"A STUDY OF FUNCTIONAL OUTCOME OF SUBTROCHANTERIC FEMUR FRACTURE TREATED BY PROXIMAL FEMORAL NAIL IN RURAL POPULATION"

By

DR. WAYAL UTKARSHA ASHOK

SDUAHER

DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, KOLAR, KARNATAKA

In partial fulfilment of the requirements for the degree of

MASTER OF SURGERY
IN
ORTHOPAEDICS

Under the Guidance of

DR. P. V. MANOHAR, M.S. (ORTHO),

PROFESSOR AND UNIT HEAD,

DEPARTMENT OF ORTHOPAEDICS,

SRI DEVARAJ URS MEDICAL COLLEGE,

TAMAKA, KOLAR-563101

2018

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"A study of functional outcome of subtrochanteric femur fracture treated by proximal femoral nail in rural population."** is a bonafide and genuine research work carried out by me under the guidance of **Dr. P. V. MANOHAR**, Professor and Unit head, Department of Orthopaedics, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award "**M.S.DEGREE IN ORTHOPAEDICS**", the examination to be held in May 2018 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

Date:

Place: Kolar

DR. WAYAL UTKARSHA ASHOK
Postgraduate in Orthopaedics
Sri Devaraj Urs Medical College
Tamaka, Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"A STUDY OF FUNCTIONAL OUTCOME OF SUBTROCHANTERIC FEMUR FRACTURE TREATED BY PROXIMAL FEMORAL NAIL IN RURAL POPULATION."** is a bonafide research work done by **Dr. WAYAL UTKARSHA ASHOK,** under my direct guidance and supervision at Sri Devaraj Urs Medical College, Kolar**,** in partial fulfilment of the requirement for the degree of "**M.S. IN ORTHOPAEDICS"**.

Date:

Place: Kolar

DR. P. V. MANOHAR, MS
Professor and Head of Unit
Department Of Orthopaedics
Sri Devaraj Urs Medical College
Tamaka, Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

CERTIFICATE BY THE HEAD OF DEPARTMENT

This is to certify that the dissertation entitled "**A STUDY OF FUNCTIONAL OUTCOME OF SUBTROCHANTERIC FEMUR FRACTURE TREATED BY PROXIMAL FEMORAL NAIL IN RURAL POPULATION."** is a bonafide research work done by **DR. WAYAL UTKARSHA ASHOK,** under direct guidance and supervision of **DR. P. V. MANOHAR**, Professor and Unit head, Department of Orthopaedics at Sri Devaraj Urs Medical College, Kolar**,** in partial fulfilment of the requirement for the degree of "**M.S. IN ORTHOPAEDICS"**.

Date:

Place: Kolar

Dr. ARUN.H.S , MS

Professor & HOD

Department of Orthopaedics

Sri Devaraj Urs Medical College

Tamaka, Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

ENDORSEMENT BY THE HEAD OF THE DEPARTMENT AND PRINCIPAL

This is to certify that the dissertation entitled **"A STUDY OF FUNCTIONAL OUTCOME OF SUBTROCHANTERIC FEMUR FRACTURE TREATED BY PROXIMAL FEMORAL NAIL IN RURAL POPULATION."** is a bonafide research work done by **DR. WAYAL UTKARSHA ASHOK,** under the direct guidance and supervision of **DR. P. V. MANOHAR**, Professor and Unit head, Department of Orthopaedics, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award "**M.S. DEGREE IN ORTHOPAEDICS**"**.**

Dr. ARUN.H.S,	**Dr. M. L. HARENDRA KUMAR**
Professor & HOD	Principal,
Department Of Orthopaedics,	Sri Devaraj Urs Medical College
Sri Devaraj Urs Medical College,	Tamaka, Kolar
Tamaka, Kolar	
Date:	Date:
Place: Kolar	Place: Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

ETHICAL COMMITTEE CERTIFICATE

This is to certify that the Ethical committee of Sri Devaraj Urs Medical College, Tamaka, and Kolar has unanimously approved

DR. WAYAL UTKARSHA ASHOK

Post-Graduate student in the subject of

ORTHOPAEDICS at Sri Devaraj Urs Medical College, Kolar

to take up the Dissertation work entitled

"A STUDY OF FUNCTIONAL OUTCOME OF SUBTROCHANTERIC FEMUR FRACTURE TREATED BY PROXIMAL FEMORAL NAIL IN RURAL POPULATION."

to be submitted to the

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA,

Member Secretary

Sri Devaraj Urs Medical College,

Kolar–563 101.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

COPY RIGHT

I hereby declare that the Sri Devaraj Urs Academy of Higher Education and Research, Kolar, Karnataka shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic/research purpose.

DR. WAYAL UTKARSHA ASHOK

Date:

Place: Kolar

ACKNOWLEDGEMENT

With humble gratitude and great respect, I would like to thank my teacher, mentor and guide, **DR. P. V. MANOHAR**, Professor and Unit head, *Department of Orthopaedics, Sri Devaraj Urs Medical College, Kolar, for his able guidance, constant encouragement, immense help and valuable advices which went a long way in moulding and enabling me to complete this work successfully.*

I have great pleasure in expressing my gratitude to ***Dr. ARUN.H.S,*** *Professor and Head, Department of Orthopaedics, Sri Devaraj Urs Medical College, Kolar. Without his initiative and constant encouragement this study would not have been possible.*

I would like to express my sincere thanks to ***Dr. B.S.NAZEER, Dr. S. N. PATIL, Dr. SATYARUP, Dr. NAGAKUMAR J. S, Dr. ANIL KUMAR S. V., Dr. PRABHU.E, Dr. HARIPRASAD, Dr. MAHESH KUMAR, Dr. P. A. PATIL*** *and to all other teachers of Department of Orthopaedics, Sri Devaraj Urs Medical College for their valuable support, guidance and encouragement throughout the study. Their vast experience, knowledge, able supervision and valuable advices have served as a constant source of inspiration during the entire course of my study.*

I am highly grateful to ***DR. M.L.HARENDRA KUMAR****, Principal, Sri Devaraj Urs Medical College, Kolar, for permitting me to conduct this study.*

I am extremely grateful to the patients who volunteered to this study, without them this study would never have been possible.

All the nursing staff and technical staff at Sri Devaraj Urs Medical College, Kolar, have also made a significant contribution to this research work, to which I express my humble gratitude.

I am eternally grateful to The Almighty and my family, ***Mrs. MALTI ASHOK WAYAL, Mr. ASHOK WAYAL, Dr. SANKALP WAYAL,*** *my wife* ***Dr. SONAL UTKARSH WAYAL , Dr VINOD SHEWALE, Dr. KIRTI V SHEWALE, Mr. & Mrs. AMBADAS SASTE*** *for their love, perseverance and eternal support. Their blessings and faith made me what I am today. They have been the axiom of support and encouragement in every step.*

My special thanks to ***Dr. VAIBHAV MITTAL, Dr. RANI K. N., Dr. MALLIKA GANESH, Dr. NITESH SINGH, Mr. SHRIPAD JAGDALE, Dr. AYANAKSHA MALLICK, Dr. SACHINDRA NAYAK, Dr. KARTHIK REDDY, Dr. JISHNU JONALGADDA, Dr. KESHAV GOWDA, Dr. PRATHAP URUMKAR*** *for their constant love, exchange of ideas and support without which it was impossible to bring out this dissertation work in the present form.*

*I am also thankful to all my juniors **Dr. SAGAR, Dr. HARSHA, Dr. RONAK, Dr. ABHISHEK, Dr. ABHIMANYU, Dr. UMESH & Dr. SARATH** for helping whenever it was needed.*

*All the nursing staff and technical staff at Sri Devaraj Urs Medical College, Kolar, have also made a significant contribution to this research work. I express my humble gratitude to **Mr. PRABHAKAR, Mr. ARUN, Mr. SURENDRA, Mr. NAVEEN, Mr. VISHWANATH, Mr. MURALI, Mr. CHIRANJEEVI, Mrs. RAMANI, Mr. AMBRISH.***

DR. WAYAL UTKARSHA ASHOK

Affectionately dedicated to my small world

Mr. ASHOK WAYAL

MRS. MALTI A WAYAL

DR. SANKALP A WAYAL

&

My wife

DR. SONAL UTKARSH WAYAL

Who were, are and will be always with me

To love teach and guide

ॐ असतो मा सद्गमय । तमसो मा ज्योतिर्गमय ।

मृत्योर्मा अमृतं गमय ।ॐ शान्तिः शान्तिः शान्तिः ॥

LIST OF ABBREVIATIONS

PFN	Proximal Fenoral Nail
DHS	Dynamic Hip Screw
AO	Arbeitsgemeinschaft fur osteosynthesefragen
AP	Anteroposterior
ASIF	Association of Study of Internal Fixation
ORIF	Open Reduction and Internal Fixation
CRIF	Closed reduction and internal fixation
RTA	Road traffic accident
DM	Diabetes Mellitus
HTN	Hypertension
cm	Centimeter
mm	Millimeter
M	Male
F	Female
i.e.	That is
MHHS	Modified Harris Hip Score

ABSTRACT

Background

Among fractures around the hip, Subtrochanteric fractures are one of the commonest fractures encountered in last few decades. Subtrochanteric fracture is difficult to reduce and even more dificultto stabilize owing to the tremendous muscular forces that act on this region. This mostly occurs due to the incomplete understanding of the biomechanics around the subtrochanteric area, over-confidence on new surgical techniques and disregard to established procedures. Aim of this study is to evaluate the functional outcome when treated by using proximal femoral nail.

Aims and objectives:

To study the functional outcome in patients treated with proximal femoral nail for subtrochanteric femur fracture during 6 months of follow up period in rural population.

Materials and methods

In this prospective study, 30 patients with subtrochanteric fractures of femur were treated with proximal femoral nail at R. L. Jalappa Hospital, Kolar during a period of August 2015 to August 2017. All patients were hailing from surrounding rural area. Patients with pathological, periprosthetic and pediatric patients were excluded from the study. Patients were followed up for a period of 6 months and functionally assessed using Modified Harris Hip score.

Results

Out of 30 patients, 19 were males & 11 females. Minimum age of patient included was 20 years and maximum of 90. Mean age of patients was 55 years. Road traffic accident was cause of injury in 60% of patients. 40% of patients had Seinsheimer type IIIA fracture. In 90% of patients closed reduction was achieved. Mean duration of hospital stay was 20 days and mean duration of union of fracture was 17 weeks. 96.67% of patients had slight to no pain, most of the patients could perform their daily activities without any restriction and all patients had good range of motion without any deformity. 70% of patient showed excellent results while 27% showed good and 3% showed fair results.

Conclusion

At the end of the study we conclude that proximal femoral nailing provides stability, strength, early mobility and excellent union rate of subtrochanteric fractures in rural population where early return to hard working routine is required.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF CHARTS / GRAPHS

INTRODUCTION

Among fractures around the hip, Subtrochanteric fractures are one of the commonest fractures encountered in last few decades. It is largely owed to the fast and rapid transportation leading to more number of road traffic accidents and increased life expectancy with more number of geriatric population. Subtrochanteric fractures contribute 10-34% of total fractures around hip. [1,2,3]

Many treatment options are available. We have moved far ahead from the consideration of conservative management, as it is associated with significant shortening, mal-rotation, morbidity and mortality due to prolonged immobilization. Surgical repair for restoration of anatomy and early mobilization were recognized which led to vast research and improvement in implants.[4,5] As comminution is common in this region, the implant must withstand significant muscular forces and early loading.[6]

Many studies have been done in the past using gamma nail, dynamic hip screw and proximal femoral nail in the management. The results are satisfactory. But It is difficult to manage subtrochanteric fractures mostly due to following reasons:

1) The usual instability of fracture pattern.
2) The forces of the muscles acting on the proximal and distal fracture fragments.
3) The powerful abductors and ilio-psoas muscle attach to the proximal fragment and force it into abduction, flexion and external rotation making the fracture prone for non-unions.[7]

A multitude of implants, both intra and extra-medullary have been extensively researched upon and their superiority over one another still remains a matter of debate.

Surgical treatment of subtrochanteric fractures is aimed at achieving anatomic alignment, stable internal fixation, early mobilization of the patient and early functional rehabilitation. [8]

Biomechanical studies have suggested that intra-medullary devices provide more stable construct, preserves fracture haematoma, acts as load shearing device, less blood loss and less loss of soft tissues. Proximal femoral nail, an intra-medullary fixation device fits in the requirement laid for an ideal implant in treatment of subtrochanteric fractures.[5]

Proximal Femoral Nail (PFN) has advantages of the closed intramedullary nail (less operative time, less exposure, less disturbance to the fracture milieu) compared to other implants. Distinct practical advantages of PFN are reduced limb length discrepancies and the need to restitute the medial buttress has been made obsolete. The healing time is faster and the delayed and non unions are rare.[9]

The additional anti-rotational hip pin screw prevents rotation and reduces the incidence of implant cut out while the fluting of the nail tip (i.e. the tip has smaller diameter) reduces the stress at the tip and hence reduces the energy fractures at the tip. Hence PFN is the acceptable implant for treating subtrochanteric fracture now a days. The extent of functional outcome after surgery is a growing research topic in the field of orthopedics. Many tools are available to grade the functional outcome, one such tool is Modified Harris Hip Score.[10,11.]

In view of high grade manual work setting in rural population, need for good functional outcome after surgeries are expected. Very few studies have been done in past to grade the functional outcome following surgery among rural population.

In our study, we aim to evaluate outcome of patients with subtrochanteric fractures treated with proximal femoral nailing.

OBJECTIVE

To study the functional outcome in patients treated with proximal femoral nail for subtrochanteric femur fracture during 6 months of follow up period in rural population.

REVIEW OF LITERATURE

The orthopedic surgeon's faculties must beadaptable to awide compass;

the delicacy of a neurosurgeon, required innerve and tendon surgery;the power and accuracy of a sculptor wielding the osteotome and heavy mallet; the engineering skill of a fitter in using precision tools in bone grafting and internal fixation; the indefinable art of closed reduction in manipulating a fracture with the touch and craft of a bonesetter; pleasure in perfect dissection under a tourniquet and satisfaction in the carnage of hindquarter amputation.

Sir John Charnley

HISTORICAL ASPECTS

- **SUBTROCHANTERIC FEMUR FRACTURE**

Fractures around hip are known since times of Hippocrates. Sir Astley Cooper (1822) first distinguished extra capsular from intra capsular fractures and gave the reliable and logical description of fracture occurring at upper end of femur[12].

In 1902 Hibbs[2] established conservative management of subtrochanteric factures using splint. He showed if the limb kept in flexion, abduction and external rotation improves the reduction and bring distal and proximal fragments together.[2]

Hey-Groves EW [4] in (1918) not only described various gunshot injuries in different long bones but also laid the foundation for intra-medullary bone grafts and steel rods with entry from greater trochanter in subtrochanteric fractures.[4]

In 1949, Boyd and Griffin took a task to classify peritrochanteric area fractures of femur. They classified fractures in the peritrochanteric area of the femur into the 4 types. They described subtrochanteric fractures as a type of peritrochanteric fractures and described that its results are highly unsatisfactory after surgical treatment[7].

Alike Boyd et al [7] in 1949, Fielding et al [13] in 1966 and Zickel et al [14] in 1976, made suggestions about surgical management for pertrochanteric and subtochanteric fracture.

In 1978, Seinsheimer et al [15] brought forward a complex but concise classification involving eight subgroups.

- **TREATMENT MODALITIES**

In 1939, Kuntscher was the first to report treatment of subtrochanteric fractures with intra medullary nailing.[6] Aronoff P M et al [5] reported the result of cephalomedullary nails as better than conventional methods of treatment in subtrochanteric fractures in general and non unions of these fractures in particular.

Jewett nail remained the device of choice for subtrochanteric femoral fracture fixation in early 1940 to l960. It was popularized by Boyd & Griffin[7], Krik Watson & Campbell[8].

Fielding et al [13]in a study with Jewett nail noted 35-55% failure rates depending upon the type of subtrochanteric fracture.

Fielding et al [13]in 1966 proposed a classification which was simpler in nature and defined subtrochanteric fractures as per distance from lesser trochanter.

AO in 1969 designed a new angle blade plate with “U” profile and fixed angle of 95 and 135 degrees. [14]

In 1978 Hanson G W et al [9] reported 87.5% union rates with this device that made AO blade plate an immensely popular device in late 70s.

By late 1970s and early 1980s, the Zickel device was the treatment of choice for pathologic subtrochanteric fractures[14]

Templeton et al [10] in 1979, noted shortening frequently with the Zickel device and also observed that it required additional fixation for grossly comminuted fractures.

In 1984, Russell and Taylor developed a closed- section, cloverleaf, interlocking centromedullary nail and subsequently a closed-section, interlocking cephalomedullary nail known as the reconstruction nail to reduce implant failure and maximize torsional stability.[16]

AO/ASIF designed Dynamic Hip Screw which was popularized in 1992 by Simmermacher et al[11] for selected subtrochanteric fractures.[11]

In 1992, Halder et al [17] introduced Gamma Nail and in his study on 421 patients reported that Gamma nail transmits weight closer to the calcar than Dynamic Hip Screw and had less operative complications in unstable pertrochanteric fractures. However few complications including the fracture of base of greater trochanter and fractures of shaft of femur at the distal end of the nail have been reported.

- **EVOLUTION OF PROXIMAL FEMORAL NAIL**

In 1996 the AO/ASIF developed the proximal femoral nail (PFN) as an intramedullary device for the treatment of unstable per-, intra- and subtrochanteric femoral fractures in order to overcome the deficiencies of the extramedullary fixation of these fractures. This nail as the following advantages compared to extramedullary implant-such as decreasing the moment arm, can be inserted by closed technique, which retains the fracture hematoma an important consideration in fracture healing, decreases blood loss, infection, minimizes the soft tissue dissection and wound complications.[11]

In 1999, Simmermacher RK et al [11] in their study on Proximal Femoral Nail showed a relatively low percentage of complications and low incidence of implant failure as compared to Gamma nail.They contributed their finding by mentioning that the proximal femoral nailing system is extremely effective in pertrochateric fractures. The technical failures that occurred were due to poor reduction, malrotation or wrong choice of screws as seen in 4.6% of the cases. To overcome these problems they introduced a 6.5mm anti-rotation screw along with a 8mm hip screw to provide rotational stability.

In 2002, a prospective randomized study of 206 patients by Sudan M et al [12] compared Dynamic Hip Screw with Proximal Femoral Nail and stated the advantages of this intramedullary nail.

In 2003, Boldin C et al[18] et al inferred through his prospective study that proximal Femoral Nail is a better implant for unstable proximal femoral fractures with minimal invasion when he treated 55 patients with PFN. They neither noticed any fracture of the femoral shaft nor break in the implant, in comparison to the Gamma nail. This is because of the tapered narrow tip of the nail which prevents the stress concentration.

Gotze et al (1998) in an experimental study compared the loading ability of osteosynthesis of unstable per and subtrochanteric fractures and found that the PFN could bear the highest loads of all the devices.[18]

A comparative study by Woo-Kie Min et al[19] in 2007, on Proximal Femoral Nail and Gamma Nail for Reverse oblique trochanteric fractures reported better biomechanics results with PFN group, in terms of less sliding of lag screw and less change of neck shaft angle.

In 2007, Jiang L S et al [20] in his study, suggested that long PFN or long Gamma nail is a reliable implant for subtrochanteric fractures, leading to high rate of bone union and minimal soft tissue damage.

In 2008, Ballal MSG et al [21] inferred that to avoid failure or revision with Proximal Femoral Nail, a good reduction with minimal dissection, use of appropriate length of nail and proper positioning of the nail and screws are necessary.

Park S Y et al[22] in 2008 came to a conclusion that 2 factors play an important role in stability of subtrochanteric fracture, 1) lesser trochanteric fragment and 2) postero-medial defect, to avoid the fixation failures in the PFN group to excessive sliding of the femoral neck screw.

In 2008 to 2009, SidhuA S et al [23] in their study of 30 patients with closed pertrochanteric and subtrochanteric fractures with 24 weeks of follow up concluded that PFN is a minimally invasive evolving approach to treat intertrochanteric and subtrochanteric fractures.

In 2009, a retrospective study conducted by Kuzyk P R T et al [24] comparing outcomes of intramedullary and extramedullary fixation of subtrochantric fractures and suggested that intramedullary implants provide faster operative time and more reliable fixation than extramedullary implants.

In 2014, a study conducted by Shetty N et al [25], compared advantages of Proximal Femoral Nail over Dynamic Hip Screw among patients with Subtrochanteric Fractures. They came to a conclusion that proximal femoral nail provides not only the rotational stability but also axial stability in cases of subtrochanteric fractures that facilitates a faster postoperative restoration of walking ability, when compared with the dynamic hip screw.

In 2015, Yadkikar S V et al [26] studied the management of trochanteric and subtrochanteric fractures of femur using proximal femoral nail and inferred four main advantages of Proximal Femoral Nail, that are a) biomechanically sound fixation, b)minimal invasion which permits early mobilization, c) prevention of excessive varus collapse at fracture site, d) less stress riser effect below tip of nail.

In 2015, Srinivas K et al[16] in their study on surgical management of intertrochanteric and subtrochanteric fractures with PFN inferred that proximal femoral nail offers superior stabilization and good fracture union.

Ozkan K et al[27] in 2015 conducted a study of biomechanical comparison of proximal femoral nails and locking proximal anatomic femoral plates on synthetic bones in femoral fracture fixation. At the end of the study they concluded that proximal femoral intra-medullary nail provides more stability and allows for earlier weight bearing than the locking plate when used for the treatment of unstable intertrochanteric and subtrochanteric fractures of the femur.

In May 2017, Codesido P, Mejia A, Riego J, Theis C O[28] conducted a study over elderly people with subtrochanteric fractures treated with intramedullary fixation. Theyfound out that though the outcomes were better but it had a negative effect on qulity of life.

- ## FUNCTIONAL OUTCOME WITH MODIFIED HARRIS HIP SCORE

In 2015, Batra A V et al [29], shared their functional outcome of management of sub trochanteric fractures of femur with PFN on 40 patients using Modified Harris Hip score and concluded that PFN is a reliable and minimally invasive implant with good to excellent outcomes.

Reddy N et al [30] in 2016 found out in a study of subtrochanteric fractures treated with proximal femoral nailing that it provides good to excellent functional outcomes provided optimal reduction of the fracture and good positioning of the nail and screws are achieved.

In 2016, Tiwari M et al [31] in a prospective study of 30 cases with subtrochanteric fractures, concluded that with PFN one achieves early reduction and internal fixation. They measured the functional outcome with Modified Harris Hip score and found that use of proximal femoral nail in subtrochanteric fractures helps in patient comfort, better nursing care, early mobilization and reduced hospital stay.

