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Functional outcomes of subtrochanteric fractures of femur treated with long proximal femoral nail (PFN)

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Abstract
Background and Objectives: Subtrochanteric fractures of the femur remain one of the most challenging fractures facing orthopaedic surgeons. Most fractures in the elderly results from trivial fall from standing or walking, while in the younger age group it is mainly due to road traffic accidents. Closed management of these subtrochanteric fractures poses difficulties in obtaining and maintaining a reduction, making operative management the preferred treatment. Hence this study intended to determine the effectiveness of intramedullary fixation of subtrochanteric fractures with long proximal femoral nail and the complications involved in the management of subtrochanteric fractures.
Methodology: This is a prospective study of 25 cases of Subtrochanteric fracture admitted to Rajah Muthiah Medical College and Hospitals between May 2016 and Aug 2018 treated with long proximal femoral nail. Cases were taken according to inclusion and exclusion criteria, ie. Fresh Subtrochanteric fracture in adults. Pathologic fractures, multiple fractures, fractures in children, old neglected fractures were excluded from the study.
Results: In our study of 25 cases, there were 16 male and 9 female patients with age ranging from 17 years to 75 years with most patients in between 21-40 years; 67% of the cases admitted were road traffic accidents, 23% due to fall from height and 10% due to trivial fall with right side being more common side affected. Seinsheimer Type IIIA fracture accounted for 40% of cases. Mean duration of hospital stay was 12 days and mean time of full weight bearing was 14 weeks in our patients. Out of 25 cases. Good-to-excellent results were seen in 80% of cases in our study.
Conclusion: From our study, we conclude that long PFN is a reliable implant for subtrochanteric fractures leading to hig rate of bone union and minimal soft tissue damage. Intramedullary fixation has biological and biomechanical advantages but the operation is technically demanding. Gradual learning and great patienceare needed in order to make this method truly minimally invasive.

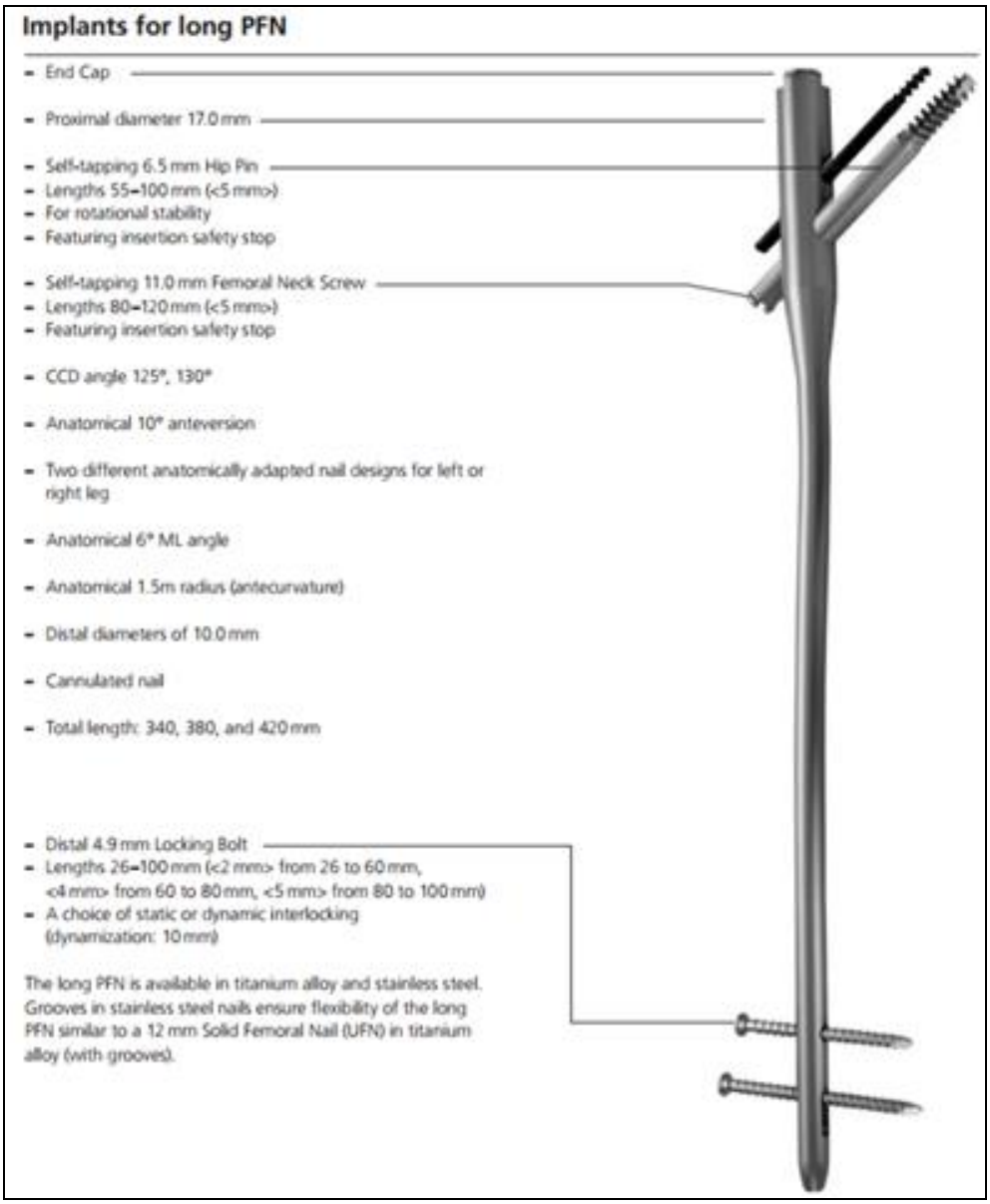
Keywords: long PFN, subtrochanteric fractures, seinsheimer classification, harris hip score

