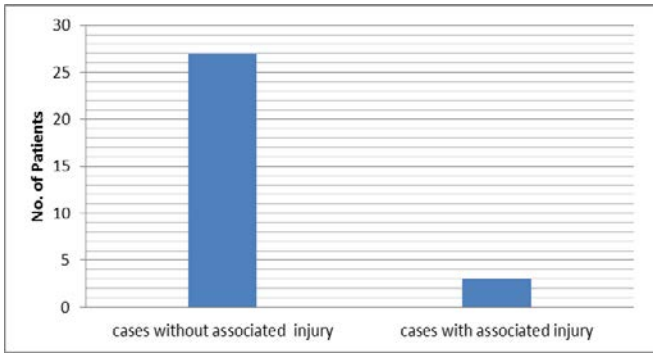


Fig 7: Showing Number of cases with or without associated injuries.

Classification of Subtrochanteric fractures

In this study, Subtrochanteric fractures are classified according to Seinsheimer Classification where Majority of fractures are type 2B and type 5 (26.6% of cases in each group), and least number of cases are from type 3b and no cases from type 1 are reported.

Table 6: Showing number and percentage of cases according to Seinsheimer classification

Type of fracture	No. of patients	Percentages
I	00	00
IIA	0 1	3.30
IIB	08	26.6
IIC	04	13.3
IIIA	04	13.3
IIIB	02	6.6
IV	03	10
V	08	26.6

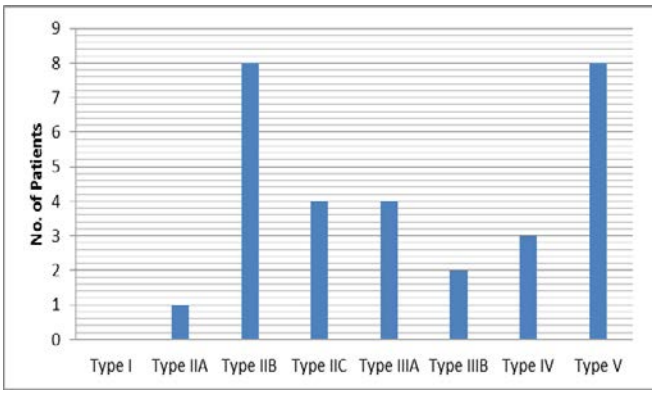


Fig 8: Showing number of cases according to Seinsheimer classification.

Time of Surgery

All the fractures were fresh which underwent surgery at the earliest possible in our hospital. Medical condition and associated injury of the patients was the reason for delay of the surgery. All the patients were operated at an average interval of 4.30 days from the date of trauma.

Intra operative details

In our study, we considered various intraoperative parameters such as duration of radiographic screening-more exposure in case of comminuted fractures with difficult reduction. Blood loss-measured by mop count (each fully soaked mop containing 50mlblood).

In our study, the average operative time was 80 minutes and average duration of x-ray exposure was 90 minutes, as compared to average operative time of 56 minutes and average x-ray exposure time of 60 minutes, in a study conducted by Pavelka T, Kortus J and Linhart M [34].

Table 7: Showing mean duration of screening, operation and blood loss.

Mean duration of screening (x-ray exposure - in seconds)	90
Mean duration of operation (in minutes)	80
Mean blood loss (in millilitres)	130

Intraoperative Complications

In our study, we had two Intra operative complications (8.33%) as compared to 14 intra operative complications (9.52%) in a study conducted by Pavelka T, Kortus J and Linhart M. [34] in one case we experienced jamming of the drill sleeve and in one case we had guide wire breakage. However, in both the cases we were able to manage the cases accordingly, i.e. the jammed drill sleeve was removed and the surgery was continued using another drill sleeve and in another case the broken guide wire was also removed successfully.

Table 8: Table showing number and percentage of intraoperative complications.