In 2017, in a prospective comparative study of 50 patients conducted by Gowda P R et al .[32] about the clinical outcomes of subtrochanteric and trochanteric fractures treated with PFN vs dynamic hip screw inferred that PFN is implant of choice in unstable trochanteric fractures and has better results in stable and unstable subtrochanteric fractures for restoration of better hip biomechanics.

In 2017, in a prospective study conducted by Ahmad S et al [33] regarding union rates and functional outcomes of subtrichanteric fractures treated with long PFN concluded that it provides high rate of bony union, provides stable fixation, early mobilization, early rehabilitation and return to pre-fracture status.

RELEVANT ANATOMY

The femur, the longest and strongest bone in the skeleton, is almost perfectly cylindrical in the greater part of its extent. In erect posture it is not vertical, being separated above from its fellow by a considerable interval, which corresponds to the breadth of the pelvis, but inclining gradually downward and medial ward, so as to approach its fellow towards its lower part, for the purpose of bringing the knee joint near the line of gravity of the body. The proximal end of femur consists of head, neck, greater and lesser trochanter.

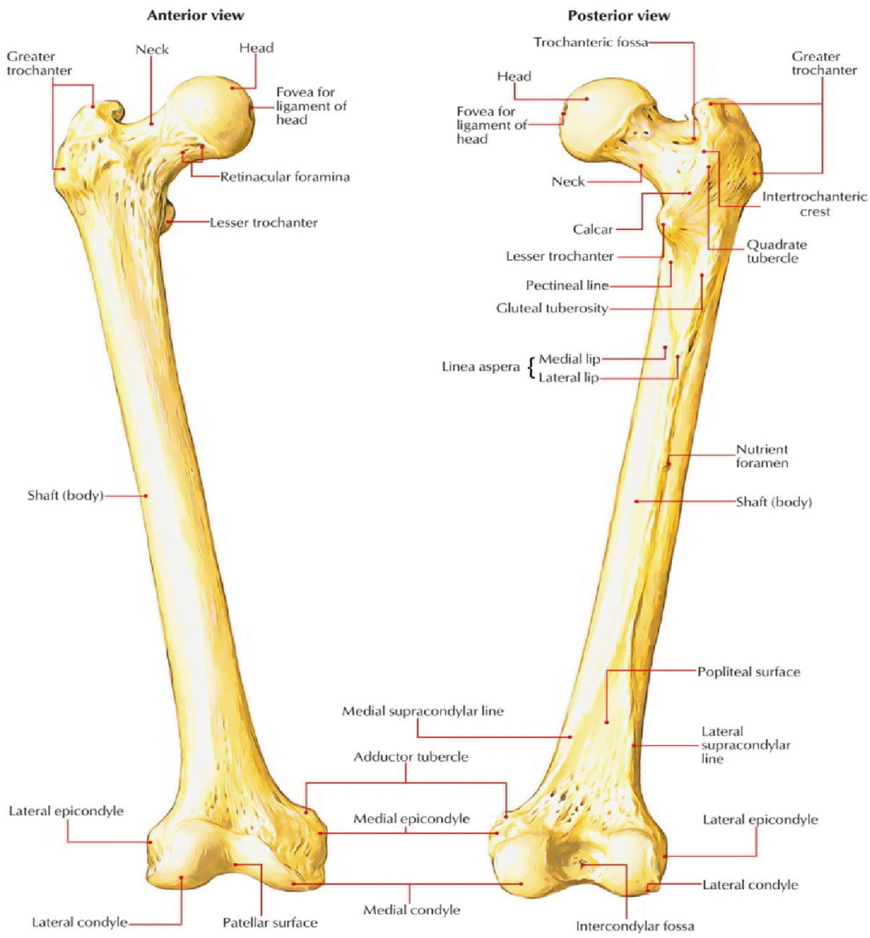


Fig 1: Anterior and Posterior aspect of femur

The proximal extremity of femur:

The Head (caput femoris)- is globular and forms rather more than ahemisphere, is directed upward, medialward, and a little forward, the greater part of its convexity being above and in front. Its surface is smooth, coated with cartilage except over an ovoid depression, the fovea capitis femoris, which gives attachment to the ligamentum teres.

The Neck (collum femoris).- is a flattened pyramidal process of bone,connecting the head with the body and forming with the latter a wide angle opening medialwards. In the adult, the neck forms an angle of about 125° with the body. In addition to projecting upward and medialward from the body of the femur, the neck also projects somewhat forward; the amount of this forward projection is extremely variable, but on an average is from 12° to 14°. The neck is flattened from before backward, contracted in the middle, and broader laterally than medially. The anterior surface of the neck is perforated by numerous vascular foramina. The posterior surface is smooth, and is broader and more concave than the anterior: the posterior part of the capsule of the hip-joint is attached to it about 1 cm. above the intertrochanteric crest. The superior border is short and thick, and ends laterally at the greater trochanter; its surface is perforated by large foramina. The inferior border, long and narrow, curves a little backward, to end at the lesser trochanter.

The trochanters - are prominent processes which afford leverage to themuscles that rotate the thigh on its axis. They are two in number, the greater and the lesser. The Greater Trochanter is a large, irregular, quadrilateral eminence, situated atthe junction of the neck with the upper part of the body. It is directed a little lateral ward and backward, and, in the adult, is about 1 cm. lower than the head. It has two surfaces and four borders. The lateral surface, quadrilateral in form, is broad, rough, convex, and marked by a diagonal impression, which extends from the posterosuperior to the antero-inferior angle, and serves for the insertion of the tendon of the Gluteus medius. Above the impression is a triangular surface, sometimes rough for part of the tendon of the same muscle, sometimes smooth for the interposition of a bursa between the tendon and the bone. Below and behind the diagonal impression is a smooth, triangular surface, over which the tendon of the Gluteus maximus plays, a bursa being interposed. The medial surface, of much less extent than the lateral, presents at its base a deep depression, the trochanteric fossa (digital fossa), for the insertion of the tendon of the Obturator externus, and above and in front of this an impression for the insertion of the Obturator internus and Gemelli. The superior border is free; it is thick and irregular, and marked near the center by an impression for the insertion of the Piriformis. The inferior border corresponds to the line of junction of the base of the trochanter with the lateral surface of the body; it is marked by a rough, prominent, slightly curved ridge, which gives origin to the upper part of the Vastus lateralis. The anterior border is prominent and somewhat irregular; it affords insertion at its lateral part to the Gluteus minimus. The posterior border is very prominent and appears as a free, rounded edge, which bounds the back part of the trochanteric fossa.

The Lesser Trochanter (trochanter minor; small trochanter) is a conicaleminence, which varies in size in different subjects; it projects from the lower and back part of the base of the neck. From its apex three well-marked borders extend; two of these are above—a medial continuous with the lower border of the neck, a lateral with the intertrochanteric crest; the inferior border is continuous with the middle division of the linea aspera. The summit of the trochanter is rough, and gives insertion to the tendon of the psoas major.

The Intertrochanteric Crest- Running obliquely downward and medialwardfrom the summit of the greater trochanter on the posterior surface of the neck is a prominent ridge, the intertrochanteric crest. Its upper half forms the posterior border of the greater trochanter, and its lower half runs downward and medialward to the lesser trochanter. A slight ridge is sometimes seen commencing about the middle of the intertrochanteric crest, and reaching vertically downward for about 5 cm. along the back part of the body: it is called the linea quadrata, and gives attachment to the Quadratus femoris and a few fibers of the Adductor magnus. Generally there is merely a slight thickening about the middle of the intertrochanteric crest, marking the attachment of the upper part of the Quadratus femoris. On the upper part of the crest is a round protuberance called the quadrate tubercle. A prominence, of variable size, it is the point of meeting of five muscles: the Gluteus minimus laterally, the Vastus lateralis below, and the tendon of the Obturator internus and two Gemelli above.

The Intertrochanteric Line- Running obliquely downward and medialwardfrom the tubercle is the intertrochanteric line (spiral line of the femur); it winds around the medial side of the body of the bone, below the lesser trochanter, and ends about 5 cm. below this eminence in the linea aspera. Its upper half is rough, and affords attachment to the iliofemoral ligament of the hip-joint; its lower half is less prominent, and gives origin to the upper part of the Vastus medialis.

The Calcar femorale[1]- In 1957, Harley and Griffin clarified the definition ofthe calcar femorale, as a dense vertical plate of bone within the femur, which originates in the posteromedial portion of the shaft, under the lesser trochanter, and radiates laterally through the cancellous tissues towards the greater trochanter.

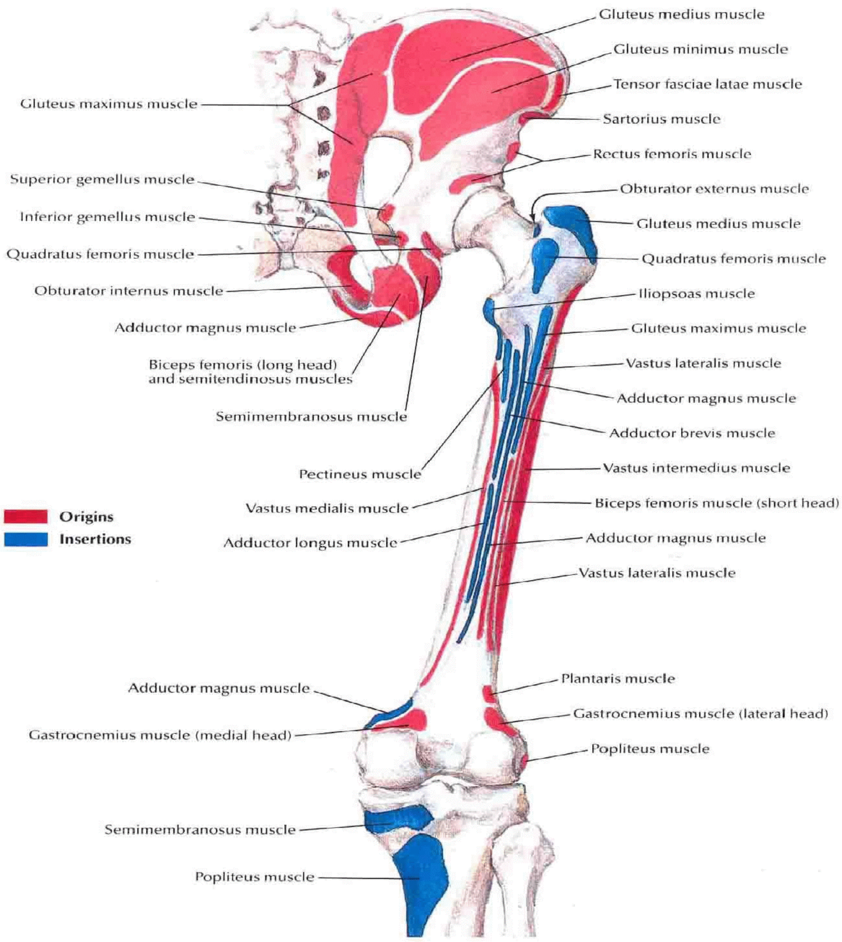


Fig 2 : Muscular attachment of femur

The Body or Shaft (corpus femoris).—The body, almost cylindrical in form, isa little broader above than in the center, broadest and somewhat flattened from before backward below. It is slightly arched, so as to be convex in front, and concave behind,

where it is strengthened by a prominent longitudinal ridge, the linea aspera. It presents for examination three borders, separating three surfaces. Of the borders, one, the linea aspera, is posterior, one is medial, and the other, lateral.

The linea aspera is a prominent longitudinal ridge or crest, on the middle thirdof the bone, presenting a medial and a lateral lip, and a narrow rough, intermediate line. Above, the linea aspera is prolonged by three ridges. The lateral ridge is very rough, and runs almost vertically upward to the base of the greater trochanter. It is termedthe gluteal tuberosity, and gives attachment to part of the Gluteus maximus: its upper part is often elongated into a roughened crest, on which a more or less wellmarked, rounded tubercle, the third trochanter, is occasionally developed. The intermediate ridge or pectineal line is continued to the base of the lesser trochanter and gives attachment to the Pectineus; the medial ridge is lost in the intertrochanteric line; between these two a portion of the Iliacus is inserted. Below, the linea aspera is prolonged into two ridges, enclosing between thema triangular area, the popliteal surface, upon which the popliteal artery rests. Of these two ridges, the lateral is the more prominent, and descends to the summit of the lateral condyle. The medial is less marked, especially at its upper part, where it is crossed by the femoral artery. It ends below at the summit of the medial condyle, in a small tubercle, the adductor tubercle, which affords insertion to the tendon of the Adductor magnus. From the medial lip of the linea aspera and its prolongations above and below, the Vastus medialis arises and from the lateral lip and its upward prolongation, the Vastus lateralis takes origin. The Adductor magnus is inserted into the linea aspera, and to its lateral prolongation above, and its medial prolongation below. Between the Vastus lateralis and the Adductor magnus two muscles are attached—viz., the Gluteus maximus inserted above, and the short head of the Biceps femoris arising below. Between the Adductor magnus and the Vastus medialis four muscles are inserted: the Iliacus and Pectineus above; the Adductor brevis and Adductor longus below. The linea aspera is perforated a little below its center by the nutrient canal, which is directed obliquely upward.

The other two borders of the femur are only slightly marked: the lateral border extends from the antero-inferior angle of the greater trochanter to the anterior extremity of the lateral condyle; the medial border from the intertrochanteric line, at a point opposite the lesser trochanter, to the anterior extremity of the medial condyle.

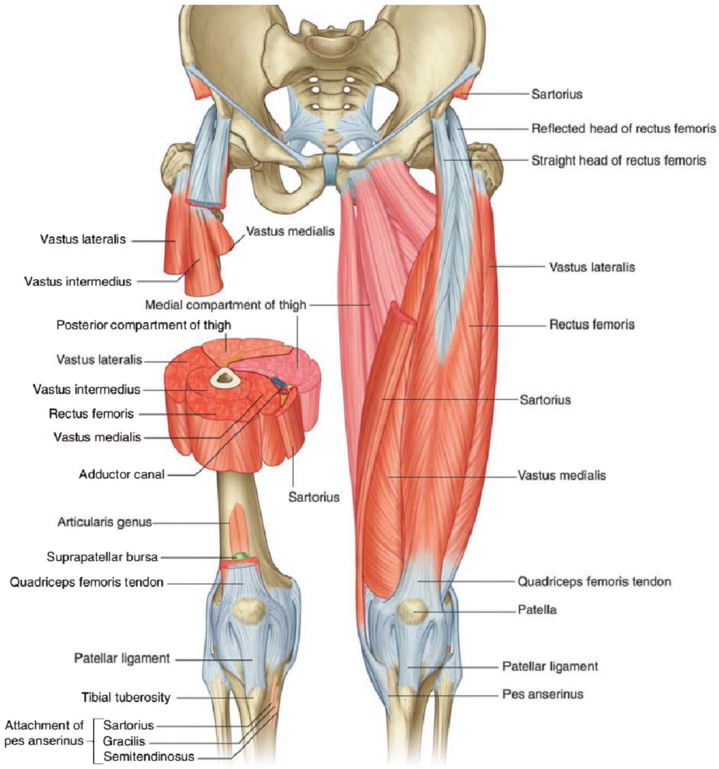


Fig 3 : Muscles of anterior compartment of thigh

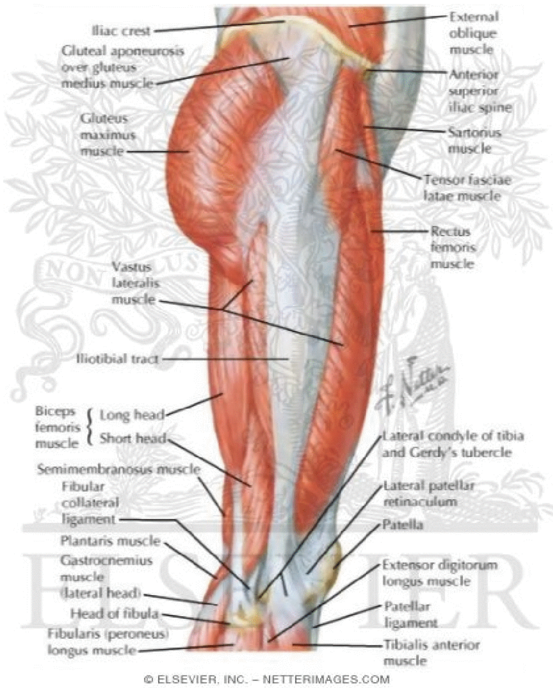


Fig 4 : Lateral view of muscles of the thigh

The anterior surface includes that portion of the shaft which is situated between the lateral and medial borders. It is smooth, convex, broader above and below than in the center. From the upper three-fourths of this surface the Vastus intermedius arises.

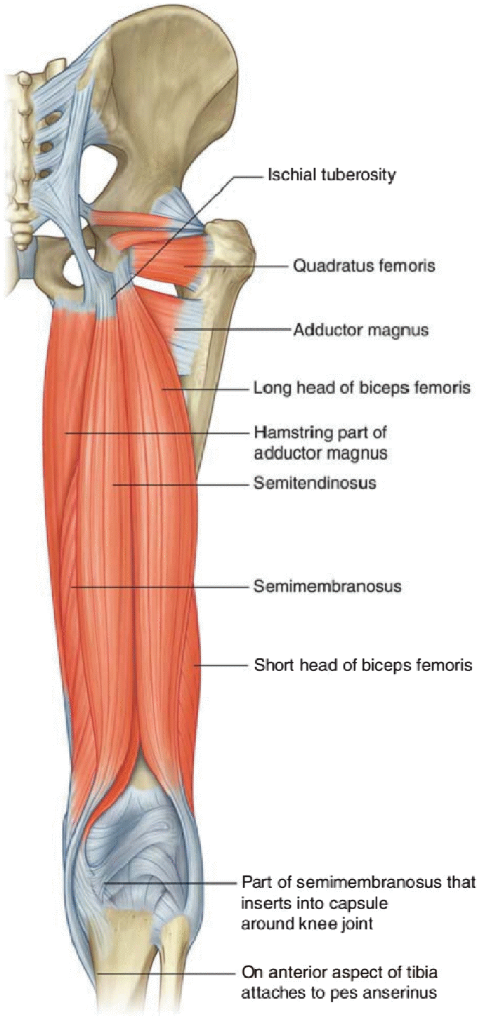


Fig 5 : Muscles of posterior compartment of thigh

The lateral surface includes the portion between the lateral border and the linea aspera; it is continuous above with the corresponding surface of the greater trochanter, below with that of the lateral condyle: from its upper three-fourths the Vastus intermedius takes origin.

The medial surface includes the portion between the medial border and thelinea aspera; it is continuous above with the lower border of the neck, below with the medial side of the medial condyle: it is covered by the Vastus medialis.

BLOOD SUPPLY :

The description of adult vessels is based on the work of Trueta and Harnington (1953). Since the vascular pattern established during the phase of growth is not replaced at maturity, but persists throughout in life, the basic arrangement is one of an epiphyseal and metaphyseal circulation, even when the growth plate has disappeared outline the anastomotic arrangement around the upper femur.

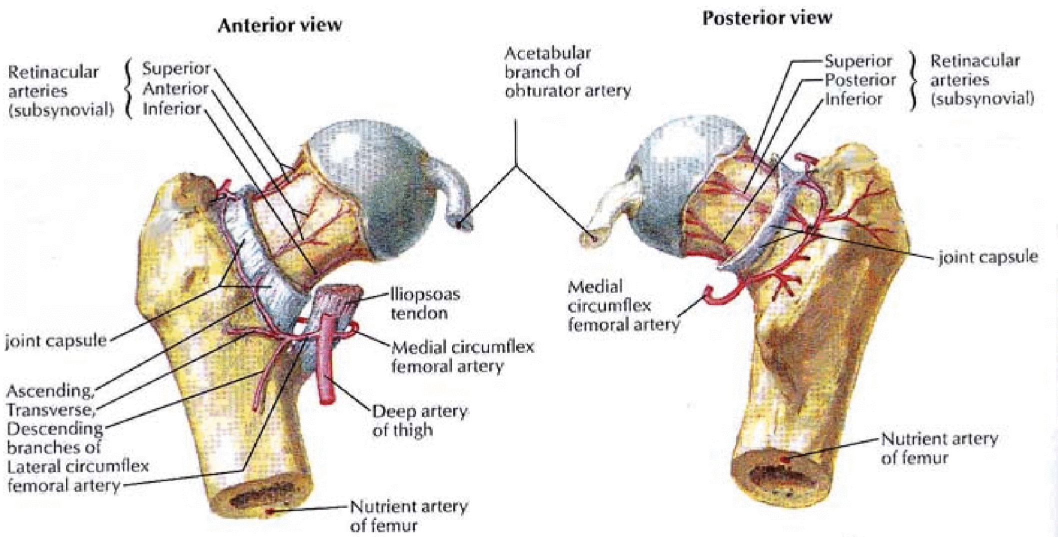


Fig 6: Blood supply of Femoral neck showing medial and lateral circumflex femoral arteries.

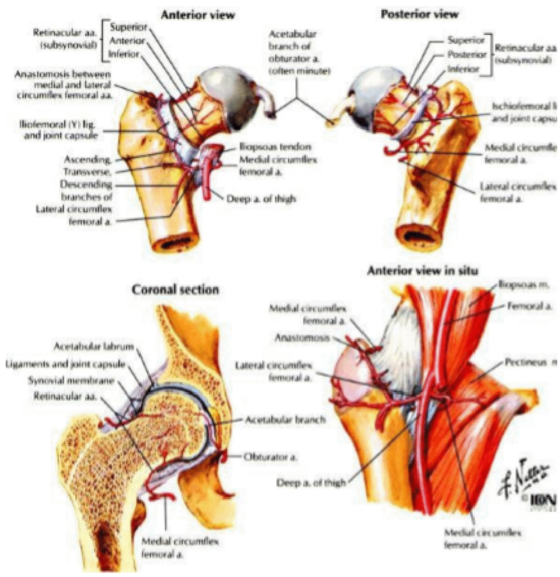


Fig 7: Blood supply, Ligaments and capsular attachment of femoral neck.

Blood supply to the proximal end of the femur is divided into three major groups.

a. An extracapsular arterial ring located at the base of the femoral neck.

b. Ascending cervical branch of the arterial ring on the surface of femoral neck.

c. Arteries of the ligamentum teres.

The extracapsular arterial ring- It is formed posteriorly by large branch of medial femoral circumflex artery and anteriorly by branch from lateral femoral circumflex artery. The ascending cervical branches of retinacular vessels, ascend on the surface of the femoral neck in an anterior, posterior, medial and lateral groups.