Introduction
Subtrochanteric fractures are femoral fractures occursbelow the lesser trochanter to 5 cm distal ly in the shaft of femur [1]. These fractures occur typicallym at the junction between trabecular bone and cortical bone where the mechanical stress across the junction is highest in the femur, which is responsible for their frequent commination. These fractures account for 10% to 34% of all hip fractures [2]. The subtrochanteric region is usually exposed to higher stresses during activities of daily living Axial loading forces through the hip joint, create a large lever arm with significant lateral tensile stresses and medial compressive loads. In addition to the bending forces, muscle forces at the hip also create torsional effects that lead to significant rotational shear forces. During normal activities of daily living, up to 6 times the body weight is transmitted to the subtrochanteric region of the femur. As a result of these high forces, the bone in this region is a thick cortical bone with less vascularity and results in increased potential for healing disturbances. Hence, subtrochanteric fracture is difficult to manage and associated with many complications [3]. Closed management of these subtrochanteric fractures thus poses difficulties in obtaining and maintaining a reduction, making operative management the preferred treatment. The goal of operative treatment is restoration of normal length and angulation to restore adequate tension to the abductors and to start early mobile sation and weight bearing. Hence, the objective of this study is to determine the rate of union, complications, operative risks and functional outcomes in subtrochanteric fractures treated with the long proximal femoral nail [3].

Methodology

The present study consists of 25 adult patients with subtrochanteric fractures of femur who were treated with long PFN in Rajah Muthiah Medical College and Hospitals between May 2016 and Aug 2018, after getting clearance from Institutional Ethical Committee and Academic Review Board. The fractures were classified according to Seinsheimer classification; 25 cases were followed at regular intervals. Only fresh Subtrochanteric fractures in adults were included in the study. Pathological fractures, Fractures in children, Old neglected fractures and Peri-prosthetic fractures were excluded from the study. As soon as the patient with suspected subtrochanteric fracture was seen, necessary clinical and radiological evaluation was done and admitted to the ward after necessary resuscitation and splint age with skeletal traction. Routine blood investigations were done on all patients. With adequate preoperative planning, which includes measuring thedia meter of the femur at the level of Isthmus for nail diameter and neck shaft angle by goniometer. In our study, we used the standard length PFN of 340-440 mm with distal diameter of 9, 10, 11 mm.