Complication	No. of Patients	Percentage
Jamming of instruments	1	3.3
Failure of distal locking	1	3.3
Breakage of guide wire	1	3.3

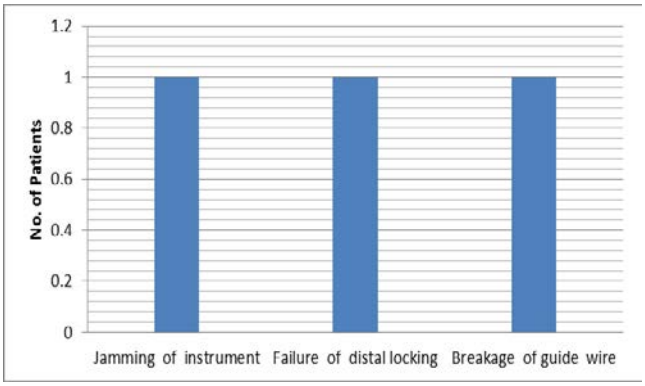


Fig 9: Showing number of intraoperative complication

Post-operative complications

In immediate post-operative period no complications.

Delayed Complications

We had one case of implant breakage, 3 cases of delayed union, 1 case of shortening of 1.5 cms in one case due to varus collapse and 1 case of secondary infection.

Table 9: Showing number and percentage of delayed complications

Complication	Number of cases	Percentage
Hip joint stiffness	00	00 %
Knee joint stiffness	00	00 %
Delayed union	03	10 %
Nonunion	00	00 %
Shortening of >1cms due to varus collapse	01	3.3 %
Implant failure	01	3.3 %
Sec Infection	01	3.3 %

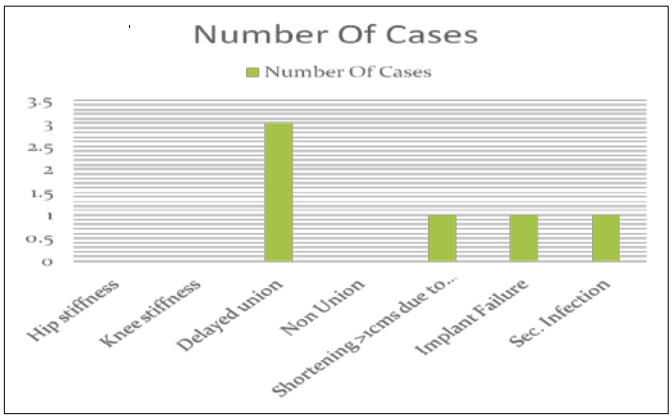


Fig 10: Showing number of delayed complications

Results of the surgery

Table 10

Anatomical result	Good	Poor
Shortening	≤ 1cm	>1cm
Varus deformity	Absent	Present

Hip movements	Full range	Restricted
Knee movements	Full range	Restricted

Functional Results
Based on following haris hip scoring system was assessed.

Hip pain
Assessment of Results

- Average duration at hospital stay was 6.83 days.
- Full weight bearing observed was 12.75 weeks as mean time.
- All patients met with good range of hip and knee range of motion.
- Post-operative mobility was aided in immediate period but later all patients were ambulatory independently with or without walking aid after 6 weeks, except in two patients.

Table 10: Showing assessment of results.

Mean duration of hospital stay	6.83 Days
Mean time to full weight bearing(in weeks)	12.75 Weeks
Total no. of cases in which full range of movements (12 weeks postoperatively) are present	
Hip joint –0 to 110	28
Knee joint—0 to 120	30

Follow Up
Follow up was done at 6 weeks, 12 weeks, 6 months and some patients upto 1 year and further if required. Radiograph of operated hip with upper half femur was done AP and lateral view and assessed for fracture union and implant failure which also included screw cut out at each follow up.

Anatomical Results
Anatomical results were recorded by clinical presence or absence of deformities, shortening, hip and knee range of motions. One patient had shortening of 1.5 cms in this study.