The lateral vessels are most important. Their proximity to the surface of the femoral neck makes them vulnerable to injury in femoral neck fractures. As the articular margin of the femoral head is approached by these ascending cervical vessels, a second less distinct ring of vessels is formed, commonly referred to by Chung as the sub synovial intra articular arterial ring. It is from this ring of vessels that vessels penetrate the head and are referred to as epiphyseal arteries, the most important being the lateral epiphyseal arterial group supplying the lateral weight bearing portion of the femoral head. These epiphyseal vessels are joined by inferior metaphyseal vessels and vessels of the ligamentum teres. Blood supply to the femur, like that of all tubular bones, is by the way of metaphyseal, periosteal and endosteal supply. The periosteal supply is related to the multiple muscle origins from the shaft to the femur the nutrient arteries perforate the femoral shaft along the linea aspera. The arteries are derived from perforating branches of profounda femoris artery.

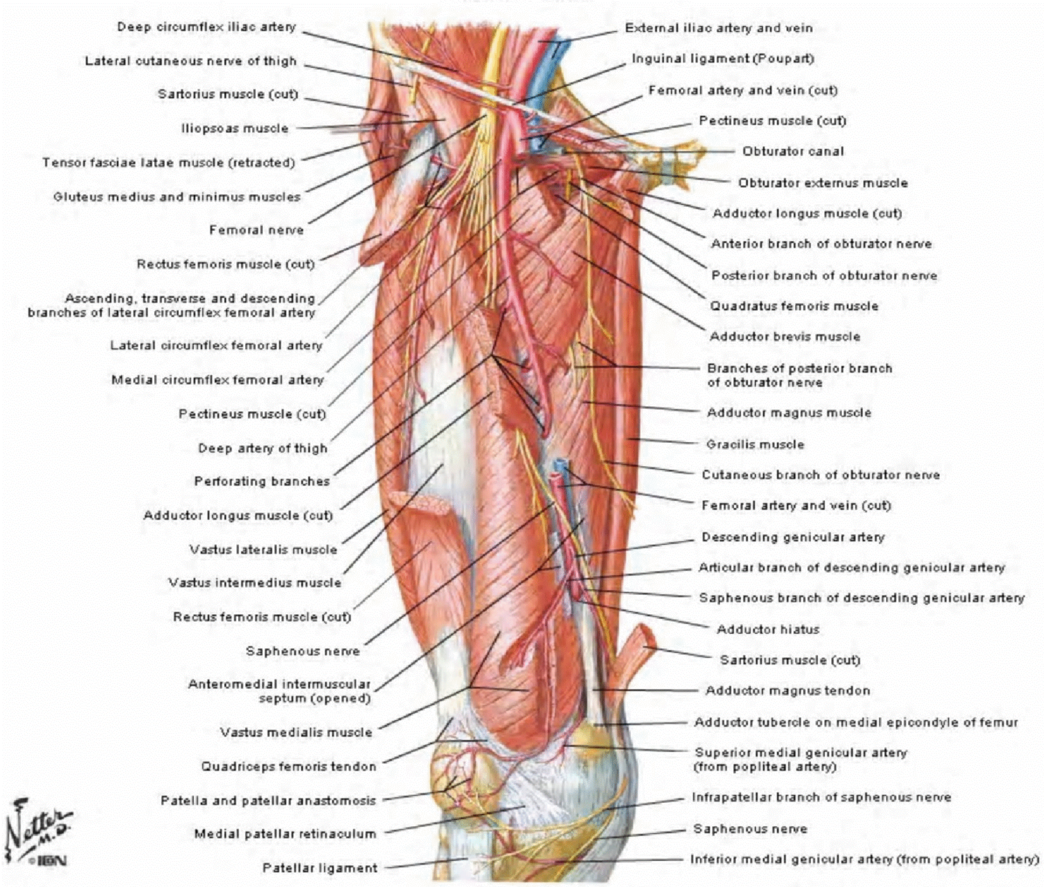


Fig 8: Blood supply of thigh.

The Architecture of the Femur –

Mathematical analysis has shown that in every part of the femur there is a remarkable adaptation of the inner structure of the bone to the mechanical requirements due to the load on the femur-head. The various parts of the femur taken together form a single mechanical structure wonderfully well-adapted for the efficient, economical transmission of the loads from the acetabulum to the tibia.

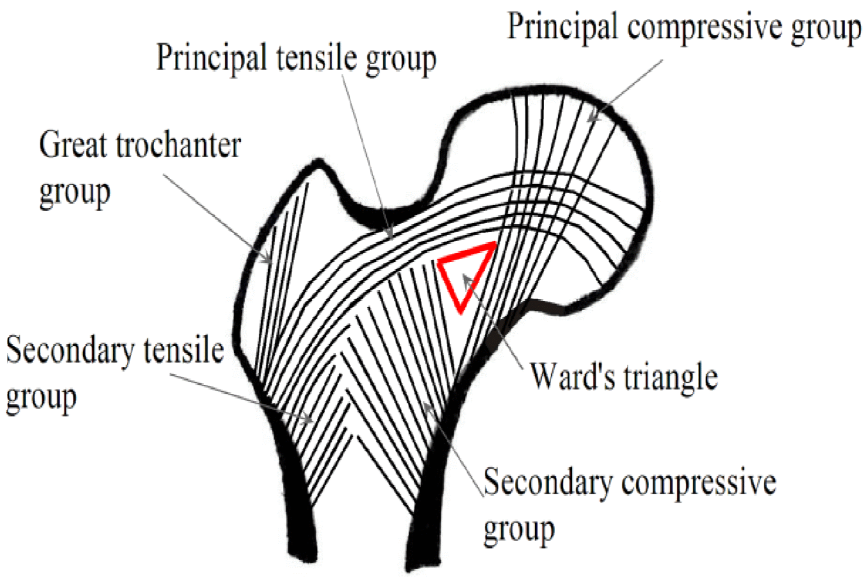


Fig 9 : The Inner Architecture of the Upper Femur

The internal structure is everywhere so formed as to provide in an efficient manner for all the internal stresses which occur due to the load on the femur-head. The femur obeys the mechanical laws that govern other elastic bodies under stress; the following laws of bone structure have been demonstrated for the femur:

1. The inner structure and external form of human bone are closely adapted to the mechanical conditions existing at every point in the bone.
2. The inner architecture of normal bone is determined by definite and exact requirements of mathematical and mechanical laws to produce a maximum of strength with a minimum of material.

The Inner Architecture of the Upper Femur:

The spongy bone of the upper femur (to the lower limit of the lesser trochanter) is composed of two distinct systems of trabeculae arranged in curved paths: one, which has its origin in the medial (inner) side of the shaft and curving upward in a fan-like radiation to the opposite side of the bone; the other, having origin in the lateral (outer) portion of the shaft and arching upward and medially to end in the upper surface of the greater trochanter, neck and head. These two systems intersect each other at right angles.

A. Medial (Compressive) System of Trabeculae- As the compact bone of the medial (inner) part of the shaft nears the head of the femur it gradually becomes thinner and finally reaches the articular surface of the head as a very thin layer. From a point at about the lower level of the lesser trochanter, 2 1/2 to 3 inches from the lower limit of the articular surface of the head, the trabecula branch off from the shaft in smooth curves, spreading radially to cross to the opposite side in two well-defined groups: a lower, or secondary group, and an upper, or principal group.

The Principal Compressive Group.— This group of trabeculae springs from the medial portion of the shaft just above the group above described and spreads upward and in slightly radial smooth curved lines to reach the upper portion of the articular surface of the head of the femur. These trabeculae are placed very closely together and are the thickest ones seen in the upper femur. They are a prolongation of the shaft from which they spring in straight lines which gradually curve to meet at right-angles to the articular surface. There is no change as they cross the epiphyseal line. They also intersect at right angles to the system of lines which rise from the lateral side of the femur.

The Secondary Compressive Group.— This group of trabeculae leaves the inner border of the shaft beginning at about the level of the lesser trochanter, and for a distance of almost 2 inches along the curving shaft, with which the separate trabeculae make an angle of about 45 degrees. They curve outwardly and upwardly to cross in radiating smooth curves to the opposite side. The lower filaments end in the region of the greater trochanter, the adjacent filaments above these pursue a more nearly vertical course and end in the upper portion of the neck of the femur. The trabeculae of this group are thin and with wide spaces between them. As they traverse the space between the medial and lateral surfaces of the bone they cross at right angles to the system of curved trabeculae which arise from the lateral (outer) portion of the shaft.

B. Lateral (Tensile) System of Trabeculae— As the compact bone of the outer portion of the shaft approaches the greater trochanter it gradually decreases in thickness. Beginning at a point about 1 inch below the level of the lower border of the greater trochanter, numerous thin trabeculae are given off from the outer portion of the shaft. These trabeculae lie in three distinct groups.

The Greater Trochanter Group— These trabeculae rise from the outer part of the shaft just below the greater trochanter and rise in thin, curving lines to cross the region of the greater trochanter and end in its upper surface. Some of these filaments are poorly defined. This group intersects the trabeculae of group (a) which rise from the opposite side. The trabeculae of this group evidently carry small stresses, as is shown by their slenderness.

The Principal Tensile Group— This group springs from the outer part of the shaft immediately below group c, and curves convexly upward and inward in nearly parallel lines across the neck of the femur and ends in the inferior portion of the head. These trabeculae are somewhat thinner and more, widely spaced than those of the principal compressive group. All the trabeculae of this group cross the compressive trabeculae at right angles. This group is the most important of the lateral system (tensile) and, as will be shown later, the greatest tensile stresses of the upper femur are carried by the trabeculae of this group.

The Secondary Tensile Group.—This group consists of the trabeculae which spring from the outer side of the shaft and lie below those of the preceding group. They curve upward and medially across the axis of the femur and end more or less irregularly after crossing the midline, but a number of these filaments end in the medial portion of the shaft and neck. They cross at right angles the principal compressive group.

In general, the trabeculae of the tensile system are lighter in structure than those of the compressive system in corresponding positions. The significance of the difference in thickness of these two systems is that the thickness of the trabeculae varies with the intensity of the stresses at any given point.

The trabeculae of the upper femur, are arranged in two general systems, compressive and tensile, which correspond in position with the lines of maximum and minimum stresses in the femur determined by the mathematical analysis of the femur as a mechanical structure. The thickness and spacing of the trabeculae vary with the intensity of the maximum stresses at various points in the upper femur, being thickest and most closely spaced in the regions where the greatest stresses occur. The amount of bony material in the spongy bone of the upper femur varies in proportion to the intensity of the shearing force at the various sections. The arrangement of the trabeculae in the positions of maximum stresses is such that the greatest strength is secured with a minimum of material.

Ossification of the femur:

The femur is ossified from five centers: one for the body, one for the head, one for each trochanter, and one for the lower end. Of all the long bones, except the clavicle, it is the first to show traces of ossification. This commences in the middle of the body at about the seventh week of fetal life and rapidly extends upward and downward. The centers in the epiphyses appear in the following order- in the lower end of the bone, at the ninth month of fetal life (from this center the condyles and epicondyles are formed); in the head, at the end of the first year after birth; in the greater trochanter, during the fourth year; and in the lesser trochanter, between the thirteenth and fourteenth years. The order in which the epiphyses are joined to the body is the reverse of that of their appearance; they are not united until after puberty, the lesser trochanter being first joined, then the greater, then the head and lastly the inferior extremity, which is not united until the twentieth year.

ANATOMY AND BIOMECHANICS

The plane of the femoral head and neck is anteverted 13° +- 7° to the plane of the femoral shaft in most adults. In Asian populations, anteversion may approach 30°. The average neck-shaft angle in women is 133°+- 6.6°, and it is 129° +- 7.3° in men. The plane of the femoral neck and head is also anteriorly positioned 1 to 1.5 cm in relation to the center axis of the femoral shaft. If the centerline of the femoral shaft is continued through the intertrochanteric region, it emerges from the femur in the region of the piriformis fossa[1].

The lesser trochanter is a posteromedial prominence at the termination of the intertrochanteric ridge and serves as the prominent insertion point of the iliacus and psoas tendons. The femoral shaft is bowed primarily anteriorly, but also slightly laterally. The plane of the bow is situated approximately 15° lateral to the pure AP plane. In the subtrochanteric and shaft regions, the femur is covered circumferentially by well-vascularized muscle groups.

The trabeculae of the compressive system carry heavier stresses than those of the tensile system in corresponding positions. The maximum tensile stress at a section in the outermost fiber is 771 pounds per square inch, and at the corresponding point on the compressive side the compressive stress is 954 pounds per square inch. The thickness and closeness of spacing of the trabeculae varies in proportion to the intensity of the stresses carried by them. The trabeculae lie exactly in the paths of the maximum tensile and compressive stresses. The tensile system of trabeculae corresponds exactly with the position of the lines of maximum and minimum tensile stresses which were determined by mathematical analysis. The compressive system of trabecula corresponds exactly with the lines of maximum and minimum compressive stresses computed by mathematical analysis. The amount of vertical shear varies almost uniformly from a maximum of 90 pounds to a minimum of 5.7 pounds.

Muscle Forces:

The upper end of the femur is surrounded by a mass of powerful muscles. Inclusion of muscle forces necessary during single leg support adds to the complexity of the problem and can increase the stress to much higher values. On the other hand, some muscles such as the tensor fascia lata, may act to partially neutralize bending forces under certain conditions. In a normal hip, the strong gluteal muscles abduct and the powerful psoas flexes and rotates. These forces are balanced by the adductor and hamstrings. With a subtrochanteric fracture, the forces are unbalanced and the unopposed muscular action produces the characteristic abduction, rotation and flexion deformity described by Froimson.

The same muscle forces act upon the fixation device after operation. These forces have been shown to generate high forces on the femoral head even when the patient is in bed, which in turn cause stresses in the subtrochanteric area as shown by Koch. Rydell has demonstrated that muscular pull for merely flexing or extending the hip in bed caused as much pressure on the femoral head as did slow walking with or without crutches[1].

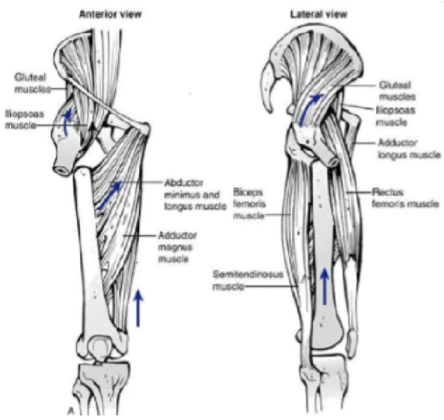


Fig 10: Deforming forces at the fracture site

Medial Buttress and Cross-Sectional Area :

The medial wall or the so-called medial buttress upon trauma explodes because of the great compressive forces. When the medial buttress is absent and the cross sectional area bearing load is minimum, all the stress is concentrated on the plate at the fracture site. This results in fatigue fracture of the implant and non-union. Therefore, the anatomy and functional continuity of the bone at the fracture site should be established by fixing fracture pieces by lag screws, cerclage wires, etc., and the medial wall should be reconstructed by massive bone grafting. Thus, the cross sectional area to bear the load is increased and less force acts on the plate. Hence, integrity of the medial wall of the proximal femur is very important[37]. The major regional nerves are the sciatic posteriorly and the femoral anteriorly. They are rarely involved in closed injuries. Because of the transition from cancellous bone in the intertrochanteric region to thick cortical bone in the diaphysis, the subtrochanteric region has a thinner cortex than the rest of the femur does[38].

Compression stress exceeds 1200 lb/inch2 in the medial subtrochanteric area 1 to 3 inches distal to the level of the lesser trochanter. Lateral tensile stresses are approximately 20% less. Higher bending force is borne by an implant applied laterally (e.g., a plate and screw device) than by a centromedullary device, which is closer to the line of joint reaction force[39].

The proximal fragment, including the greater trochanteric attachment, is abducted by the gluteus medius and minimus muscles. The iliopsoas flexes and externally rotates the proximal fragment if the lesser trochanter is attached. The adductors and hamstrings cause shortening and adduction of the distal fragment, thereby resulting in relative varus of the hip. All three forces must be neutralized for successful immobilization of the fracture[40].

Mechanisms of Injury

Fractures from low-energy trauma usually involve minimal comminution, and spiral fractures are relatively common. Frequently, these fractures occur in more osteopenic bone with widened medullary canals and thinner cortices. Subtrochanteric fractures from high-energy trauma are often associated with comminution involving large areas of the proximal end of the femur, with the potential for significant soft tissue damage even in closed injuries, and with compromise of the vascularity of the fracture fragments. Most subtrochanteric fractures are caused either by direct lateral force to the proximal part of the thigh or by axial loading failure in the subtrochanteric region. Low- energy trauma usually results in transverse, short, oblique or spiral fractures[45].

Anatomic and Functional Consequences of Injury

A subtrochanteric fracture results in shortening of the affected extremity and varus positioning of the femoral head and neck, effectively creating a functionally weakened abductor muscle group. If not corrected, this deformity causes a significant limp (abductor lurch) because of the shortened working length of the abductor muscles. Therefore, the goals of subtrochanteric fracture management are restoration of normal length and rotation and correction of the femoral head and neck angulation to restore adequate tension to the abductor muscles[45].

CLASSIFICATION

There are a number of classifications for subtrochanteric fractures. Based on the pathoanatomy and the fracture mechanics, the medial cortical support and the fracture stability determine management outcome.

Introduction of various classification systems gives insight into the evolution of treatment options and also indicates the uncertainty regarding the treatment and prognosis of this complex fracture.

Fielding and magliato's classification[13]: Fielding and Magliato devised a three part classification in 1966. This is a pure anatomical classification describing the position of the major fracture line with respect to the lesser trochanter.

According to Fielding's classification of subtrochanteric fractures,

Type 1 fracture - at the level of the lesser trochanter,

Type 2 fracture - between 2.5 and 5 cm below the lesser trochanter, and

Type 3 fracture - occurs 5 to 7.5 cm below the lesser trochanter.

Transverse fractures fit this classification well, but oblique and comminuted fractures may involve more than one of the levels described and should be classified according to where the major portion of the fracture occurs.

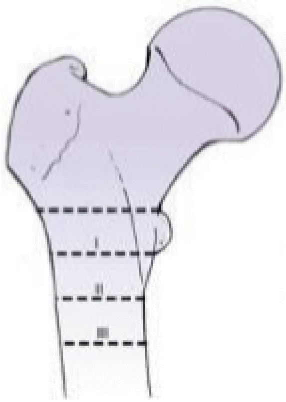


Fig 11: Feilding's classification

Seinsheimer classification[15]: is developed based on the number of fragments and the location and configuration of the fracture lines.

Seinsheimer classification is the most useful of the available subtrochanteric fracture classifications in clinical practice to assist with decision making and predicting prognosis.

The Seinsheimer classification takes into account the factors affecting the stability of the fractures. It introduces the concept of the posteromedial cortical support, which has a direct effect on the stability. It also indicates that the more distal the primary fracture line is, the higher the incidence of complications will be. This classification offers guidelines for management and prognosis.

Type I: Non displaced fracture or one with less than 2mm of Displacement.

Type II: Two part fracture

Type II A: Transverse fracture

Type II B: Spiral configuration with lesser trochanter attached to proximal fragment

Type IIC: Spiral configuration with lesser trochanter attached to distal fragment

Type III: Three part fracture

Type III A: Three part configuration with lesser trochanter part of third fragment.

Type III B: Three part spiral configuration with third part a butterfly fragment.

Type IV: Comminuted fracture with four or more fragments

Type V: Subtrochanteric – intertrochanteric configuration

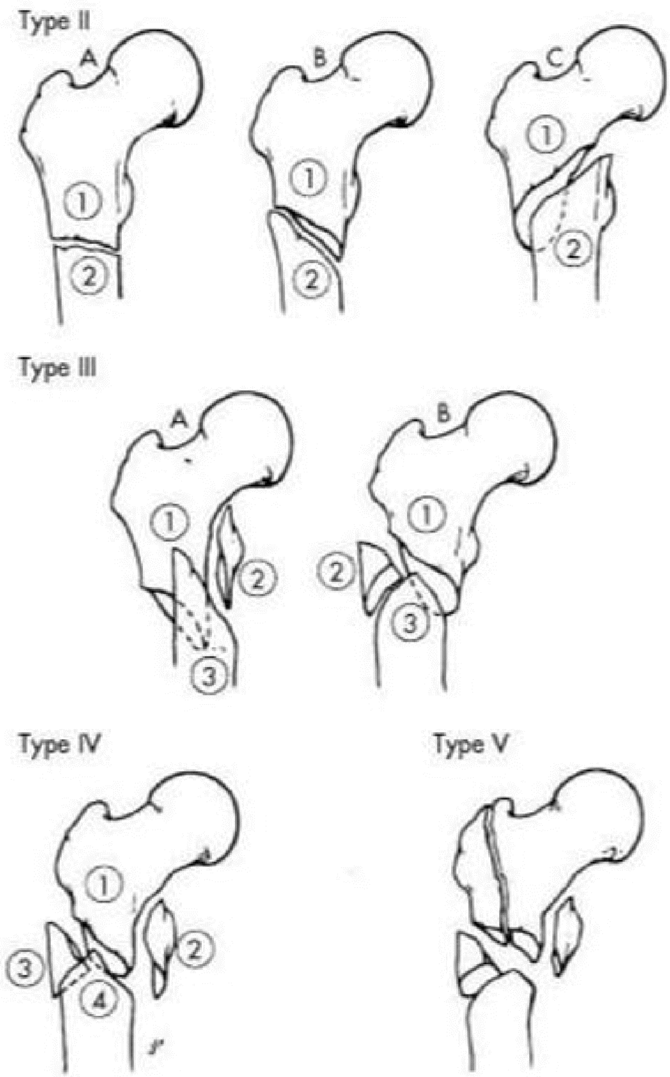


Fig.12 : Seinsheimer Classification

Russell and Taylor classification : is based on lesser trochanteric continuity and fracture extension posteriorly on the greater trochanter involving the piriformis fossa, the major two variables influencing treatment

Type I fractures - do not extend into the piriformis fossa,

Type II fractures - involve the piriformis fossa, the most commonly used nail entry portal.

Type IA fractures - the lesser trochanter is intact, and comminution and fracture lines extend from below the lesser trochanter to the femoral isthmus; any degree of comminution may be present in this area, including bicortical comminution.

Type IB fractures - the lesser trochanter is fractured and have fracture lines and comminution involving the area of the lesser trochanter to the isthmus.

Type IIA fractures - extend from the lesser trochanter to the isthmus with extension in to the piriformis fossa, as detected on lateral roentgenograms, but significant comminution or major fracture of the lesser trochanter is not present Type IIB fractures - the fracture extends into the piriformis fossa with significant comminution of the medial femoral cortex and loss of continuity of the lesser trochanter.

In type I fractures, closed intramedullary nailing has the advantage of minimizing vascular compromise of the fracture fragments.

In type II fractures the extension into the piriformis fossa complicates closed nailing techniques.