Instrumentations

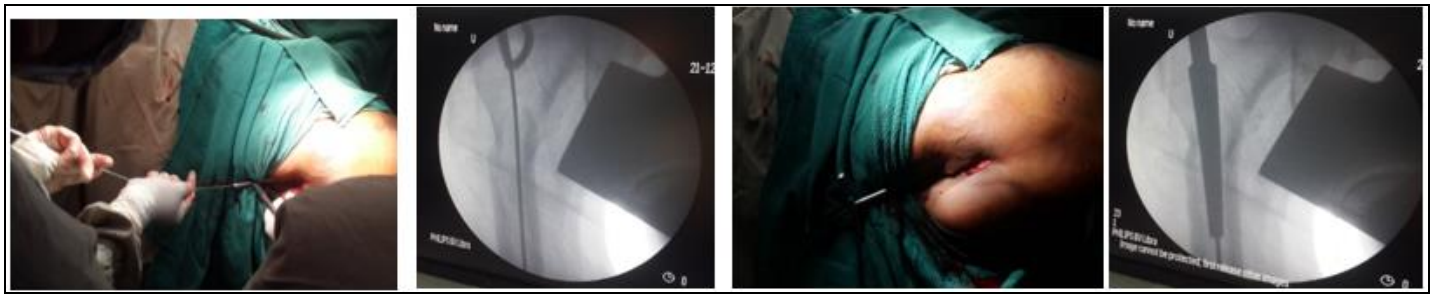


Operative Technique

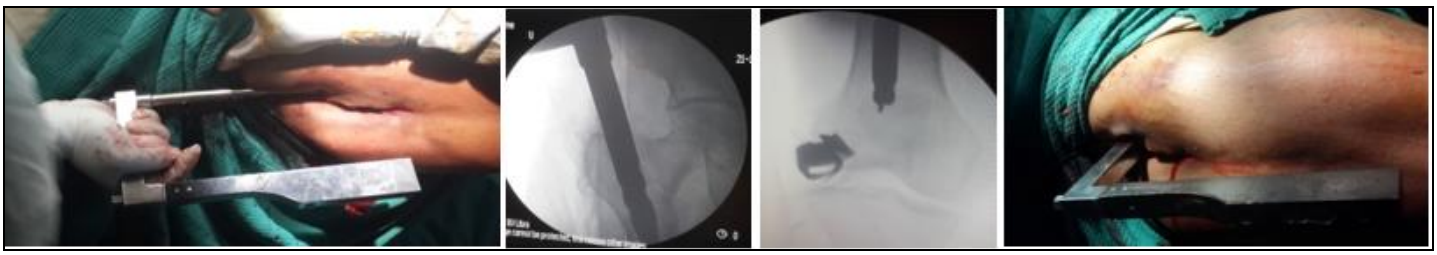
The patient is placed in supine position on fracture table with adduction of the affected limb by 10-15 degrees and closed reduction of the fracture was done by the traction and internal rotation and checked under image intensifier. Open reduction is performed if closed reduction failed. Prophylactic antibiotic is given in all patients 30 minutes before surgery. A5 cms longitudinal incision was taken