Functional Results
In our series of 30 operated cases, no deaths reported during the study period.

Table 11: Showing Functional results of subtrochanteric fracture treated with PFN.

Functional results	Number of cases	Percentage
Excellent (90-100)	24	80 %
Good(80-90)	5	16.6 %
Fair(70-80)	1	3.3%
Poor <70	0	0 %

Associated medical problems

- Four patients had Hypertension for which they were on treatment.
- Four Patients had hypertension with Diabetes Mellitus for which they were on treatment.
- Two patients had Diabetes Mellitus for which they were on treatment.

Radiological Assessment

Table 12: Showing radiological evaluation

Union Time (Weeks)	No. of cases
6 TO 18 weeks	20
19 TO 24 weeks	07
25 TO 36 weeks	03
More Than 36 weeks	00

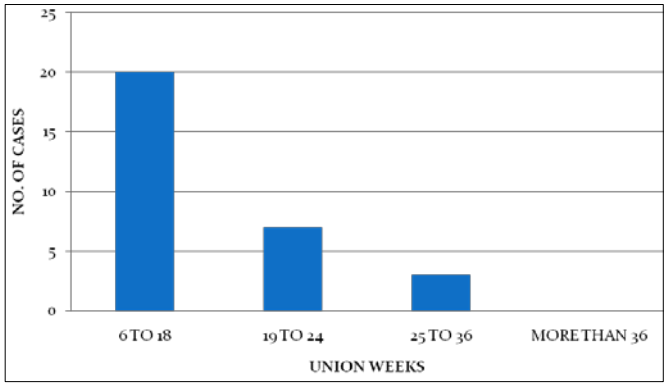


Fig 11: Showing radiological Evaluation in our series.

4. Discussion
Fractures of the proximal femur are challenging injuries for the orthopaedics surgeon. The subtrochanteric femoral fracture treatment is associated with some failures. The reasons may be as follows: disregarding the biomechanics, overestimation of new surgical techniques potentials or not following the established protocols [10]. The results of treatment of this type of fracture in young and middle-aged adults are also influenced by the amount of trauma suffered at the time of injury [11]. These factors makes the surgeon to think about proper selection of the implant. Subtrochanteric femoral fractures is one of the most challenging and difficult fractures faced by orthopaedic surgeons. Non operative management of such fractures have difficulty in maintaining and obtaining reduction and hence, operative treatment is advisable. The high amount of stresses in the subtrochanteric region makes the designing of the ideal implant difficult. Muscular forces exerted on the proximal fragment causes difficult reduction and fixation [15]. Although there are many treatment options for subtrochanteric, there is now a trend towards the use of devices intramedullary. The nature of such fracture geometry and the problems with the intramedullary fixation has made it technically a demanding surgery. For successful nailing in the subtrochanteric fractures good knowledge of the anatomy and the implant is necessary. The commonly used devices for fixation nowadays variety available blade plate, sliding screw and Intramedullary devices. Theoretically, there are biomechanical advantages of intramedullary devices, but these have not been seen in the clinical practice. Results have been comparable weather intramedullary or extramedullary devices have been used.
Excellent clinical results for unstable subtrochanteric fractures treated with second generation nails have been reported. Intramedullary device are inserted by means of closed reduction and internal fixation. This has the advantage of preserving the fracture haematoma which is the first step for the fracture healing. It also ensures minimal blood loss, minimal soft tissue dissection and other wound complications. The strength of the implant bone construct would be greater in younger patients with stronger bone. As the subtrochanteric fracture is not

common hence, the learning curve is slow and it takes a long time to gain experience. It has been seen that the rate of complications decrease with the increase in the learning curve, as the surgeon gains experience he can decide the right implant for the subtrochanteric femur fracture [15].