In type A fractures, the lesser trochanter is intact, thus making medial stability more likely. Plate fixation may be the device of choice.

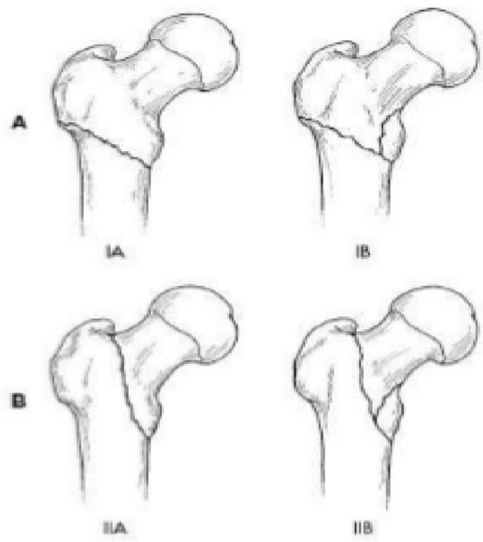


Fig 13 : Russell and Taylor classification

Boyd and Griffin (1949) classification[7]: This classification included all fractures from the extracapsular part of the neck to a point 5 cm distal to the lesser trochanter and classified fractures in the peritrochanteric area of the femur into four types, and included subtrochanteric elements in types 3 and 4.

Type 1: Fractures that extend along the intertrochanteric line from the greater to the lesser trochanter. Reduction usually is simple and is maintained with little difficulty.

Type 2: Comminuted fractures, the main fracture being along the intertrochanteric line but with multiple fractures in the cortex. Reduction of these fractures is more difficult because the comminution can vary from slight to extreme.

Type 3: Fractures that are basically subtrochanteric with at least one fracture passing the proximal end of the shaft just distal to or at the lesser trochanter. Varying degree of comminution are associated. These fractures are usually more difficult to reduce and result in more complications.

Type 4: Fractures of the trochanteric region and the proximal shaft, with fracture in at least two planes. If open reduction and internal fixation is used two plane fixation is required.

Type 3 and 4, most difficult type to manage. Account for only one third of the trochanteric fractures.

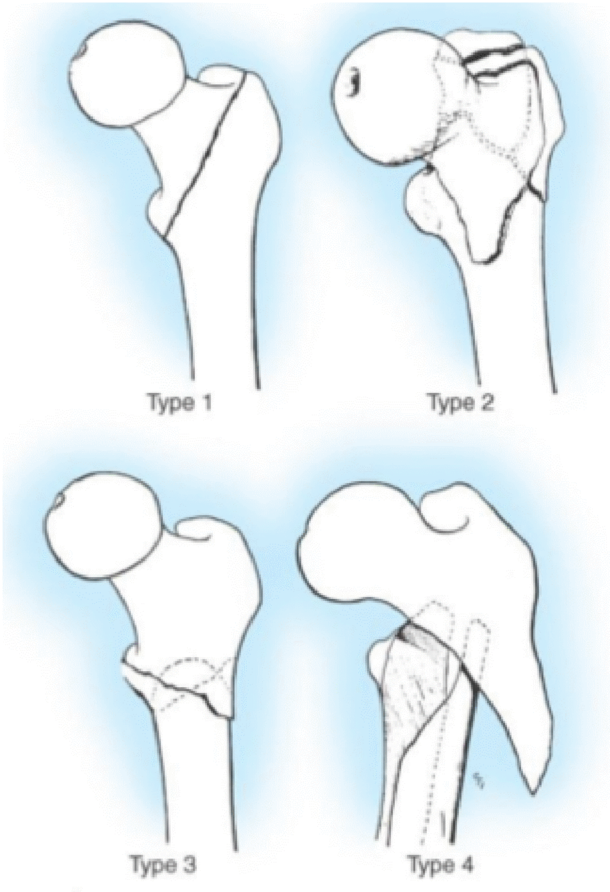


Fig 14: Boyd and Griffin

Evan's classification:

Type 1: The fracture line extends upwards and outwards from the lesser trochanter.

Type 2: The fracture line is of reversed obliquity, the major fracture line extends outward and downward from the lesser trochanter and are unstable.

A widely used classification system based on the stability of the fracture pattern and the potential to convert an unstable fracture pattern to a stable reduction. Evans observed that the key to a stable reduction is restoration of posteromedial cortical continuity.

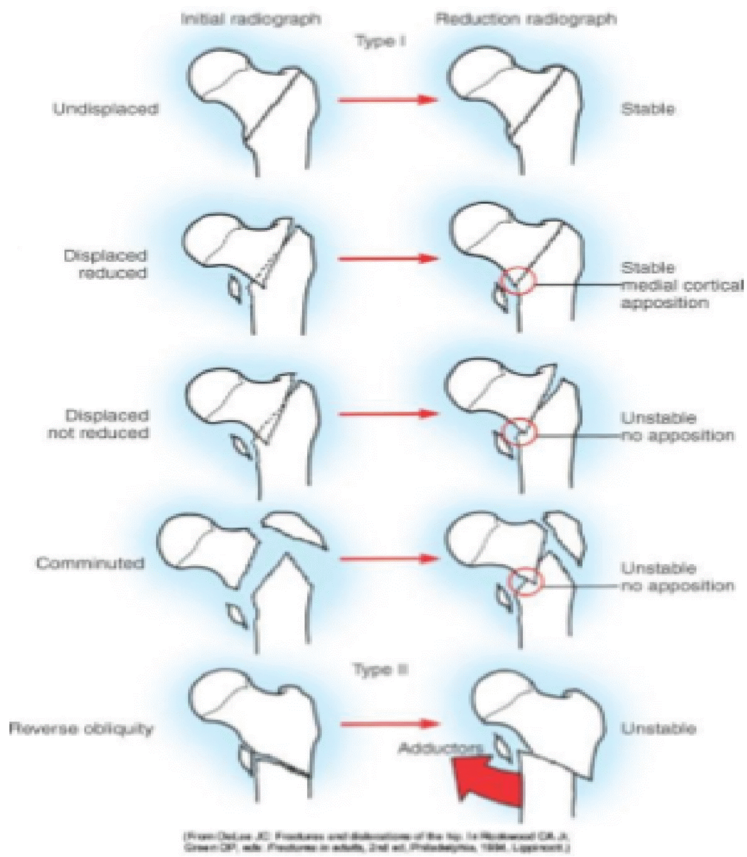


Fig 15: Evans Classification

AO Classification (Muller – 1990): The AO classification is a descriptive classification based on the fracture configuration.

The subtrochanteric fracture belongs to the group of femoral diaphyseal fracture 32(X-#)-1. _X‘ is the sub-classification of the fracture patterns, and these patterns are subclassified into a, b, and c subgroups.

Subgroup ‗a‘ is simple fracture, group ‗b‘ is wedge fracture, and ‗c‘ represents complex fractures. The numeric description # indicates the degree of comminution

A 1.1 Simple fracture spiral

A 2.1 Simple facture oblique (>30°)

A 3.1 Simple fracture transverse (<30°)

B 1.1 Wedge fracture, spiral wedge

B 2.1 Wedge fracture, bending wedge

B 3.1 Wedge fracture, fragmented wedge

C 1. Complex fracture, spiral

C 1.1 With two intermediate fragments

C 1.2 With three intermediate fragments

C 1.3 With more than three intermediate fragments

C 2. Complex fracture, segmental

C 2.1 With one intermediate segmental fragment

C 2.2 With one intermediate segmental fragment and additional wedge fragment(s)

C 2.3 With two intermediate segmental fragments

C 3.1 Complex fracture, irregular

C 3.1 With two or three intermediate fragments

C 3.2 With limited shattering (<5cm)

C 3.3 With extensive shattering (>7cm)

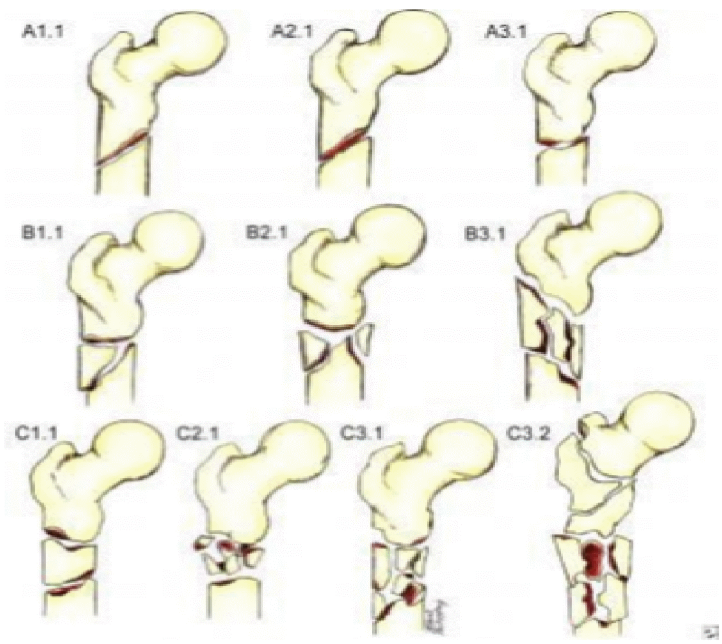


Fig 16: AO Classification

MANAGEMENT OF SUBTROCHANTERIC FRACTURES

DIAGNOSIS -

History

The patient's history of high or low energy trauma is most significant. Inability to bear weight on the affected extremity is universal .Patients who report minimal trauma or no trauma associated with their subtrochanteric fracture should be extensively evaluated to rule out preexisting pathologic bone disease.

Physical Examination:

The patient is usually apprehensive and in pain from the injury. Examination most often reveals a shortened extremity with a swollen thigh. Internal or external rotation of the foot results from loss of continuity at the fracture site. Patients are unable to flex their hip actively or move it through a range of motion. Neurologic and vascular deficits are unusual with these fractures unless they are the result of a penetrating injury. On palpation, prominence of the proximal fragment as a result of flexion, abduction, and external rotation of the hip is common. Haemorrhage in the thigh may be significant and the patient should be monitored for hypovolemic shock.

Radiographic Imaging:

Radiographic evaluation consists of full-length views of the femur from the hip to the knee in both the AP and lateral views, together with an AP radiograph of the pelvis.

Both the pelvis and knee must be inspected carefully because of the frequency of associated injuries. Because of treatment ramifications, attention should be paid to the inner and outer diameter of the medullary canal, the curvature of the femoral shaft, the neck-shaft angle of the unaffected side, and any preexisting deformities or implants of the femur. In patients with neurologic deficits, further evaluation is indicated to rule out intraspinal or lumbo-sacral plexus injury; sciatic nerve injury is rare in patients with subtrochanteric fractures.

The X-ray of the hip and the pelvis is viewed to determine the presence or degree of osteoporosis in elderly patients before a decision regarding open versus closed treatment is made.

Differential Diagnosis:

The differential diagnosis of subtrochanteric fractures essentially requires discrimination only between purely traumatic lesions and those with underlying pathology. If the patient gives a history of pre injury pain or limp or metastatic disease, the surgeon should always consider biopsy of the proximal end of the femur during surgical repair[7].

TREATMENT

Various modalities of subtrochanteric fracture management:

- Non-operative Treatment

Nonoperative treatment of the fracture may be an option for patients who are not surgical candidates. Some low-energy-induced fractures may be treated with non-operative means. A clear understanding of the deformities involved is essential to a successful closed reduction and non-operative treatment with skeletal traction.

The most common method to reduce the fracture is by skeletal traction with a transcondylar Steinmann pin, which is inserted into the condyles while the patient is under local anesthesia. Skeletal traction is set up with the femoral shaft flexed to align with the proximal segment. In most cases, 90 degree flexion is used to relax the ilio-psoas and thus correct the flexion and external rotational deformities. The abduction deformity of the proximal segment is usually corrected by tightening the muscles under skeletal traction. The period of traction ranges from 12 to 16 weeks and should be monitored with regular radiological imaging.

- Operative treatment:

With the modern concept of operative treatment of the diaphyseal fracture of the long bone, anatomical alignment and stable internal fixation are the widely accepted goals of treatment as compared with the doctrine of anatomical reduction and rigid fixation. The restoration of the length and the correction of angular deformities are the primary goals of reduction. The reduced fracture should be repaired with stable internal fixation to allow early mobilization. The technique of internal fixation must follow the guidelines of minimizing the trauma to the soft tissues and the osseous fragments to facilitate fracture healing. Biomechanically, it must be strong enough to counteract the stress across the subtrochanteric region, which can best be achieved by restoring the posteromedial cortical continuity.

Open Method:

The AO group has advocated the open technique since the early 1960s. The aims of treating fractures were strongly emphasized to be anatomical reduction andrigid fixation to achieve immediate mechanical stability by applying fixation with inter-fragmentary compression. The use of strong implants provides strength by neutralizing the external deforming force so that the inter-fragmentary fixation is protected to facilitate primary fracture healing. This technique may be possible in fractures with minimal comminution but it demands an extensive dissection. In the more common fractures with postero-medial comminution, the fixations is a race between fracture healing and implant failure. Bone grafting must be performed posteromedially to enhance fracture healing and restore postero-medial stability. The implant used in this scenario is similar to splinting and weight-bearing may not bepossible until the fracture heals. Another disadvantage of the open technique is the extensive soft tissue dissection from the proximal femur to the mid-shaft in order to achieve anatomical reduction as well as to insert the implants and screws. The devascularizing effect on the osseous fragments frequently leads to delayed or nonunion.

Closed Method

The closed method follows the principle of anatomical realignment in which deformities in length and rotation are corrected to achieve a result that is as normal as possible. The closed method has several advantages in treating these difficult fractures; it does not disturb the fracture hematoma and keeps the soft tissue dissection around the fracture site to a minimum. In this way, fracture healing is not adversely affected.

The medializing of the fixation within the medullary canal decreases the moment arm of the bending stress in the implant, and the load is shared with the osseous tissue.

During the preparation of the medullary canal with reaming, the reaming material serves as a bone graft and is distributed around the fracture site. One goal of operative treatment is strong, stable fixation of the fracture fragments. Kaufer, Matthews, and Sonstegard listed the following variables as those that determine the strength of the fracture fragment-implant assembly

- Bone quality
- Fragment Geometry
- Reduction
- Fixation Device
- Device Placement

Of these five elements of stable fixation, the surgeon can control only the quality of the reduction and the choice of implant and its placement.

1. Bone Quality;

Subtrochanteric fractures occurring in elderly people are relatively low energy trauma injuries occurring in atrophic, osteoporotic or ostemalacic bone. Singh et al have developed a roentgenographic method for determining bone strength that is based on the trabecular pattern of the proximal femur. This method is simple, readily available, requires no special equipment, correlates well with histologic, controls and is sufficiently sensitive and prognostically useful. Loss of continuity of primary tension trabeculae (i.e. grade III) marks the transition between bone capable of holding an internal fixation device and bone so weak that these devices become ineffective. Clinical studies confirm that regardless of other variables internal fixation failed in 80% of fracture of the bone grade III or less. In 1838, Ward described the internal trabecular system of the femoral head. It is important that the internal fixation device be placed in that part of the head and neck where the quality of bone is best. The quality of bone for purchase within the head and neck varies from one quadrant to another. Although the optimal position of a compression screw within the head and neck is controversial, all agree that it should be central or slightly inferior and posterior. The bone of poorest quality is in the anterosuperior aspect of the head and neck.

2. Fragment Geometry:

Much clinical attention has been focused on the number, size, shape, location and displacement of sub trochanteric fracture fragments. Stable subtrochanteric fractures are those in which it is possible to re-establish bone to bone contact of the medial and posterior femoral cortex anatomically, when this is possible, an internalfixation device will act as a tension band on the lateral femoral cortex, and impaction

and weight bearing can occur directly through the medial cortex. In unstable fractures, medial cortical oppositions is not attainable secondary to comminution or fracture obliquity and the bending stress and the loads will concentrate in on the internal fixation device which greatly increase the risk of implant failure.

3) Fixation Device:

High incidence of complications reported, after surgical treatment has led to series of internal fixation devices. Various commonly employed internal fixation devices are

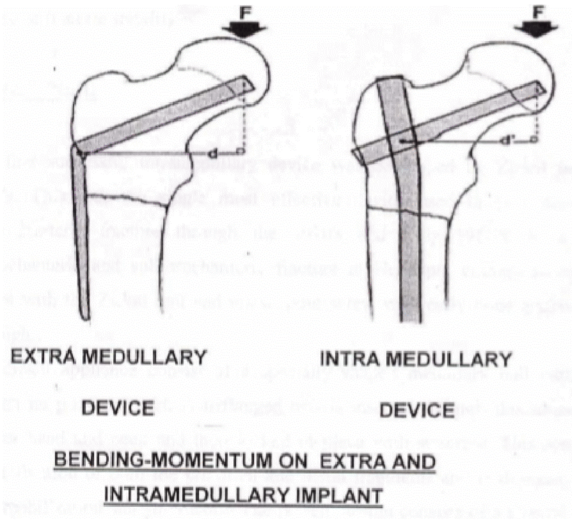


Fig. 17- Bending momentum on extra and intramedullary implant

I) EXTRAMEDULLARY DEVICES:

1. Fixed angle nail-plates

2. A.O. 95 degree blade-plate

3. DCS

4. DHS

5. Medoffs axial compression Screw

Intra-medullary fixations :

During the past century a better understanding of the biomechanics of pertrochanteric and subtrochanteric fracture has led to the development of better implants and radical changes in treatment modalities. Koch analyzed mechanical stresses on the femur during weight bearing and found that compression stresses exceeded 1200 Lb per sq inch in the medial subtrochanteric area 1 to 3 cms distal to lesser trochanter. This explains why the typical comminution on the medial side after a fracture and underlines the importance of restoring medial cortical support after fracture fixation in order to achieve stable fixation.

For most subtrochanteric femur fractures, the implant of choice is an intramedullary nail. Biomechanically, these devices offer several advantages over plate and screw fixation:

1. Because the intramedullary canal is closer to the central axis of the femur than the usual plate position on the external surface of the bone, intramedullary nails are subjected to smaller bending loads than plates and are thus less vulnerable to fatigue failure.
2. Intramedullary nails act as load-sharing devices in fractures that have cortical contact of the major fragments. If the nail is not locked at both the proximal and distal ends, it will act as a gliding splint and allow continued compression as the fracture is loaded.
3. Stress shielding with resultant cortical osteopenia, commonly seen with plates and screws, is avoided with intramedullary devices; and refracture after implant removal is rare with the use of intramedullary devices, secondary to the lack of cortical osteopenia and the minimum number of stress risers created in the cortical bone.

Intramedullary devices also offer significant biological advantages over other fixation methods. Although insertion can be technically demanding, intramedullary implants do not usually require the extensile exposures required for plate application.

With use of image intensification, these devices can be implanted in a closed manner, without exposing the fracture site. These closed techniques result in low infection and high union rates, with a minimum of soft tissue scarring.

II) INTRAMEDULLARY DEVICES:

1] Condylocephalic- Enders pins

2] Cephalomedullary;

i) AP Gamma Nail

ii) Russel and Taylor reconstruction Nail,

iii) Zickels Nail,

iv) Uniflex Nail,

v) Proximal Femoral Nail (Short& Long)

Proximal Femoral Nail:

In 1997, the proximal femoral nail was introduced for treatment of pertrochanteric femoral fractures. It was designed to overcome implant-related complications and facilitate the operative treatment of unstable peritrochanteric fractures. The proximal femoral nail uses two implant screws for fixation into the femoral head and neck. The larger screw, the femoral neck screw, is intended to carry the majority of the load. The smaller screw, the hip pin, is inserted to provide rotational stability. Biomechanical analyses of the proximal femoral nail show a significant reduction of distal stress and an increase of overall stability compared with the Gamma nail. Evaluation of treatment results of the proximal femoral nail shows a relatively low percent of complications and a low incidence of implant failure. Although complication rates remain low, cut-out of the hip pin and the femoral neck screw is a serious complication that leads to revision surgery and related morbidity. The risk of cutout must be reduced as much as possible.

Proximal femoral nail has all the advantages of an intramedullary device, such as decreasing the moment arm, can be inserted by closed technique, which retains the fracture heamatoma an important consideration in fracture healing decreases blood loss, infection, minimizes the soft tissue dissection and wound complications. The PFN system, developed by AO/ASIF, has some major biomechanical innovations to overcome the previously mentioned limitations of the GN: The addition of the 6.5

mm anti-rotation hip pin to reduce the incidence of implant cut-out and the rotation of the cervico-cephalic fragment, the greater implant length, smaller valgus angle and setting of this angle at a higher level (11 cm from the proximal end), and The more proximal positioning of the distal locking, to avoid abrupt changes in stiffness of the construct. In this respect, it should be borne in mind that the neck screw must be adjusted to the calcar, taking into account the need to place the antirotational hip pin[11].

ADVANTAGES OF PFN OVER OTHER IMPLANTS

1. Biomechanically strong and rigid implant leading to high rate of bone union.
2. Incidence of implant failure is less.
3. Has two proximal locking hip screws to provide rotational stability to the proximal fragment.
4. Removal of distal locking bolt for dynamization of up to 10mm is possible to facilitate fracture union.
5. Typically reinforces the entire length of the bone thus the risk of periprosthetic fracture at its distal tip is negligible.

MATERIALS AND METHODS

The present study was carried out between August 2015 to August 2017 at Department of orthopaedics, R. L. Jalappa Hospital and Research Centre, Kolar . 30 cases who presented with subtrochanteric fracture femur were treated with internal fixation with proximal femoral nail and followed up to August 2017. Patients were followed up for a period of 6 months using Modified Harris Hip Score.

Inclusion Criteria:

1. Patient with subtrochanteric femur fracture.

Exclusion Criteria:

1. Paediatric fractures (before physeal closure)
2. Pathological fractures
3. Periprosthetic fractures

After the admission of patient, a detailed history was elicited from patient and attendants to reveal the mechanism of the injury and the severity of the medical history and pre-injury functional status. The patients were then examined thoroughly to evaluate their general condition and the local injury.

Comprehensive examination, not only of the injured limb, but also of all the limbs, to avoid missing the other associated injuries, if any, was done. The involved extremity was examined for swelling, deformity, abnormal mobility, crepitus, shortening, discoloration, skin integrity, neurological and vascular compromise, andsigns or symptoms of compartment syndrome. Medical consultation was sought expeditiously for geriatric patients. General surgeon consultation was sought to evaluate all high energy trauma victims to rule out polytrauma.

Radiographic evaluation included anteroposterior and lateral radiographs of the entire femur, including the hip joint and the knee joint. Application of manual traction of the limb during radiographs will often clarify fracture morphology. The limb was then immobilized in a Thomas splint with skin traction. The patient was then taken up for surgery after the patient was medically fit for surgery.