proximal from the tip of the greater trochanter. A parallel incision was made in fascia lata and gluteus medius was split in line with the fibres. Tip of greater trochanter is exposed. In AP view on C-arm, the entry point is on tip of greater trochanter. Then medullary canal entered with a curved bone awl; the guide wire is inserted into the medullary canal. Using a can nulated conical reamer, proximal femur is reamed for a distance of about 7 cms. After confirming satisfactory fracture reduction, an appropriate size nail as determined preoperatively is assembled to insertion handle and inserted manually. A 2.8 mm guide wire is inserted through the drill sleeve after a stab incision. A second 2.8 mm guide wire is inserted through the drill sleeve above the first one for hip pin. Drilling is done over 2.8 mm guide wire until the drill is 8 mm short of tip of the guide wire. Neck screw is inserted using can nulated screw driver. Similarly, appropriate length hip pin is inserted. Length and position of the screw are confirmed with C-arm image. Distal locking is usually performed with two cortical screws with free hand technique. Locking screw is inserted and position confirmed with image intensifier. Wound closed in layers and sterile dressing applied over wound and compression bandage given. Antibiotics were continued in postoperative period. Suture removed on the 12th post-operative day. Patients were taught Quadriceps static exercise and knee mobile sation in immediate postoperative period. Patients were taught gait training before discharge from hospital. All patients were followed up at 4 weeks, 12 weeks and every 6 weeks thereafter till fracture union is noted; then at 6 months, 9 months and 1 year. At each visit, patient was assessed clinically regarding hip and knee function, walking ability, fracture union, deformity and shortening. Hip function was assessed by Harris Hip score. X-ray of the pelvis with both, hip with thigh Antero posterior and Lateral full length was taken to assess fracture union and implant bone interaction.

Supine/Fracture Table | Incision Proximal To Gt | Entry Made Medial to Gt



Guide Wire Passed | Serial Reaming/Entry Reaming



Nail Passed

Head Screw/Derotation Screw

Distal Locking

Observation and Results

In our study, maximum age was 80 years and minimum age was 18 years. Most of the patients were between 21-40 years. Mean age was 37.53 years. The number of male patients in our series were 16 and female were 9. Right side was affected in 13 cases and left in 12 cases. The most common mode of injury in our series were road traffic accidents accounting for 10 cases followed by fall from height in 9 cases and trivial fall in 6 cases. The 25 subtrochanteric fractures in our study were classified according to Seinsheimer classification. In our study we had 6 cases of IIA, 5 cases of IIB, 6 cases of IIIA, 5 cases IIIB and 3 cases of IV Seinsheimer classification. All the patients were operated at an average interval of 10.6 days from the day of trauma. All the patients' intraoperative details were noted in terms of the duration of surgery, ease of reduction, complications, radiation exposure and amount of blood loss. In our series, we had 2 cases of superficial wound infection, which required intravenous antibiotics for 3 weeks' period. No other complications like Deep Venous Thrombosis, Systemic Infection, Acute Respiratory Distress Syndrome, Fat Embolism, etc.

The average duration of hospital stay following surgery was 12 days ranging from 10 to 14 days. All patients were followed up at 4 weeks, 12 weeks and every 6 weeks thereafter till fracture union is noted. Then at 6 months, 9 months and 1 year, 1 patients failed to attend the first follow-up and were lost for further follow-up and patients expired due to cardiac failure. At each follow-up radiographs of upper femur and hip were taken to assess the fracture union, implant failure and screw cut out. Radiological union was said to be achieved on the evidence of obliteration of fracture lines and trabecular continuity between the two fragments on antero-posterior and lateral X-rays in three cortices.

Anatomical Result

Anatomical results were assessed on 25 patients available for follow-up by presence or absence of shortening, varus deformities and range of movements in hip and knee joints; 77% of the cases had good results and 23% had fair results.

Functional Results

Functional results were assessed in 25 cases available for follow-up by Harris Hip scoring system.