Blade plates provide stability and provide high union rate in such fractures. Severely comminuted sub trochanteric femoral fractures are extremely difficult to stabilize and may lead to failure of fixation and device failure [10]. Initially gamma nail was preferred in such fractures as it allowed early weight bearing [11]. The Gamma nail which was designed for intertrochanteric and subtrochanteric fractures which are unstable. Operative complications noted were few. Distal locking screws allows to maintain stability rotationally. Fair fracture union noticed with loss of position in few cases, even seen in comminuted fractures [12]. Accurate reduction followed by proper surgical planning and technique intra-operatively is most important in the management of unstable trochanteric fractures with the PFN.PFN is said as a novel, modern intramedullary implant based on experience with the gamma nail [34]. The gamma nail observed as technical and mechanical failure rates of nearby 10% and is susceptible to fail at the lag screw-implant interface which is its weakest point. The Arbeitsgemeinschaft fur osteosynthesefragen (AO ASIF) in 1996, invented a proximal femoral nail with special an anti-rotational hip pin with distal shaft diameter reduction for minimization of the stress concentration to avoid failure of implant. The main nail advantages are: it decreases the moment arm, closed technique insertion, retains the fracture haematoma which is most important and valuable for fracture healing, lower infection rate, decreases blood loss amount, minimizes dissection of soft tissue and lastly wound complications. Simmermacher *et al.* (1999) [13], concluded PFN as technical failures after inadequate reduction, wrongly selection of screws in 5% of the cases in their study conducted. But in our study no such complication as poor reduction, mal rotation or cut out of screws were encountered. No single case of intraoperative fracture displacement observed in using the PFN as implant. Also we did not encounter any intraoperative fracture displacement after nail insertion. In comparison to gamma nail, we did not encounter neither any fracture of the femur nor any break in the implant intraoperatively. The aims and objectives of this study are to study subtrochanteric fractures of femur in adults and its biomechanics, to study the outcome of surgically managed subtrochanteric fractures with Proximal femoral nailing, to reestablish the anatomy of subtrochanteric fractures perfectly by operative treatment using proximal femoral nailing, to assess the union of subtrochanteric fractures of femur after surgical treatment using Proximal femoral nailing, the stable fixation and early mobilization of the subtrochanteric femoral fractures and the post-operative restoration of the walking ability of the patients with subtrochanteric femoral fractures. The criterias for the assessment of efficiency in our study for surgical technique including surgery duration, complications during surgery, blood loss and radiographic screening time. Assessment and examination clinically which included hip and knee function, Post-operative walking ability, fracture union time period and implant bone interaction also. In our study subtrochanteric fractures were more commonly due to RTA and self falls. In our study the age group was from 21 years upto 65 years of age, we had range of patients from 24 years to 65 years with 42.16 years as the mean. The maximum no. of cases (7 cases – 29.16%) were found between 21 to 30 years and minimum number were seen in the age group limit of 51-60 years (3 cases –12.5%), as compared to the mean age of 69 years in a study conducted by Pavelka T, Kortus J and Linhart M [14]. While in our study most fall in the age group 21–30 years (29.16%). Males gender were more commonly affected than females, males accounting to 19 cases contributing to 79.16% of cases and females contributed to 5 cases making 20.83% of cases, as compared to 40.1% male patients and females as 59.86%, in a study conducted by Pavelka T, Kortus J and Linhart M [14]. In our study, the average operative time was 80 minutes and average duration of x-ray exposure was 90 minutes, as compared to average operative time of 56 minutes and average x-ray exposure time of 60 minutes, in a study conducted by Pavelka T, Kortus J and Linhart M [14]. In 2015 a study by O'Malley *et al.* [16] recorded 46 patients of unstable trochanteric fractures treated with intra-medullary devices and observed that an average of a 7 mm lateral shift of the distal femoral shaft (i.e "Wedge effect") in their study. In our study, we made sure a nearby anatomical neck shaft angle and supported the poster-medial cortex with graft when required to ensure no varus collapse occurs. (in Case no.2 & 12) In 2015 a comparative study by Muller *et al.* [17] between PFN and DHS, concluded a significantly higher rate of screw cut-out in PFN cases. But no such thing observed in our study. The PF-LCP implants used in our study has the advantage of having three locked screws in place which offer more great stability with a less screw cut out risk. Right sided fractures were slightly more than left sided fractures accounting to 13 cases, which made for 54.16% of cases and left sided fractures accounted for 11 cases making 45.83% of cases. In our study, Seinsheimer type 2b and type 5 contributed 6 cases in each group, making to 25% in each group followed by type 3a contributing to 4 cases and making to 16.66%. In our study 100 seconds were as the mean duration of radiation exposure, mean duration of surgery was found 90 minutes and mean blood loss observed was 130 ml. The rate of postoperative infection with the proximal femoral nailing is very low because of small wound and less surgical dissection. In our work, there was one case of superficial infection (5%) [case no. [2]] and one case of deep infection (5%) [case no. [12]], which started 3 months after surgery. Rethnam and colleagues reported infection in three out of 42 patients treated with a Russell-Taylor reconstruction nail: A superficial wound infection in one patient which settled with intravenously antibiotics and the other two patients underwent surgical debridement. Alvarez *et al.* [18] reported two out of 42 cases that developed infection. In the intraoperative period, in one case we had jamming of the drill sleeve and in one case we had breaking of the guide wire, however, the jammed drill sleeve was removed and operation was continued using another drill sleeve and in case of guide wire breakage, it was removed successfully and we did not put hip screw in 8 cases and distal locking was not done in one case. 26.83 days were the mean duration of hospital stay, 12.75 weeks were the mean time for full weight bearing. All patients post operatively were ambulatory out of which two required walking aids. One patient had 1.5cms shortening, after fracture union seen on x-ray was managed conservatively with sole rise as compensation. All patients in our study had good range of hip and knee motion except four patients had hip restrictions and three patients suffered knee restrictions of movements. In our study, no deaths were reported during the study period. Over all 70.83% of patients had excellent results, 8.33% of patients had good results, 12.5% of patients had fair results and only 2 cases i.e 8.33% of patients had poor results with average HSS of 91. Kumar *et al.* [29] in his study had an average HSS of 97 in the PFN group at 2 years follow-up compared the outcome of trochanteric fractures treated with DHS and PFN.