Routine investigations done:

- Complete blood count, bleeding time, clotting time.
- Random blood sugar, blood urea, serum creatinine.
- Blood grouping and cross matching.
- Urine for sugar, albumin and microscopy.
- Other investigations depending on patient's premorbid conditions.

Any delay in the surgery was usually attributable to multiple trauma or poor medical condition of the patient. All patients were treated with IV antibiotics for the first five days post surgery and then converted to oral antibiotics till suture removal.

PRE OPERATIVE PLANNING:

1) Determination of nail diameter: Nail diameter was determined by measuring diameter of the femur at the level of isthmus on an x-ray after subtracting 10% of radiological magnification.

2) Determination of neck shaft angle: Neck shaft angle was measured on the unaffected side on an AP x-ray.

3) Length of the nail: Length measured clinically on contralateral side from tip of greater trochanter to upper pole of patella and radiologically on an AP x-ray after subtracting 10% of radiological magnification.

PROXIMAL FEMORAL NAIL IMPLANT DETAILS:

The implant consists of a proximal femoral nail which is a cephalomedullary locking device which consists of two proximal screws among which distal one is 8 mm hip screw and the other proximal 6.5 mm anti-rotation screws. Two 4.9mm distal locking options where one is static and the other is dynamic locking which allows up to 5mm of dynamization.

Proximal femoral nail is made up of 316L stainless steel. The nail is available in lengths from 240mm to 420mm. The proximal diameter of the nail is 14mm which aids for better stability for fixation in proximal femur. The distal diameter is of the nail is tapered to optional 9, 10, 11 and 12mm.

The nail has a mediolateral valgus angle of 6° which aids better stability and fixation in greater trochanter and 10° of anteversion. The nail has an anterior curvature of 1.5m radius to match the anatomic anterior femoral curvature. The nail is available with

neck shaft angle of 125°, 130° and 135°.

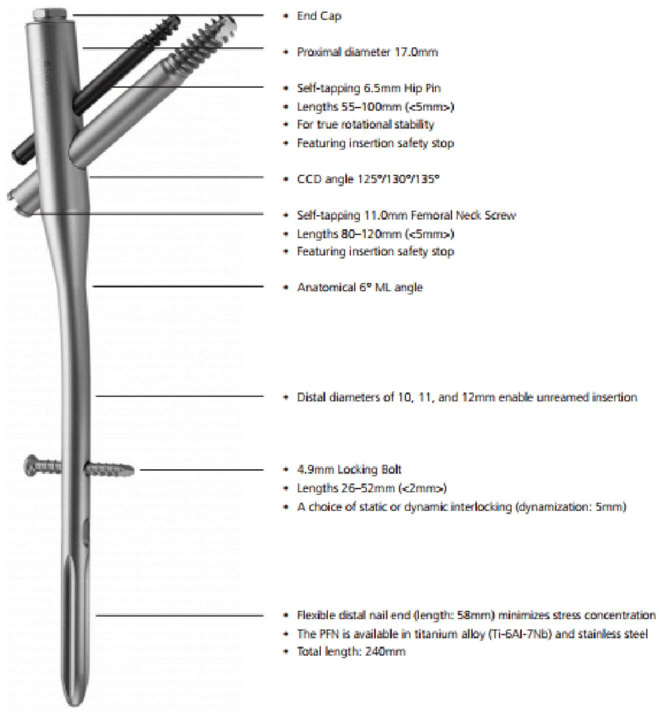


Fig. no. 18- Structure of Proximal femoral nail.

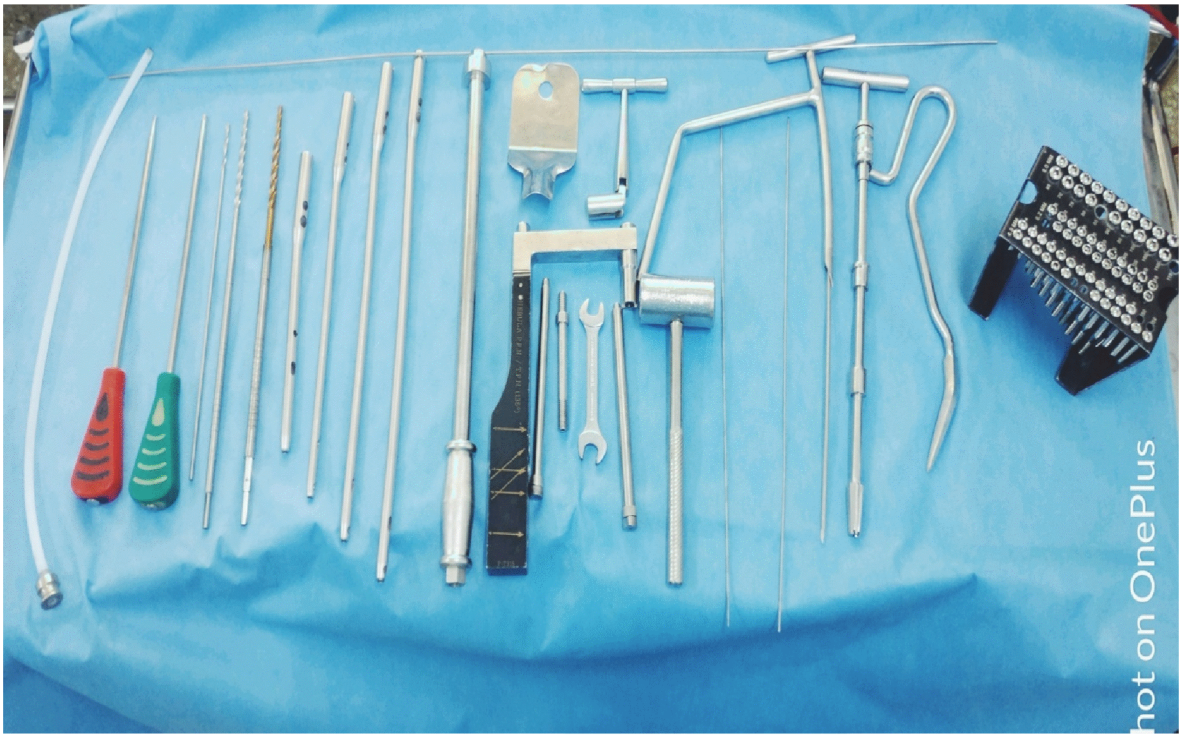


Fig. 19- Instruments Used For Proximal Femoral Nailing

OPERATIVE TECHNIOUE:

Prophylactic antibiotic was given to all patients 30 minutes before surgery. The cases were operated either under Epidural and spinal anesthesia or under only spinal anesthesia.

Patient positioning and fracture reduction:

The patient is positioned supine on the fracture table with the contralateral leg well-padded and positioned without pressure on to the calf in order to prevent peroneal nerve damage or calf muscle compartment syndrome and fixed with the help of thigh support in flexed and abducted position. A support underneath the ipsilateral buttock was given to facilitate the approach particularly in obese patients. The ipsilateral arm was positioned in an adducted or elevated position so as not to intervene during the surgical procedure.

The operating limb is adducted to 10° to 15° and internally rotated to about 15°. The image intensifier was positioned between the injured and uninjured legs, so that both AP and lateral views can be obtained easily. Closed reduction was attempted under traction and manipulation of the limb. The patient was then prepared anddraped as for the standard hip fracture fixation. Draping is applied up to the pelvic rim.

Localization of incision:

To locate the site of the skin incision, the tip of the greater trochanter and the axis of the femur are marked with the help of the image intensifier and by palpating the trochanter. 3-5cm incision is made 5cm proximal to the tip of the greater trochanter on the proximal extension of the anatomical femoral bow. The skin incision is made in line with the curved axis of the femoral canal in order to minimize the risk of injury to the superior gluteal nerve and to minimize the risk of eccentric reaming of the proximal fragment, leading to the risk of perforation of the posterior femoral shaft cortex.

Deep incision and Determination of entry point:

The fascia is opened with scissors and the gluteus muscle is split along its fibers. The trochanteric entry point which is just medial to the tip of the greater trochanter in the anterior-posterior view and along the axis of femur in lateral view is opened with the help of bone awl.

Guide wire Insertion

A 2.8mm ball tipped guide wire fixed to a universal chuck with T handle was manually inserted through the entry point made into the proximal fragment and confirmed under image intensifier in both the views. Then reduction was achieved with traction and manipulation of the fracture site and guide wire passed into distal fragment crossing the fracture site. In cases where reduction was difficult to achieve, a 4.5mm Steinmann pin was drilled only in the lateral cortex of the proximal fragment after making a small incision on the overlying skin and used as a joystick to aid reduction. In cases where reduction wasn‘t achieved in closed fashion, open reduction was done with a lateral incision centering the fracture site. The guide wire was advanced up to the distal end of femur taking care that the guide wire was centered throughout to avoid eccentric reaming and subsequent malposition of the nail.

Determination of nail length and diameter

The correct length of the nail is determined based on pre-operative clinical assessment and also by comparing a second guide wire to the one that has been inserted. The nail diameter is determined based on pre-operative x-rays as described earlier.

Reaming of medullary canal:

After the guide wire has been passed, a trochanteric protection sleeve is placed over the trochanter. Reaming done using flexible reamers starting from 8mm diameter with subsequent increments of 0.5mm up to 1mm greater than the nail diameter selected. Proximal trochanteric reaming is then carried out with the trochanteric starter reamer.

Exchange of guide wire

Teflon tube (Exchange tube) is now passed over the guide wire and advanced into the medullary cavity over the ball tipped guide wire into the distal fragment. Then the ball tipped guide wire is removed and replaced with the plane tipped guide wire and then the Teflon tube is removed after confirming the position under image intensifier. The trochanteric sleeve is then removed.

Insertion of nail:

The desired nail is mounted to the jig with the help of conical bolt. The nail is then passed over the guide wire manually as far as possible and then the nail advanced using a ram until 8mm lag screw hole was lying in line with the upper part of lesser trochanter and distal tip of the nail up to the upper pole of patella under image intensifier in both the views. The guide wire is then removed.

Proximal Locking:

Insertion of guide pins for both the lag screw and the anti-rotation screw. After confirming the position of the nail, the guide pin of 1.8mm diameter for the 8mm hip screw passed into the guide pin sleeve which was tightly secured in the jig after making a small stab incision for screw insertion. The guide pin was placed subchondrally in the inferior part of the neck and parallel to the inferior border of the neck in antero-posterior view and centrally in lateral view. In the similar fashion, guide pin for 6.5mm screw was inserted in the superior part of the neck and advanced until the tip of the guide pin for 8mm screw was parallel and the tip of guide pin for the anti-rotation screw were parallel to the ground in antero-posterior view and centrally in lateral view.

Screw insertion- The guide pin sleeve is then removed and length of the screws required is measured using an indirect measuring device.

The hip screw of appropriate length is then inserted after drilling until the tip of the screw is placed subchondrally. Then the 6.5mm anti rotation screw was inserted after drilling with appropriate drill bit. Usually the antirotation screw length used was 15-20 mm less than the length of hip screw.

Distal locking:

The distal locking was done using free hand technique under image intensifier. The lateral cortex was drilled with a 4mm drill bit and a 4.9mm locking bolt was used for distal locking either in static or dynamic fashion. In this study most of the cases were fixed with dynamic locking.

Then the jig was detached after removing the conical bolt. Sterile normal saline wash was given and the wound closed in layers. In cases where open reduction was achieved, a suction drain was placed at fracture site. Sterile dressing done.

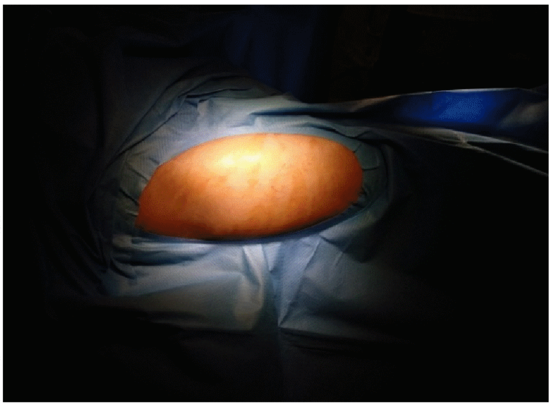


Fig 20: Painting of parts **Fig 21: Draping**

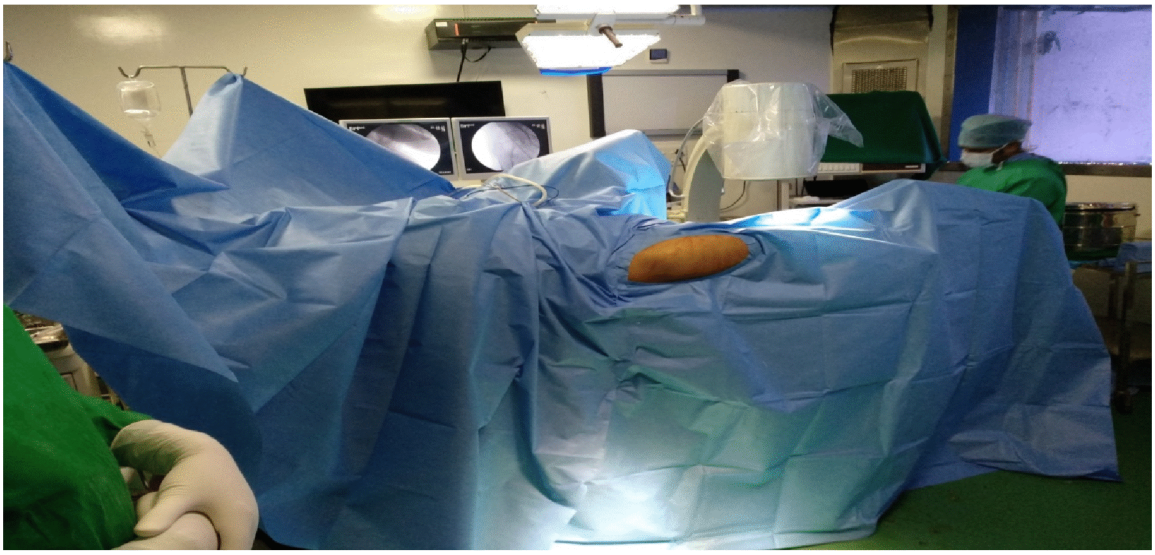


Fig 22: Prepared for surgery

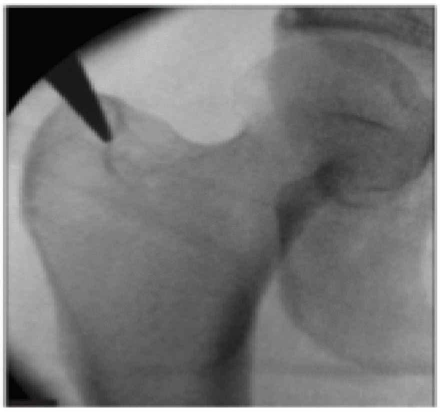
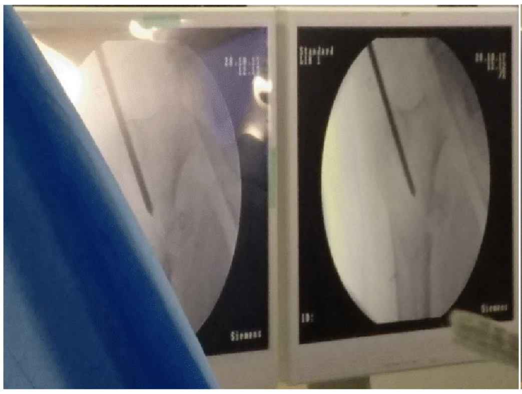


Fig 23: Incision site **Fig 24: Entry point with bone awl**



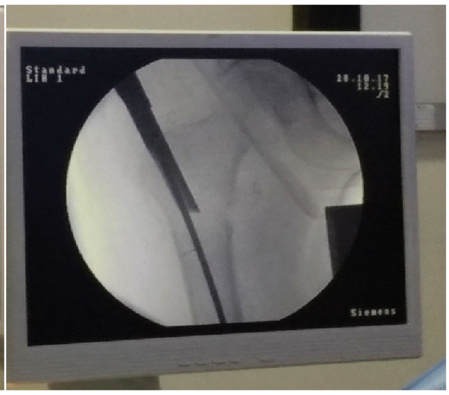


Fig 25: Guide wire insertion **Fig 26: Nail insertion**

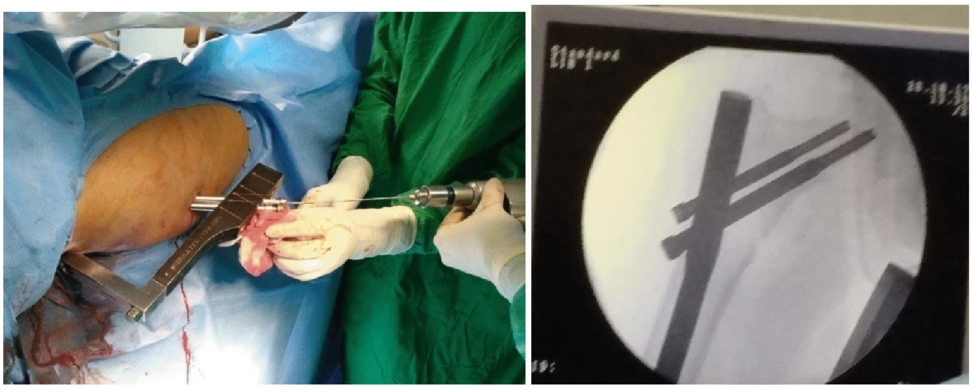


Fig 27: Hip screw insertion

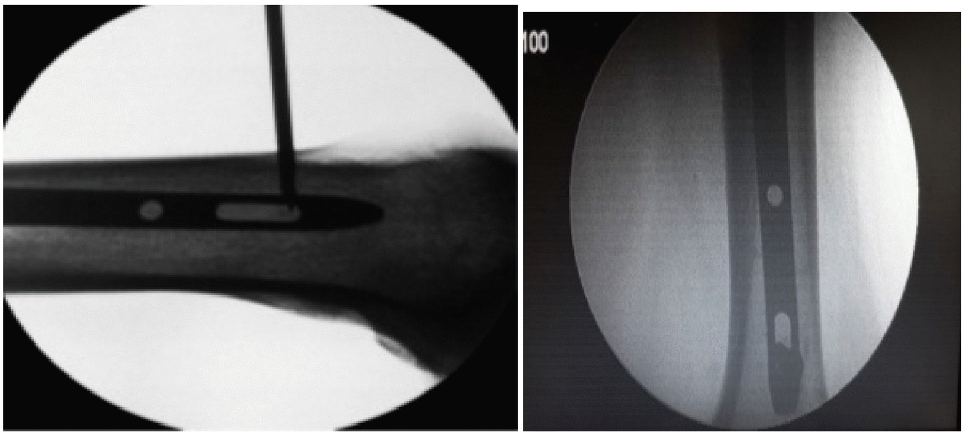


Fig 28: Distal locking

Postoperative care

- Day 1: Early active flexion and extension are essential and encouraged.

- Day 2: Isometric and range of motion exercises begun. In case if suction drain was placed, then it was removed and dressing changed under aseptic precaution.
- Day 3: Gait training progressed from use of parallel bars to a walker or crutches, with weight bearing as determined by the stability intra-operatively. In patients with stable internal fixation, touchdown weight bearing of the affected extremity was allowed. In patients with comminuted fractures and with relatively unstable fixation, weight bearing is delayed until radiological evidence of fracture healing and a fracture brace may be needed.
- Day 5: intravenous antibiotics stopped. Oral antibiotics started.
- Day 12 : Suture removal

Prophylactic antibiotics were used in all patients. By 6 weeks, if X rays showed signs of union progression, increased weight bearing was allowed. By 12 weeks, with further evidence of radiological consolidation, full weight bearing was allowed

Follow up

All the patients were followed up. With each follow up, clinical and radiological examinations were performed at 1 month, 4 months, 6 months. Clinical examination included evaluation of the complaints by the patients, assessment of the range of motion, assessment of the soft tissues, evaluation of the rotational alignment, leg length discrepancy and deformities, if any. Finally the functional implications were evaluated.

Radiological examination was performed in two planes and assessed for callus formation and varus - valgus and flexion - extension deformities. ―Union was defined as the appearance of bridging callus and trabeculations extending across the fracture site. ―Nonunion‖ was defined as no evidence of fracture union progression in 6 months of follow up. ―Delayed union was defined as the appearance of the signs of fracture union, but the progress of union to consolidation is delayed than is otherwise expected.

ASSESSMENT OF RESULTS

The results of the treatment of subtrochanteric fractures using Proximal Femoral Nail were assessed by MODIFIED HARRIS HIP SCORE system. This system is slightly modified according to the needs of the Indian patients. That is in place of 'put on shoes and socks' we have used 'squatting' and in place of 'sitting' we have used 'cross legged sitting'.

STATISTICAL ANALYSIS:

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of frequencies and proportions.

Graphical representation of data: MS Excel and MS word was used to obtain various types of graphs such as bar diagram and Pie diagram.

RESULTS

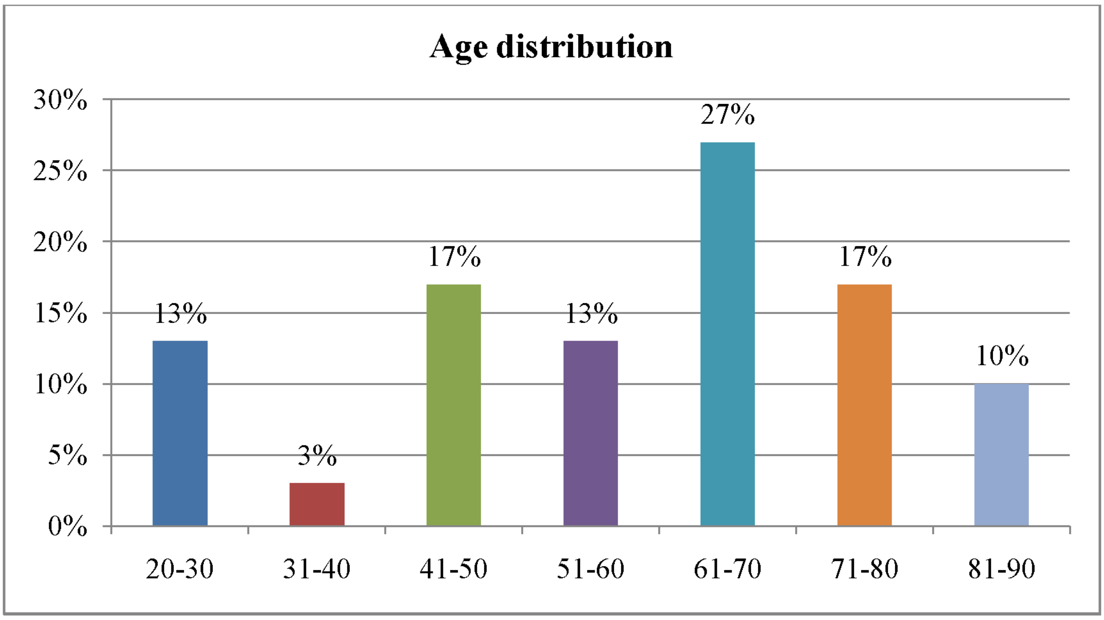
DEMOGRAPHIC DETAILS OF THE STUDY PATIENTS.