Discussion

Subtrochanteric fractures are usually the result of high-energy trauma and often subjected to significant displacement and great difficulty in close reduction through traction. The high incidence of delayed union, malunion and non-union of fractures has left conservative treatment as advocated by De Lee *et al.*..., abolished in modern trauma care [4]. Allowing a minimally open approach, intramedullary nailing is closely linked to "biological internal fixation," in addition to its mechanical benefits over plate fixation. Intramedullary fixation allows the surgeon to minimise soft tissue dissection thereby reducing surgical trauma, blood loss, infection and wound complications [5, 6]. The AO ASIF in 1996, therefore, developed the long Proximal Femoral Nail to reduce the risk of implant related complications. Therefore, in addition to the 8 mm load bearing femoral neck screw, the long PFN has a 6.5 mm anti-rotation screw to increase the rotational stability of the neck fragment. Also minimises stress concentration and tension in the femoral shaft. This should reduce the risk of intraoperative and postoperative femoral shaft fractures. Long PFN also has all the advantages of an intramedullary device such as decreasing the lever arm, can be inserted by closed technique which retains the fracture haematoma, decreases blood loss, minimizes soft tissue dissection and wound infections. In an experimental study, Gotze *et al.*.... (1998) compared the loadability of osteosynthesis of subtrochanteric fractures and found that the long PFN could bear the highest loads of all devices [7]. The aim of our study was to assess the functional outcomes of subtrochanteric fractures with this newer method of intramedullary fixation with the long proximal femoral nail. We assessed the results with respect to intraoperative details, post-operative results and functional outcome. In 2002, Inger B Schipper in his study on biomechanical evaluation of long PFN also concluded that if the hole through the nail of the hip pin was modified to a slot, there is a significant reduction of axial loads on hip pin, thereby reducing the cut out risk [8].

Werner *et al.*... was the first who introduced the term Z- effect, detected in 5 (7.1%) of 70 cases. The incidence of the cut-out of the neck screw in this study was 8.6%. The Z-effect phenomenon is referred as a characteristic sliding of the proximal screws to opposite directions during the postoperative weight-bearing period [9]. The most recent study evaluating the use of long PFN is from Fogagnolo *et al.*..., who reported 46 patients with an average rate of intraoperative technical or mechanical complications of 23.4%. They also reported 2 implant failures and 1 fracture below the tip of the nail [9]. In our study, we had no implant failure and intraoperative technical problems like failure to put derotation screws in 2 cases (5%). Daniel FA Menzes *et al.*... and Axel Gamulin (2005) in a clinical study of 155 consecutive patients treated with long proximal femoral nail, reported failure of fixation in 2%, femoral shaft in 0.7%, fixation failures included one cut out, one delayed fracture healing and one lateral displacement of the antirotation screw

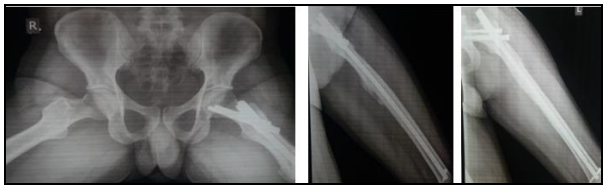
[10]. In our study, no failure of fixation occurred. Simmermacher *et al.*... (1999) in a clinical multicenter study, reported technical failures of the long PFN after poor reduction, malrotation or wrong choice of screws in 5% of the cases. A cut-out of the neck screw occurred in 0.6% [11]. In our study, we had 4% failure rate with 1caseof delayed union.

Conclusion

Subtrochanteric femoral fractures are usually treated surgically. In the last decade, extra medullary methods of fixation with various angular plates or with a compression hip screw with a plate are more and more replaced by newer intramedullary techniques because of their advantages: The surgical procedure is faster, the blood loss is smaller, the bone healing mainly remains in the reduced position with biomechanically strong fixation, what allows earlier weight bearing on the bone with less local and general complications. Because of increasing occurrence of subtrochanteric fractures in younger age active males, higher demand is placed on treating surgeon to restore near normal function. Osteosynthesis with the long proximal femoral nail offers the advantages of high rotational stability. Long Proximal femoral nail has the advantage of collapse at fracture site and is biomechanically sound as it is an intramedullary device. Postoperatively, early mobilization can begin as the fixation is rigid and the implant design. From our study, we conclude that long PFN is a reliable implant for subtrochanteric fractures leading to high rate of bone union and minimal soft tissue damage. Intramedullary fixation has biological and biomechanical advantages, but the operation is technically demanding. Gradual learning and great patience is needed in order to make this method truly minimally invasive.