5. Conclusion

In this study, 30 patients with subtrochanteric fractures of femur were surgically managed by Proximal Femoral Nail. The data was assessed, analyzed, evaluated and the conclusions were concluded: Early reduction and internal fixation which increases patient comfort, helps nursing care, helps in early mobilization and decreases the duration of hospitalization as the fracture is seen more common in the elderly group age. Anatomical reduction can be managed by closed manipulative methods. PFN has the advantage of collapse at fracture site as it is done by closed technique and which prevents collapse at fracture site and maintains neck shaft angle and neck length. Distally fixed in both dynamic and static mode so later in cases of delayed union it can be dynamised. The entry point at the tip of trochanter is the very important step in this procedure. Out of the two neck screws the proximal one is derotation screw and the distal one is collapsing screw with placement in the centre of neck and head. 6º mediolateral angulation in the nail for prevention of the medial collapse and a 135º neck shaft angle for maintenance of the normal neck shaft angle. Post-operatively early mobilization is allowed as the fixation is rigid and because of the implant design. The fixation by a PFN markedly reduces the morbidity and mortality, in the elderly group in whom the fracture is most common. If the technical details are achieved, the function of the hip joint is regained to almost near normal and the rehabilitation of the patient is smooth clinically. Most of the complications observed are surgeon and instruments related. They can be reduced by good preoperative planning and selection of patients. The operative time, radiation exposure, blood loss and intraoperative complications for treatment of subtrochanteric fractures by PFN can be reduced with the experience and knowledge gained from each case.

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