Table 1: Age distribution.

Age	Number of patients	Percentage
20-30	4	13
31-40	1	3
41-50	5	17
51-60	4	13
61-70	8	27
71-80	5	17
81-90	3	10
Total	30	100

In our study, majority of patients were in the age group ranging from 20-90years, mean age being 55 years.

Youngest patient aged 20 years and oldest was 9o years (Table 1)

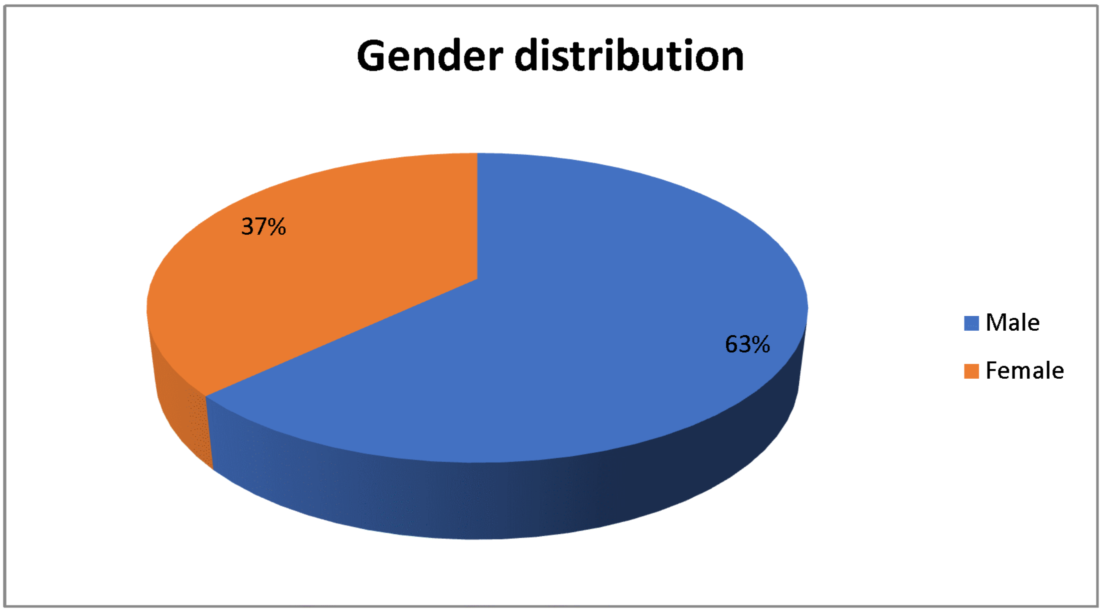


Graph1: Bar diagram showing Age distribution of study patients.

Table 2: Gender distribution.

Sex	No. of patients	Percentage
Male	19	63
Female	11	37
Total	30	100

Out of 30 patients, 19 were male and 11 were female.

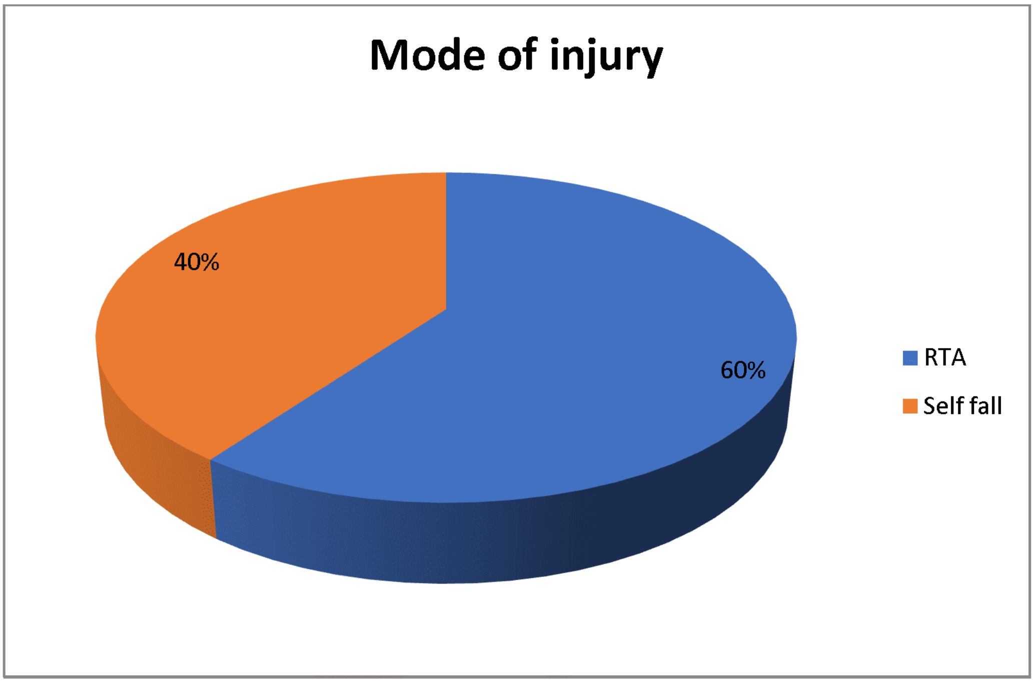


Graph2: Pie diagram showing Sex distribution of study patients.

Table 3: Mode of Injury

Mode of injury	No.of patients	Percentage
RTA	18	60
Self fall	12	40
Total	30	100

In our series, 18 patients had history of Road Traffic Accidents (RTA) and 12 patients had history of slip and fall.

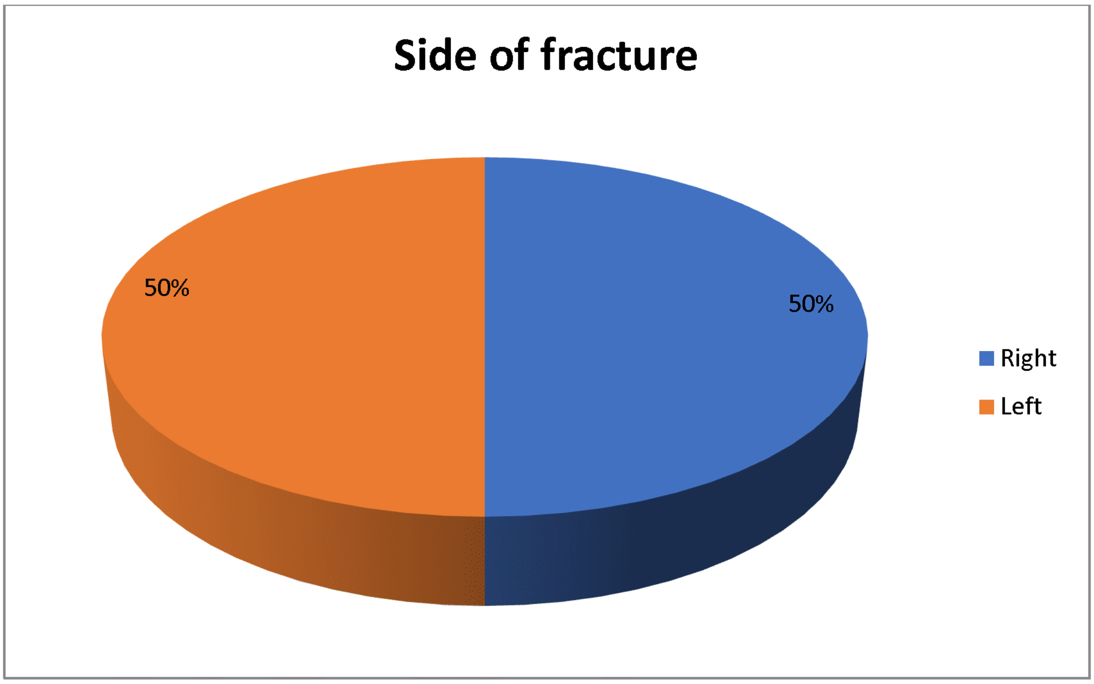


Graph3: Pie diagram showing Mode of Injury distribution

Table 4: Side of fracture

Side of fracture	No. of patients	Percentage
Right	15	50
Left	15	50
Total	30	100

In present study, 15 cases had right side femur fracture and 15 cases had left side femur fracture.



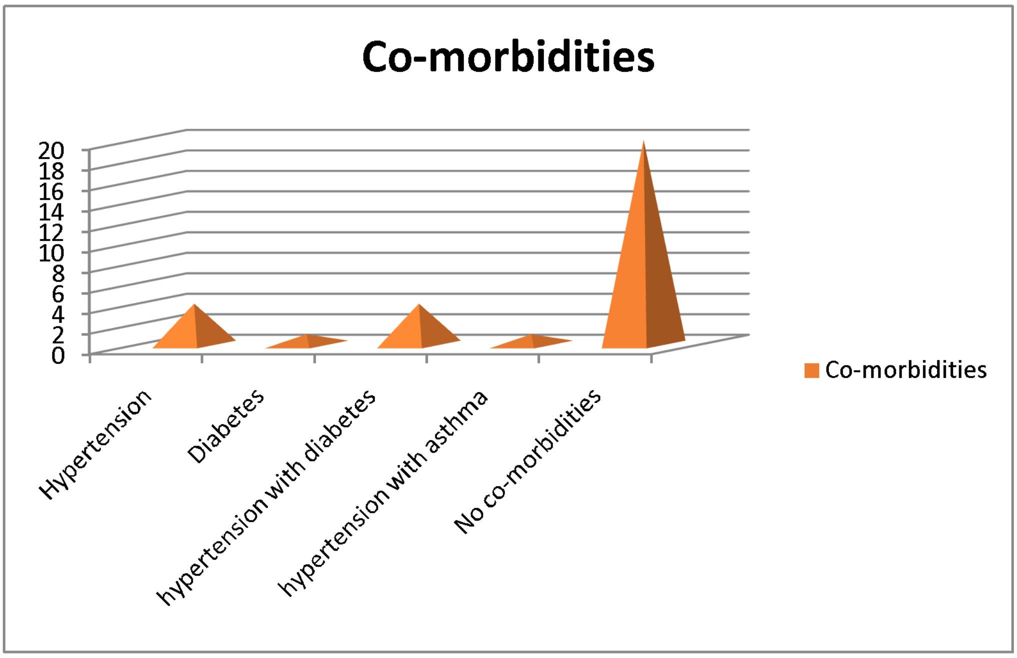
Graph4: Pie diagram showing Side of fracture distribution

Table 5: Associated Co-morbidities with femur fracture.

Co-morbid condition	No. of patients	Percentage
Only Hypertension	4	13.3
Only Diabetes mellitus	1	3.33
Hypertension and Diabetes	4	13.3
Hypertension and asthma	1	3.33
No comorbidities	20	66.7
Total	30	100

Out of 30 patients, 10 cases were with associated co morbidities. 4 patients had hypertension, 1 had diabetes mellitus and 4 patients had both diabetes and hypertension. One case had hypertension with bronchial asthma.

66.7% of patients did not have any associated comorbidity.



Graph5: Bar diagram showing associated co- morbidities with femur fracture.

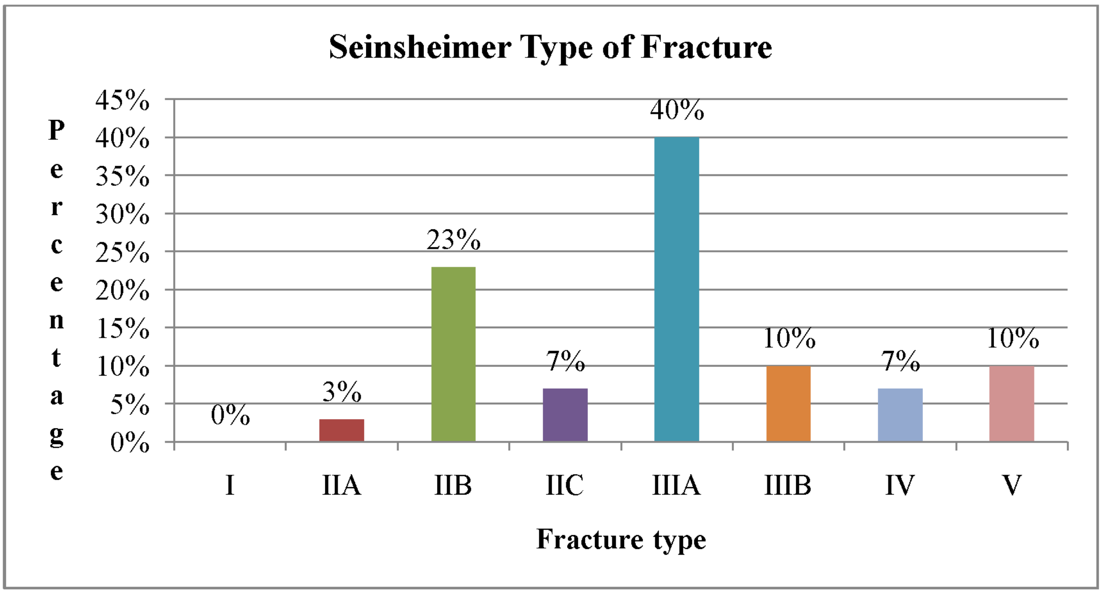
Table 6: classification of femur fracture as per Seinsheimer classification.

Fracture type	No. of patients	Percentage
I	0	0
IIA	1	3
IIB	7	23
IIC	2	7
IIIA	**12**	**40**
IIIB	3	10
IV	2	7
V	3	10
Total	30	100

In our study, **more number of patients had type IIIA fracture.**

Others were, type IIA was 1 case, IIB were 7 cases, type IIC were 2 cases, type IIIB were 3 cases, type IV were 2 cases and type V were 3 cases.

None had type I.

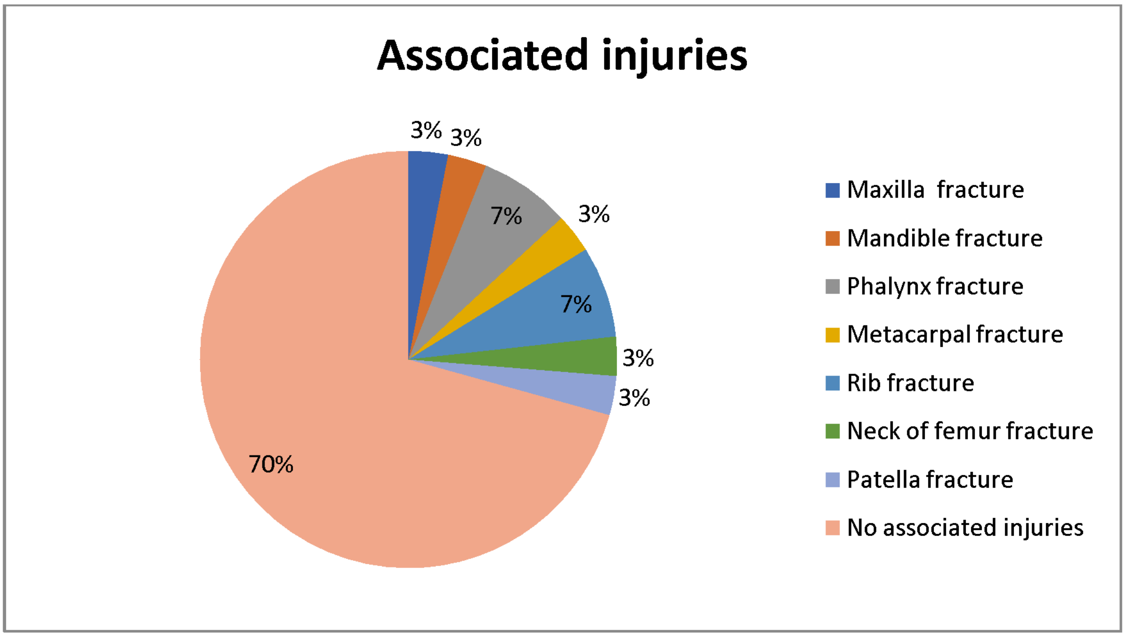


Graph6: Bar diagram showing Seinsheimer Type offemur Fracture

Table 7: Associated injuries with femur fracture.

Associated injuries	No. of patients	Percentage
Maxilla fracture	1	3
Mandible fracture	1	3
Phalynx fracture	2	7
Metacarpal fracture	1	3
Rib fracture	2	7
Neck of femur fracture	1	3
Patella fracture	1	3
None	**21**	**70**
Total	30	100

In present study, it was observed that majority(70%) of patients did not have any associated injuries.



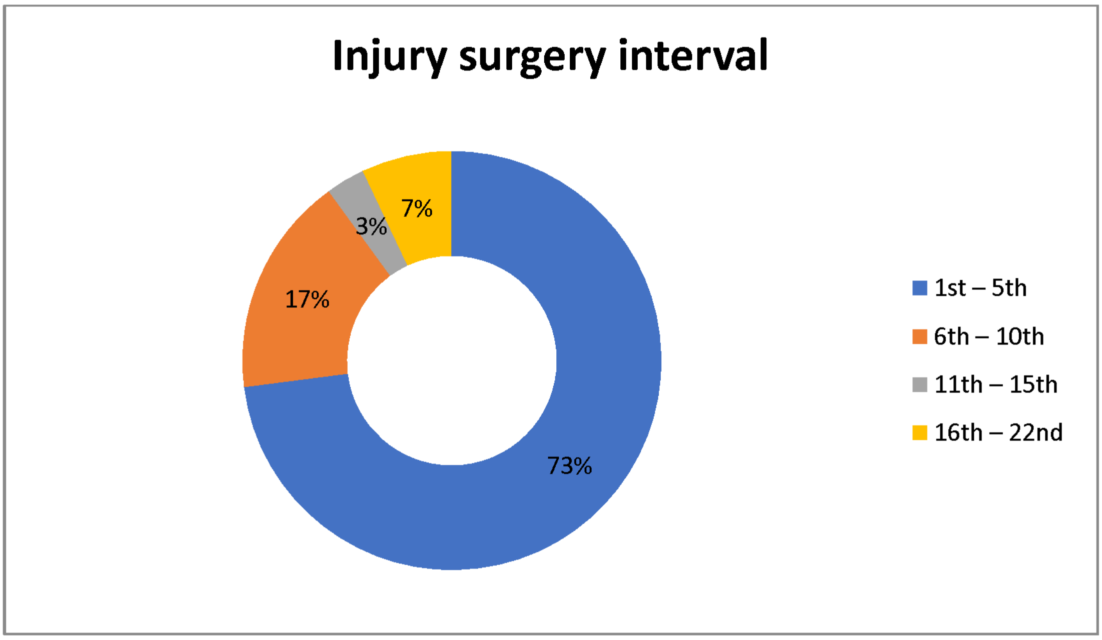
Graph 7: Pie diagram showing Associated injuries with femur fracture.

Table 8: Interval between Injury and surgery.

Injury surgery interval	No. of patients	Percentage
1st – 5th	**22**	**73**
6th – 10th	5	17
11th – 15th	1	3
16th – 22nd	2	7
Total	30	100

Patients were operated between 1-21 days of trauma, mean time of interval being 4 days.

Majority of surgery was done between 1st and 5th day after injury.

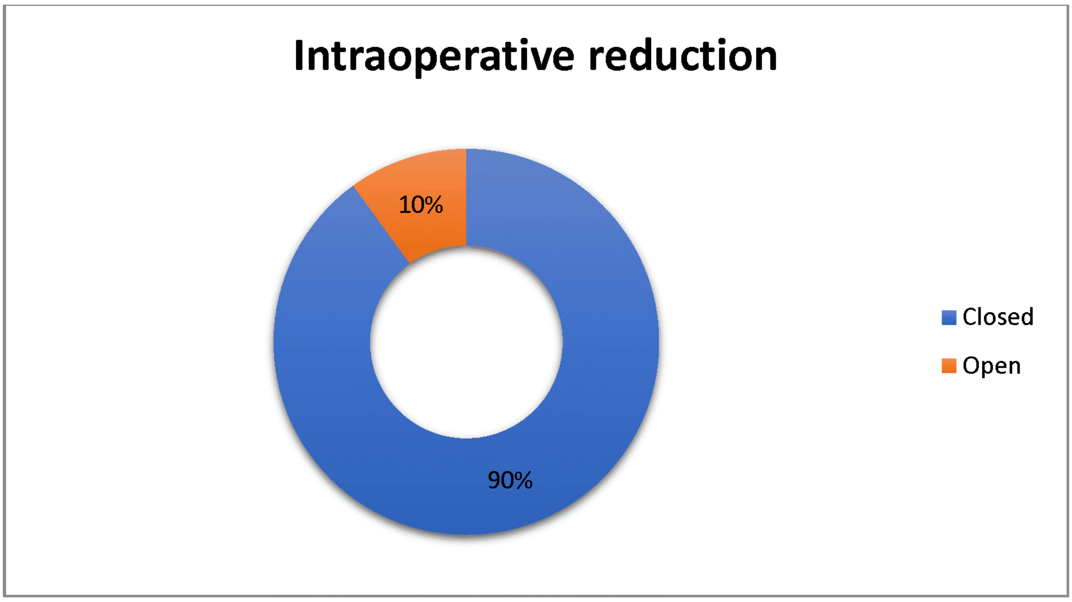


Graph8: Diagram showing Injury surgery interval

Table 9: Distribution of Intraoperative reduction method.

Intra-operative reduction	No. of patients	Percentage
Closed	27	90
Open	3	10
Total	30	100

In present study, majority (90%) of fractures were fixed after closed reduction. Only 3 cases required fixation after open reduction.