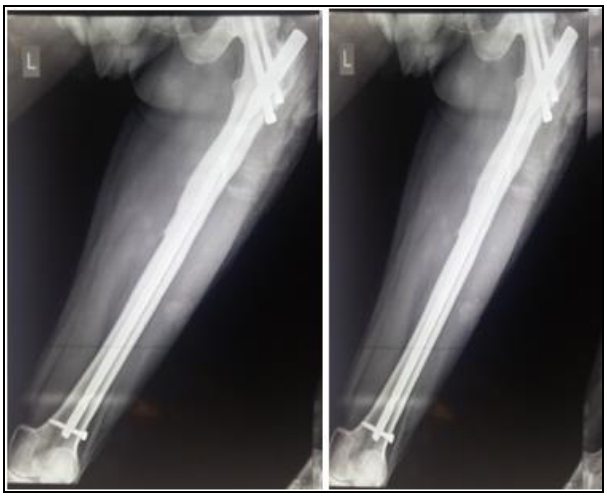
Preoperative X-Ray

3 Month Postoperative X-Ray



6 Month Postoperative X-Ray

1 Year PostOperative X-Ray



1½ Years PostOperative X-ray

2 Years PostOperative X-Ray

Flexion

Extension

Internal Rotation

External Rotation

Weight Bearing

Squatting

Sitting in Cross Legs

Implant Exit PostOperative X-ray

Unable to put derotation screw Delayed union

Complications

Intraoperative Details	
Mean duration of surgery	105 min
Reduction	
Easy	16 cases
Difficult	9 cases
Mean blood loss (mL)	180 Ml
Mean duration of radiation (sec)	140 sec

Intraoperative Complications of PFN		
Complications	**No. of Cases (25)**	**Percentage**
Failure to Achieve losed Reduction	9	36
Fracture of Lateral Cortex	0	0
Varus Angulation	0	0
Failure to Put Derotation Screw	2	8
Failure to Lock Distally	0	0
Jamming of Nail	1	4
Drill Bit Breakage	0	0
Guidewire Breakage	0	0

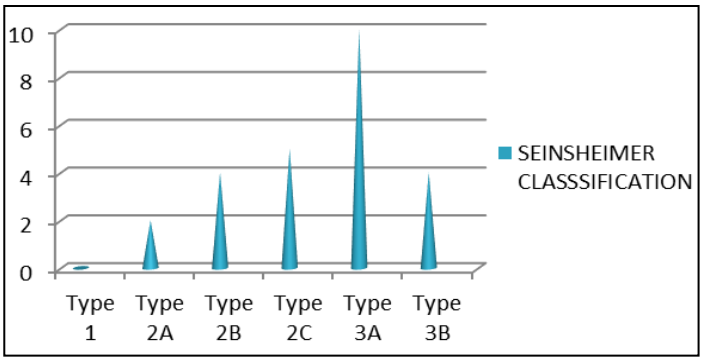
Union in Weeks		
Union in Weeks	**Frequency**	**Percentage**
0-12 wks.	0	0
13-16 wks.	0	0
17-20 wks.	0	0
21-24 wks.	2	8
25-28 wks.	6	24
Total	24	100

Delayed Complications		
Delayed Complications	**No. of Cases (24)**	**Percentage**
Hip Joint Stiffness	2	8
Knee Joint Stiffness	3	12
Delayed Union	0	0
Shortening	1	4
Implant Failure	0	0
Varus Angulation	0	0
Z Effect/Reverse Z Effect	0	0

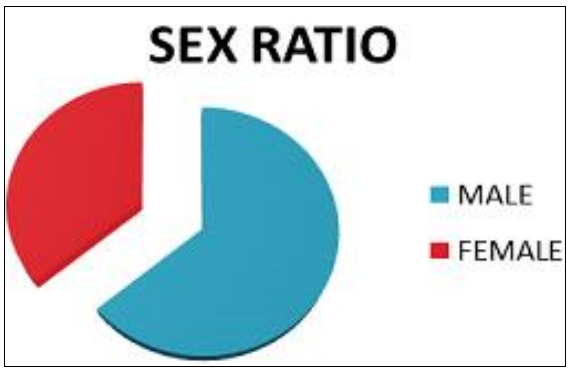
Comparison with Other Studies					
	C Boldin *et al.* [7]	**Dominigo *et al.* [9]**	**Fogagnolo *et al.* [9]**	**Simmer-macher *et al.* [11]**	**Our Study**
No. of patients	55	105	155	49	25
Duration of surgery	68 min	77 min	76 min	46 min	105 min
Bony Union (Months)	100% (4 months)	100% (9 months)	99% (6 months)	98% (6 months)	85% (6 months)
Failure of Fixation	0%	11%	2%	0%	0%
Delayed Union	-	-	0.7%%	2%	4%
Open Reduction	10%	-	1.3%	34.6%	36%
Re-operation Rate	10%	9%	12%		0%

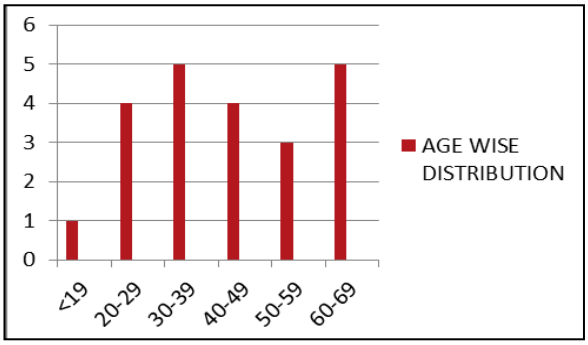
Functional results		
Results	**Frequency**	**Percentage**
Excellent	14	56
Good	6	20
Fair	3	16
Poor	2	8
Total	25	100

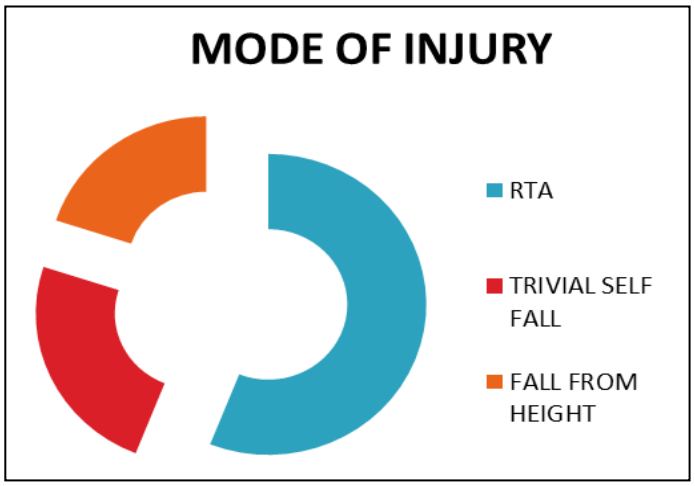
Anatomical Results		
Results-Anatomical	**Frequency**	**Percentage**
Restriction of hip ROM	0	0
Shortening >1 cm	1	4
Varus deformity	0	0
Good	24	96
Total	25	100