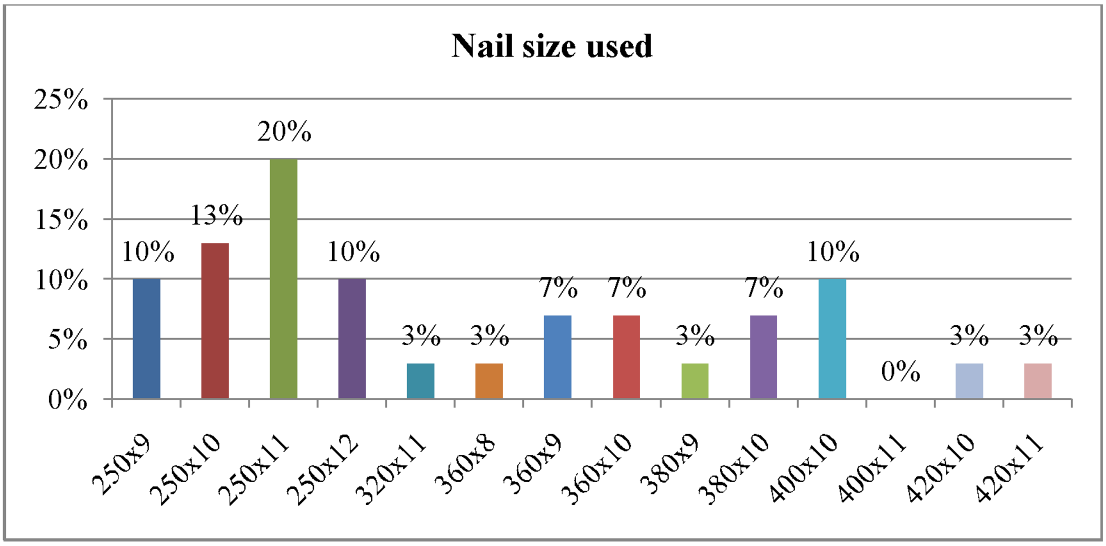
Graph9: pie diagram showing Intra-operative reduction

Table 10: Nail size used for fixation.

Nail size	No. of patients	Percentage
250x9	3	10
250x10	4	13
250x11	6	20
250x12	3	10
320x11	1	3
360x8	1	3
360x9	2	7
360x10	2	7
380x9	1	3
380x10	2	7
400x10	3	10
400x11	0	0
420x10	1	3
420x11	1	3

In our study, various proximal femoral nail sizes were used for fracture fixation.

Commonly used were 250 x11, 250 x10 and 400 x 10.



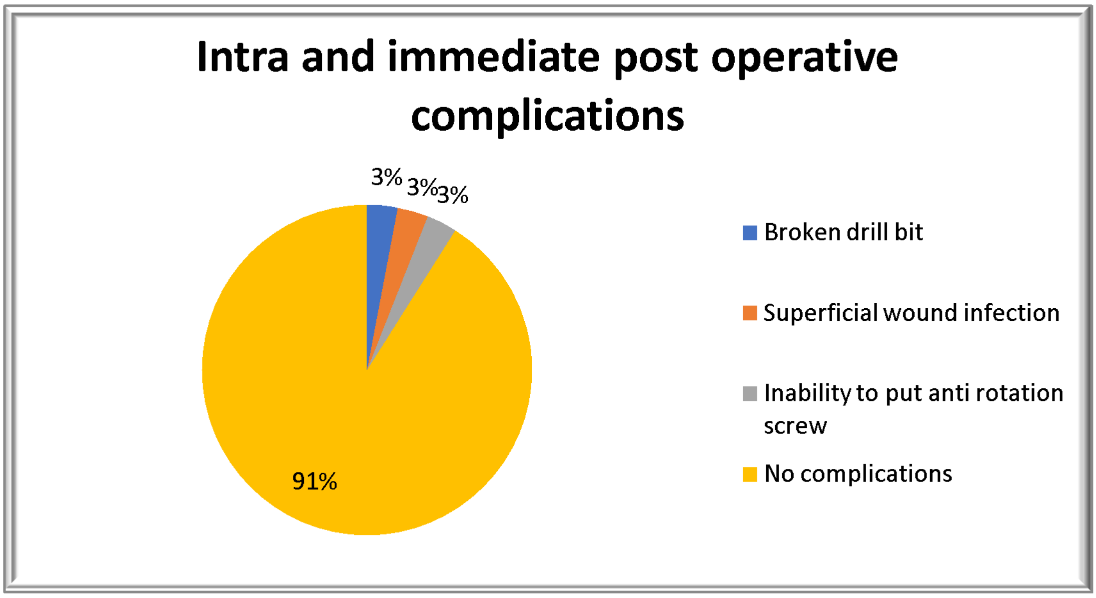
Graph10: Bar diagram showing Nail size used

Table 11: Intra-Operative and immediate post-operative complications

Intra and immediate post operative complications	No. of patients	Percentage
Broken drill bit	1	3
Superficial wound infection	1	3
Inability to put anti rotation screw	1	3
No complications	27	91
Total	30	100

In our series, 91% of patients did not have intra-operative and immediate post-operative complications.

Weencountered few intra operative complications like breaking of drill bit and inability to put anti - rotation screw in 1 case each which was because of narrow neck. Immediate post operative complication encountered in our series was superficial wound infection which subsided with regular dressing and intravenous antibiotics.



Graph11: Pie diagram showing Intra-Operative and immediate post-operative complications

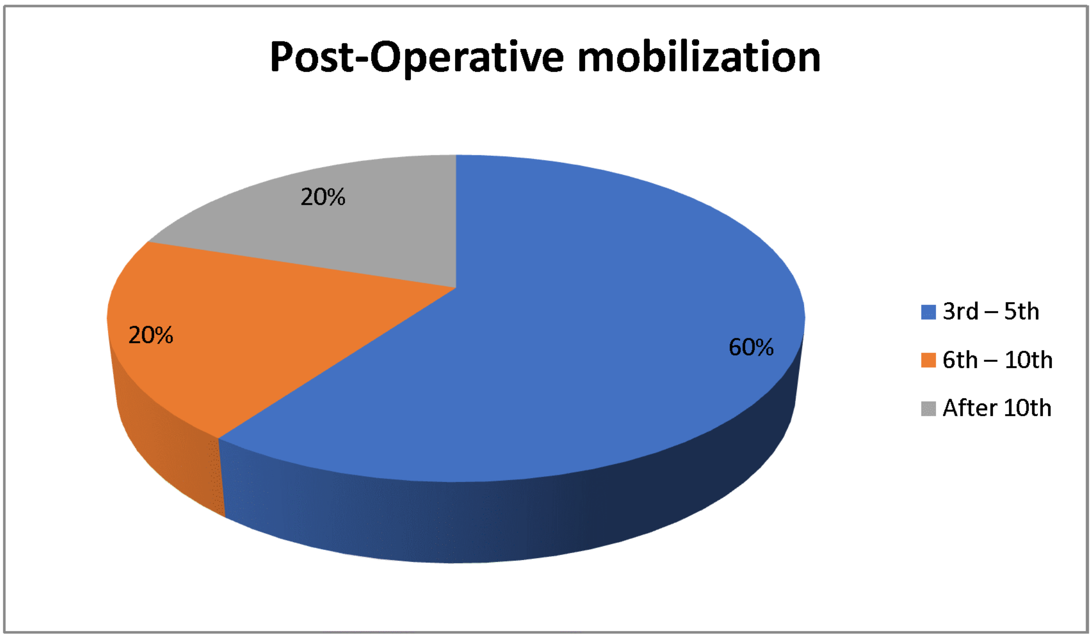
Table 12: Post-Operative mobilization

Post op day	**No. of patients**	**Percentage**
$3^{rd} – 5^{th}$	**18**	**60**
$6^{th} – 10^{th}$	6	20
After 10^{th}	6	20
Total	30	100

Partial weight bearing with walker was started on an average of day 3-5 days.

Majority(60%) of patients were mobilized on post –op **3-5 days**

Patients with significant complication were advised delayed weight bearing.

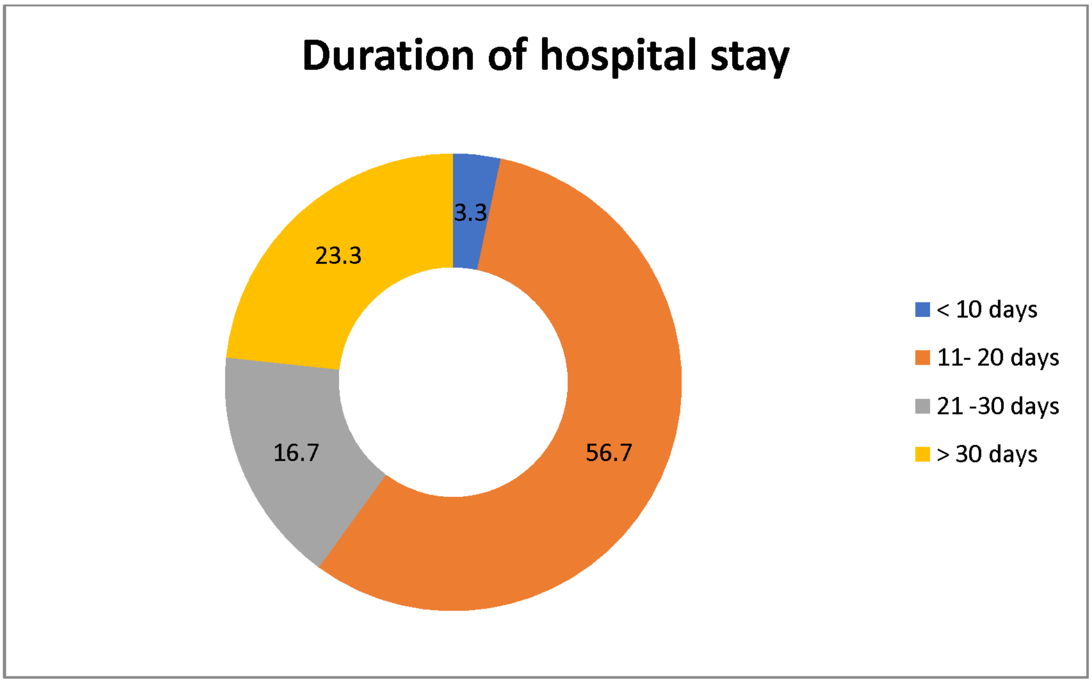


Graph62: Pie diagram showing Post-Operative mobilization

Table 13: Duration of Hospital stay

Hospital stay (Days)	Number of patients	Percentage
< 10	1	3.3
11 – 20	17	56.7
21 – 30	5	16.7
>30	7	23.3
Total	30	100

The duration of hospital stay ranged from 4 to 46 days with a mean of 20 days.

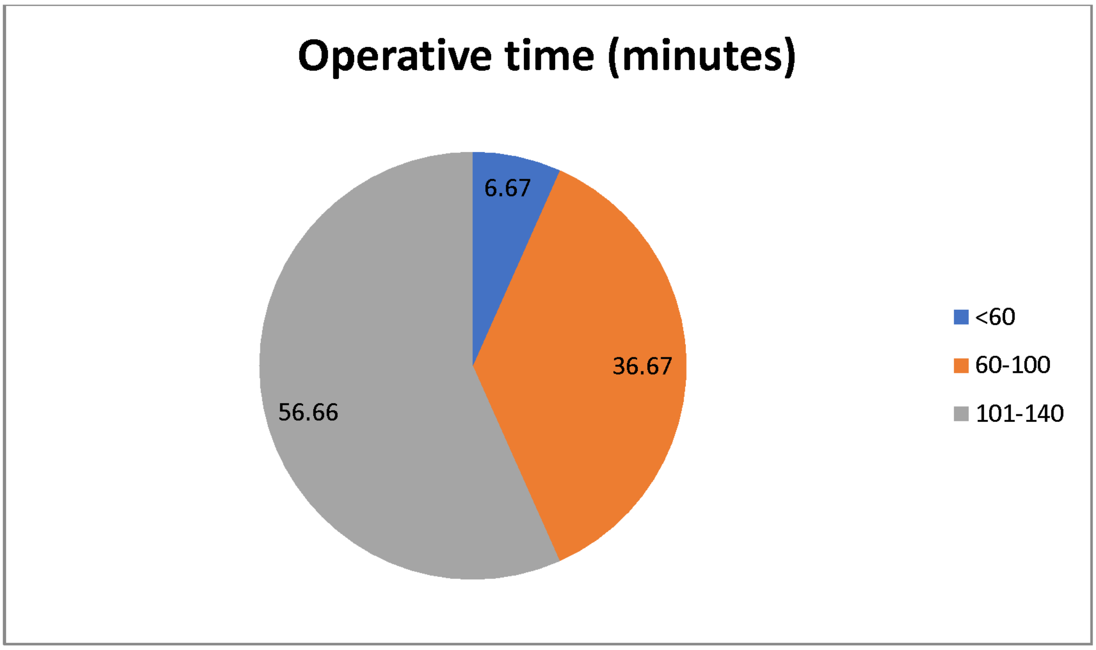


Graph 13: pie chart showing duration of hospital stay.

Table no 14: Average operative time

Average operative time	Number of surgery	Percentage
101-140 minutes	**17**	**56.66**
60-100 minutes	11	36.67
<60 minutes	2	6.67
Total	30	100

Operative Time was calculated from skin incision to closure including dressing (intra-operative), in our series it was on an average 108 min.

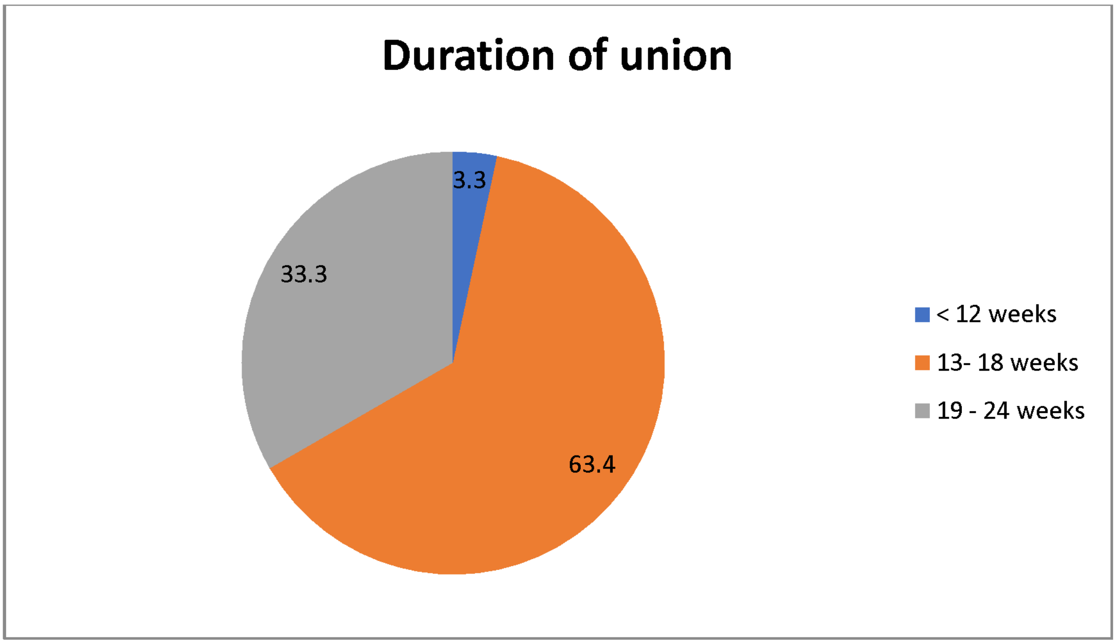


Graph. 14 – pie diagram showing opertative duration

Table 15: Duration of Fracture union

Duration for union (weeks)	Number of patients	Percentage
< 12	1	3.3
13 – 18	19	63.3
19 – 24	10	33.3
Total	30	100

Time of fracture union ranged from 12-24 weeks. Mean time of fracture union was 17 weeks in our series. Fracture union of most of the patients was seen between 13-18 weeks.



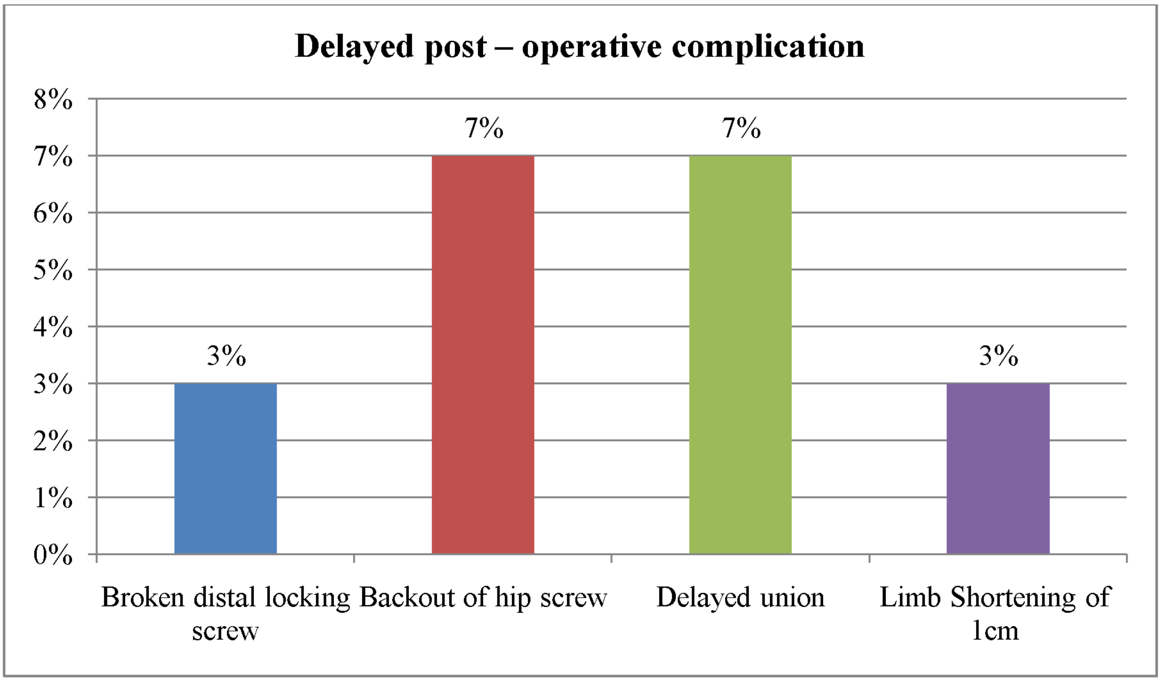
Graph 15: pie chart showing duration of fracture union.

Table 16: Delayed Post-Operative Complications

Delayed post – operative complication	No. of patients	Percentage
Broken distal locking screw	1	3
Backout of hip screw	2	7
Delayed union	2	7
Limb Shortening of 1cm	1	3
No complications	**25**	**80**
Total	30	100

In our study, majority (80%) of patients did not have any delayed post op complications.

20% of patients had delayed post op complications in the form of broken distal locking screw, backout of hip screw, delayed union and limb shortening.



Graph 16: bar graph showing delayed post –operative complications.

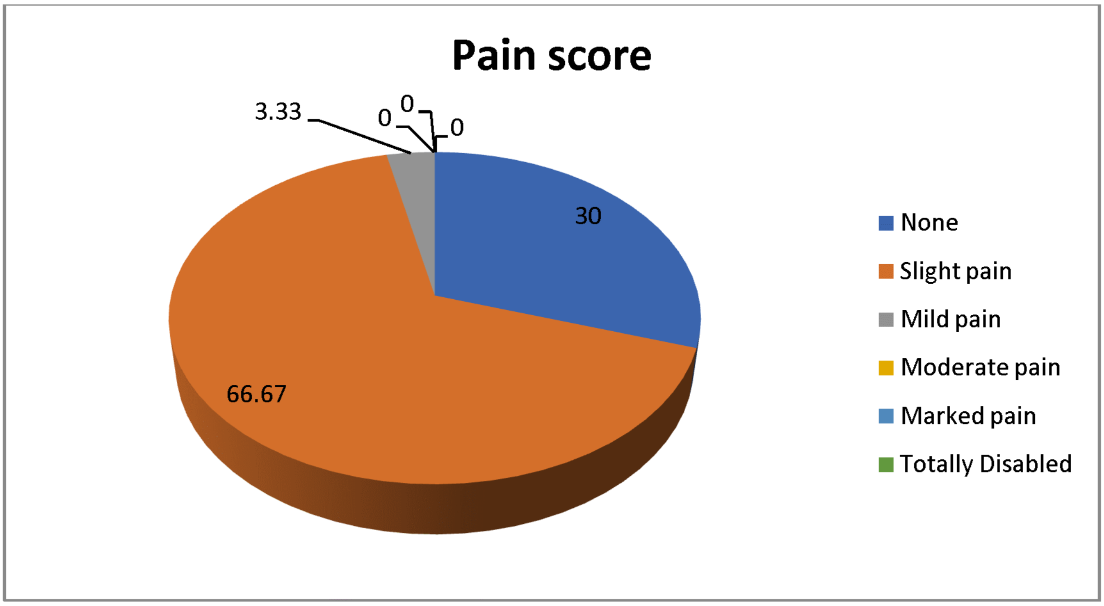
MODIFIED HARRIS HIP SCORE

Each patient was monitored and evaluated according the parameters of Modified Harris Hip Score and final outcome was drawn.

Table 17: Pain score distribution.

PAIN SCORE	NUMBER OF PATIENTS	PERCENTAGE
NONE(44)	9	30.0
SLIGHT PAIN(40)	20	66.67
MILD PAIN(30)	1	3.33
MODERATE PAIN(20)	0	0
MARKED PAIN(10)	0	0
TOTAL DISABLED(0)	0	0
TOTAL	30	100

Majority of patients in our study had slight to no pain at the end of 6 months follow up.



Graph 17: pie graph showing pain score distribution.

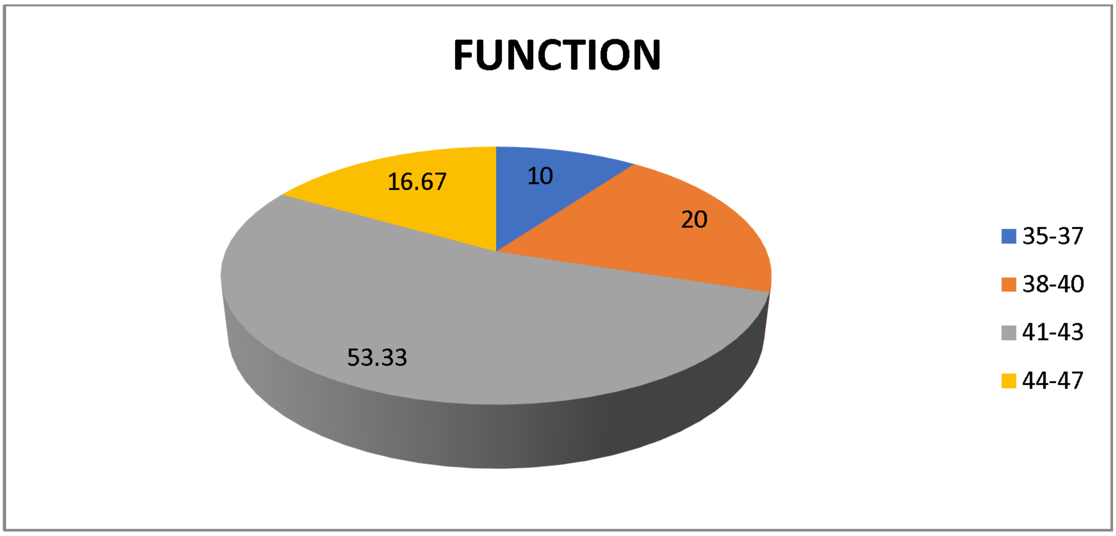
Table 18: Functional ability score

FUNCTION ABILITY SCORE AS PER MHH SCORE	NUMBER OF PATIENTS	PERCENTAGE
35 – 37	3	10
38 – 40	6	20
41 – 43	16	53.33
44 – 47	5	16.67
TOTAL	30	100

In our study, most of the patient could perform all daily activities of living without any restriction. There was no limp, they could climb stairs, squat and sit cross legs with ease.