Interpretation and Observations







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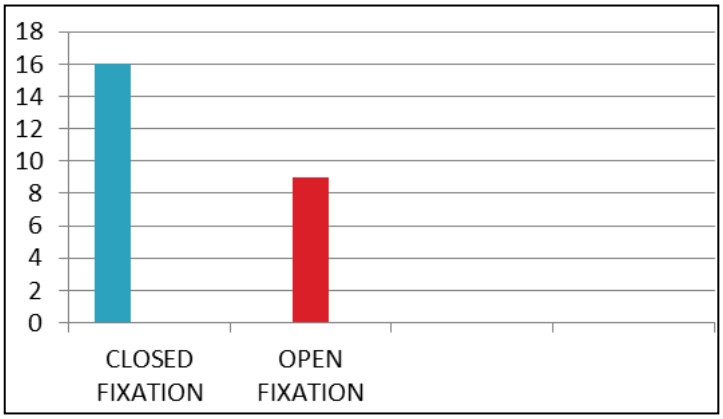
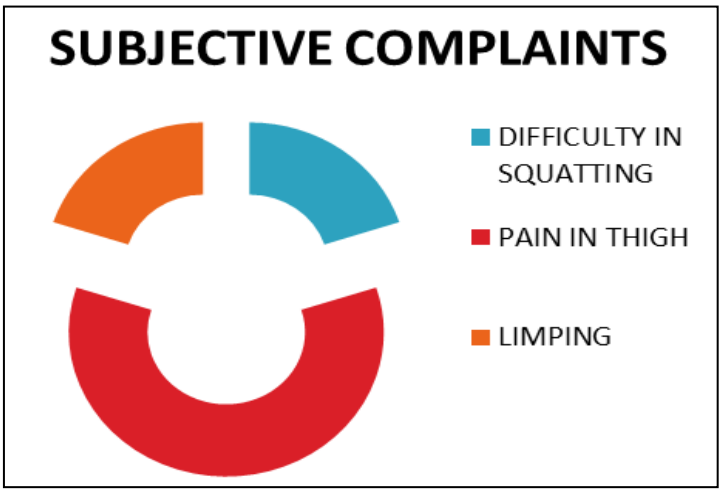
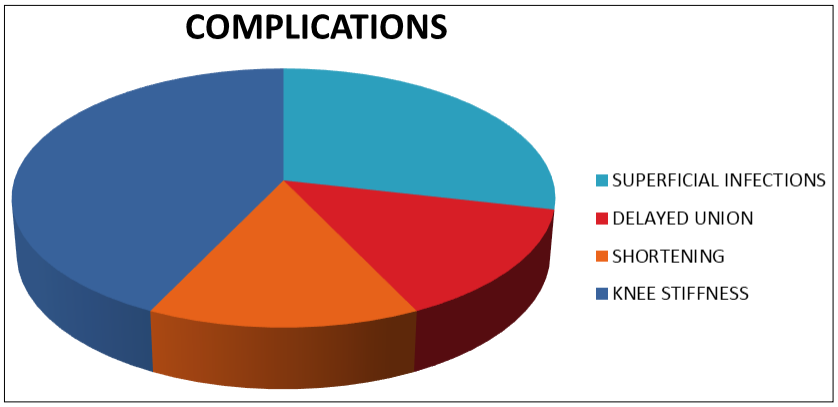
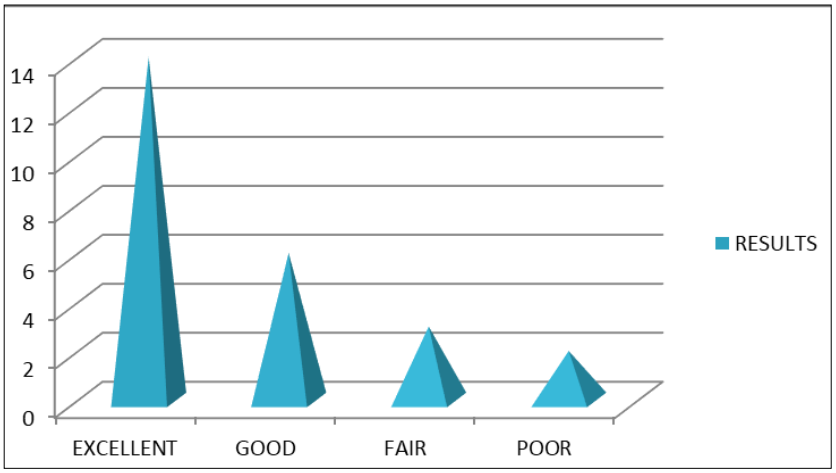


Intra Operative Complications







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