Most of them could use public transport.

One patient had slight limp because of limb length discrepancy but did not affect patient's functional ability.



Graph 18: pie graph showing functional ability score.

Table 19: Range of motion score.

TOTAL RANGE OF MOTION AS PER MHH SCORE	NUMBER OF PATIENTS	PERCENTAGE
210 – 300	30	100
161 – 209	0	0
101 – 160	0	0
61 – 100	0	0
31 – 60	0	0
0 – 30	0	0
TOTAL	30	100

Total degree measurements, was calculated as per MHH score by adding the obtained range of motion at hip.

a. Flexion (140^0)

b. Abduction (40^0)

c. Adduction (40^0)

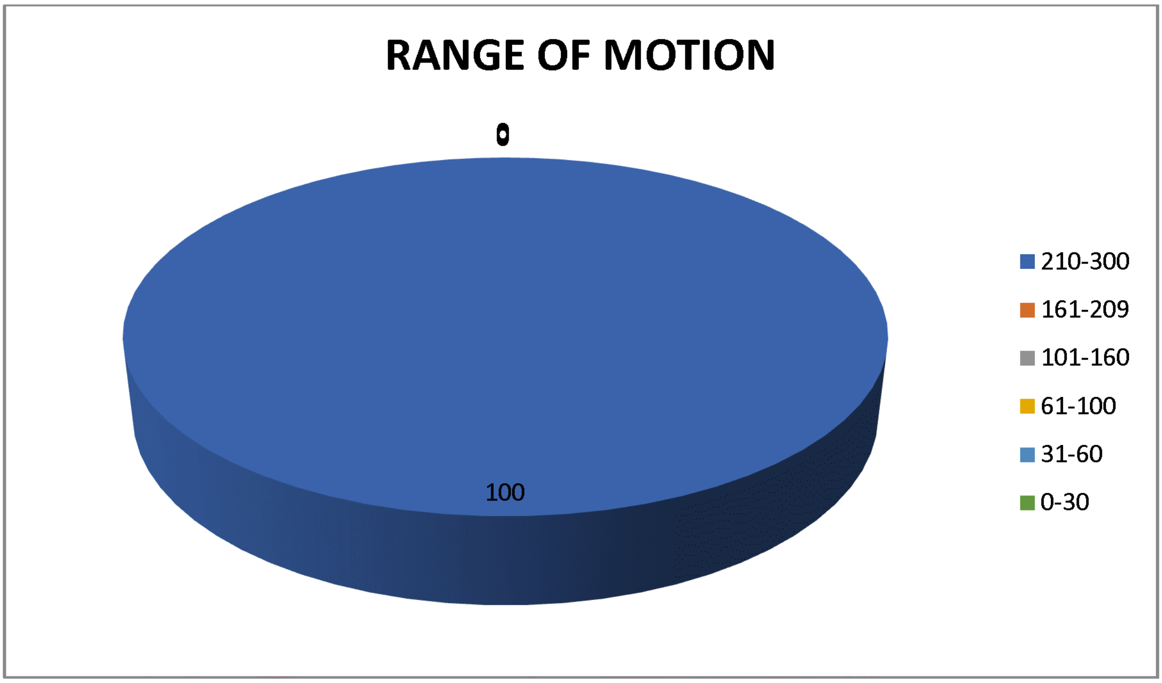
d. External rotation (40^0)

e. Internal rotation (40^0)

RANGE OF MOTION SCALE

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

All 30 patients in our study had full range of motion.

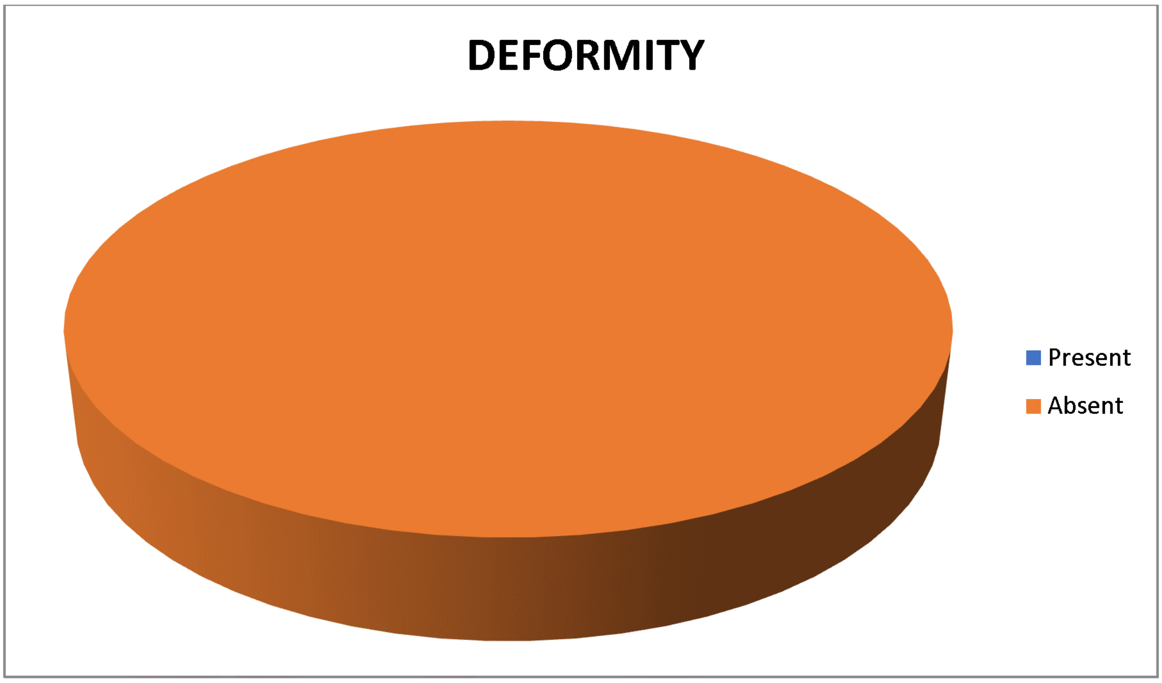


Graph19: Distribution of range of motion score.

Table 20: Deformity score.

DEFORMITY AS PER MHH SCORE	NUMBER OF PATIENTS	PERCENTAGE
PRESENT	0	0
ABSENT	30	100
TOTAL	30	100

In our study, none of the patients had deformity.



Graph20: Pie chart showing deformity score.

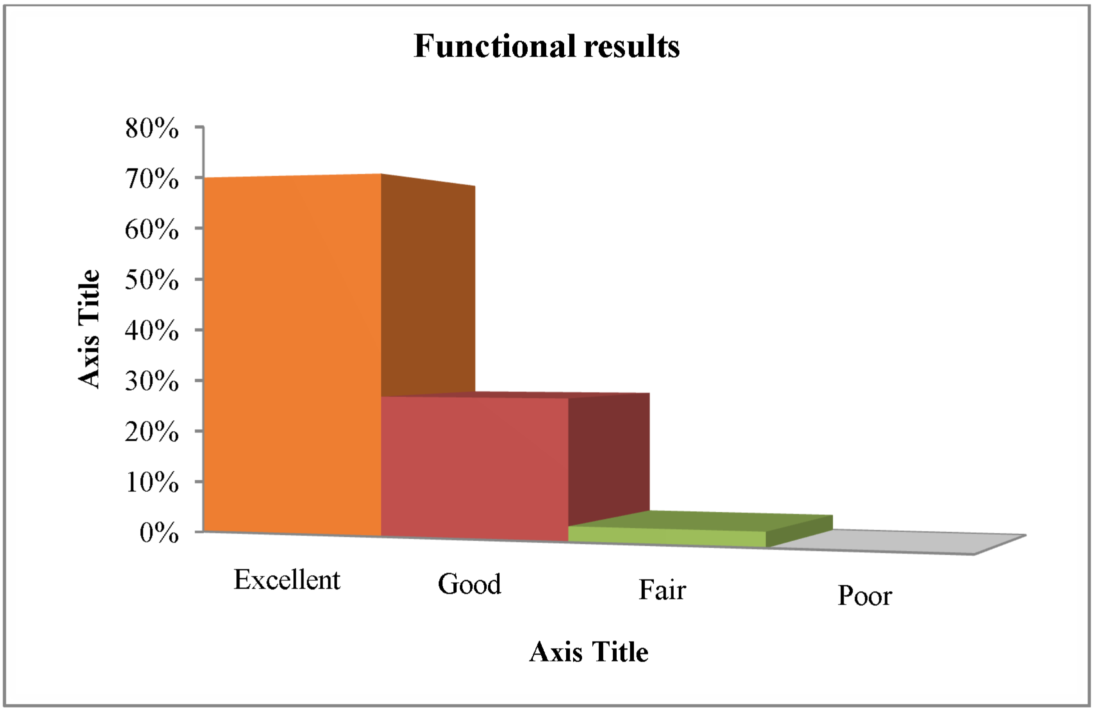
Table 21: Functional results after applying modified harris hip score.

Functional results	**No. of patients**	**Percentage**
Excellent	21	70
Good	8	27
Fair	1	3
Poor	0	0
Total	30	100

In our study, we found that majority of study patients (70%) had excellent results.

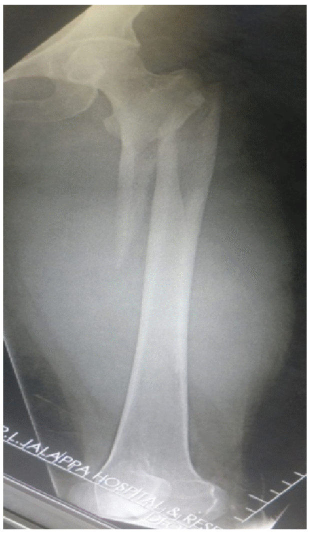
27% and 3% of patients had good and fair results respectively.

None had poor results.

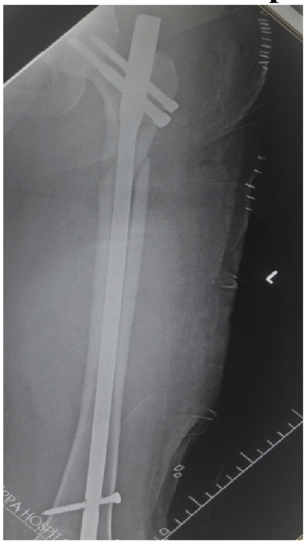


Graph 21: Bar diagram showing Functional results among subjects

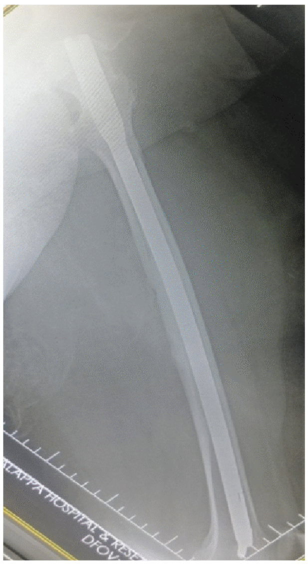
CASE 1- X RAYS



Pre-op x ray

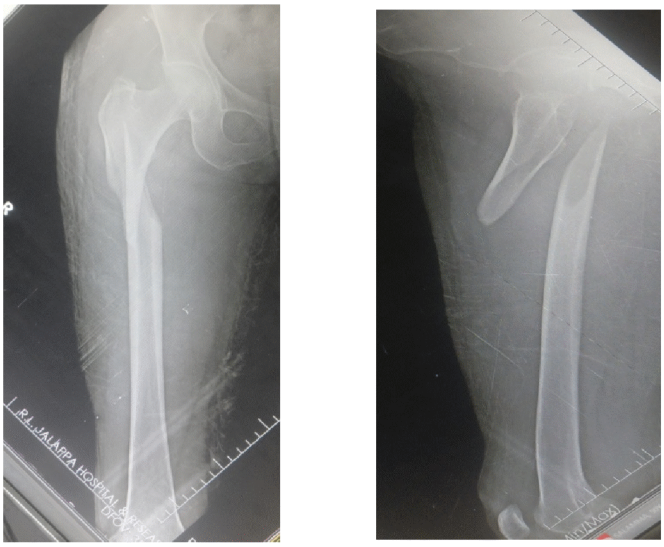


Immediate post op x ray



6 months follow up

CASE 2- X RAYS

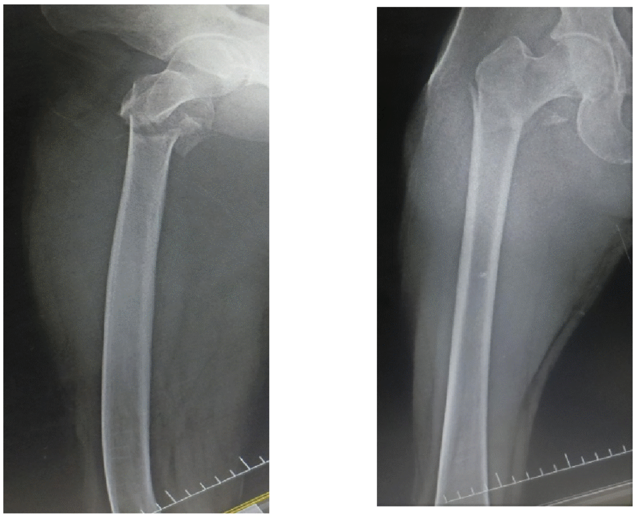


Pre- op x rays

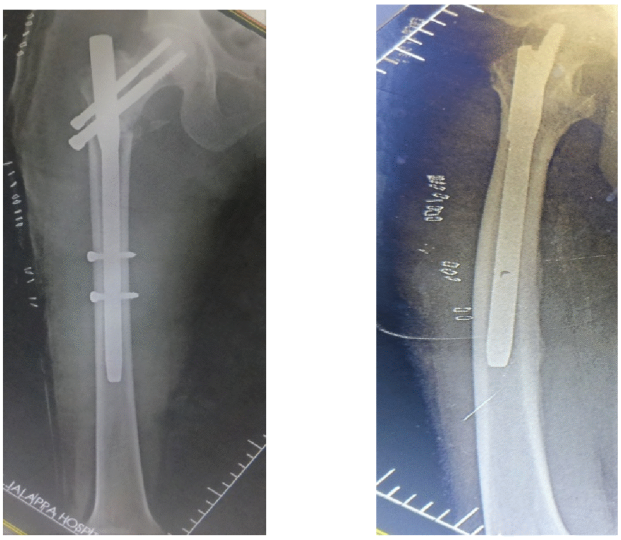
Post op x rays

6 months follow up x rays

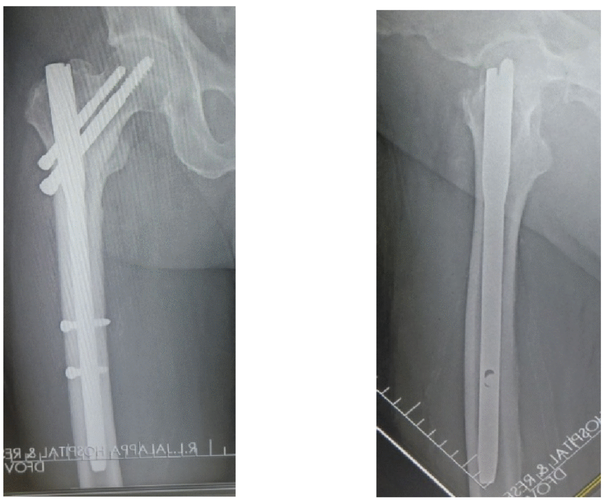
CASE 3- X RAYS



Pre- op x rays



Post- op x rays



6 months follow up x rays

Clinical photographs of patients

At 2 months follow up-

Healed surgical scar

Flexion

Abduction

Adduction

At 4 months follow up

Surgical scar

Full flexion

Full abduction

Adduction

At 6 months follow up

Flexion

Abduction

Abduction with external rotation

Squatting

Fig 29: Radiological and clinical photographs

DISCUSSION

Human body is a construct of bony cast whose strength can be boasted by femur. Femur alone has the strength comparable to a highly developed construction concrete. Subtrochanteric area bears the maximum stress exerted on femur which directly or indirectly makes it one of the highest stress bearing area in the body.

Failure of fixation is not a rare complication in subtrochanteric fractures. Subtrochanteric fractures have notorious reputation of putting orthopedicians in trouble while reducing and fixing them. This mostly occurs due to the incomplete understanding of the biomechanics around the subtrochanteric area, over-confidence on new surgical techniques and disregard to established procedures. The force required to crack femur is immensely high. Likewise, the implant required to bear the stress of femur must be strong.

Blade plate system, sliding screw system and intramedullary system are the current modes of treatment for subtrochanteric fractures. Extramedullary devices require extensive soft tissue exposure and blood loss which in turn slows the process of fracture healing. Extramedullary devices such as plating also carry more chances of fatigue breakage. Intramedullary implants on the other hand require a smaller incision, cause less blood loss, reduce operative duration and provide a more reliable fixation than extramedullary implants[24]. Thus, intramedullary devices provide a fixation similar to a 'biological internal fixation' that is suitable, reliable, faster and stable.[20]

Many implants have been tried with various modification and success. It's only when AO/ASIF introduced 'Proximal Femoral Nailing' system for pertrochanteric fractures that halted the unprecedented failures due to shortcomings of various implants.[11]

- **Age**

In our study, patients were in the age groups ranging from 20-90 years with maximum patients from 61-70 yrs age group. 31-40 yrs age group had the minimum number of cases. Mean age being 55 years which is similar to the average age of 53 years in a study conducted by Jiang LS et al [20] in 2003.

- **Mode of injury**

Road traffic accidents was found to be the major cause (60%) compared to self fall (40%). Associated injuries in elderly were minimum because the fracture was a result of self fall.

- **Gender**

In our study, male preponderance was noted. 19(63%) patients were males and 11 (37%) females, which was similar to proximal femoral nailing group of Jiang LS et al [20] and Gowda PR et al [32]but contradictory to the observations of Fogagnolo F et al. [34] The incidence of both right and left femurs was noted to be 50%.

- **Fracture type**

In our study, Seinsheimer type IIIA and type IIB were most commonly encountered. 12 (40%) cases in type IIIA and 7 (23%) cases in type IIB fracture group, with the next common type being IIIB (10%), followed by type V (10%) and least in type IIA (3%) with no cases in type I fractures. This was comparable to the research conducted by Jiang LS et al. [20]

- **Reduction**

27 (90%) fractures were fixed after closed reduction and 3 cases (10%) were fixed after open reduction. Ekstrom et al [35] and Batra et al [29] similarly fixed 90% of subtrochanteric fractures with closed reduction.

- **Hospital stay**

Patient's average hospital stay was 20 days with maximum of 40 days and minimum of 4 days. Dominingo et al showed similar duration of hospital stay of around 15 days. All patients in our study were screened preoperatively for any co-morbidities and were operated after physician clearance. Patients with co-morbidities took longer time for fitness for surgery and mobilization.

- **Union**

Average period of the union was found to be around 17.3 weeks with maximum time of 24 weeks and minimum of 12 weeks which was seen in a 20 years old patient. The co- morbidities associated with patients did not affect the duration of union which was similar to other studies as well. Average duration of union in our study was similar to that in study conducted by Ekstrom et al [35], Batra et al [29]and Reddy N et al[27].

In our study, we had 2 cases of delayed union which healed without any second procedure. This result was similar to study performed by Jiang et al [29] and superior to finding of Tiwari et al who had 10 cases of delayed union in 30 patient group.

- **Complications**

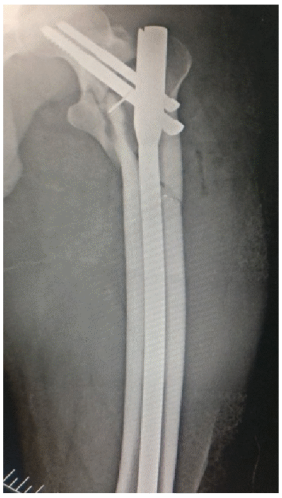
Jiang LS et al [20] in 2003 did a study to see the outcome of traumatic subtrochanteric fractures fixed with long proximal femoral nail (PFN) or long gamma nail. They included 49 patients who underwent intramedullary fixation with long PFN (18 patients or long gamma nail 931 patients) for traumatic subtrochanteric fractures. In the study, the authors encountered that in all the 49 healed subtrochanteric fractures, the screw of PFN was placed in the lower part of the femoral neck close to the femoral calcar, with screw tip reaching the subchondral bone 5 to 10 mm below the articular cartilage in anteroposterial view. In lateral view, they placed in the centre of the femoral neck. Following this method, the lag screw was placed in the area of best bone quality. In all cases walking and squatting ability was assessed which was completely restored by 6 months postoperatively. No complications related to implant breakage was seen. In our study anti-rotation screw was put in all cases except one. One case of delayed union was noticed which healed without any second procedure which is similar to the study done by Jiang LS et al. [20]

Werner was the first person to introduce the term Z-effect. The Z-effect phenomenon is referred as a characteristic sliding of the proximal screws to opposite directions during the postoperative weight-bearing period. The reverse Z-effect described by Boldin et al [18] occurred with movement of the hip pin towards the lateral side, which required early removal. A cut-out of the neck screws was seen in 2 patients because they used neck screws that were too short. [18] None of the patients in our study presented to us with Z-effect or reverse Z-effect in a six month follow up period. No cut out of screws were noted in any patient at the end of 6 months follow up in present study.

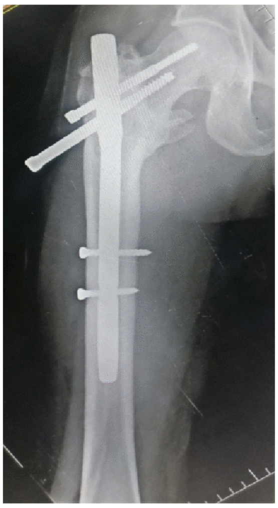
Simmermacher, et al[11] contributed their finding by mentioning that the proximal femoral nailing system is extremely effective in pertrochateric fractures. The technical failures that occurred were due to poor reduction, malrotation or wrong choice of screws as seen in 4.6% of the cases. We, however did not encounter any complication such as mal-rotation. To overcome these problems they introduced a

6.5mm anti-rotation screw along with 8mm hip screw to provide rotational stability. Gotze et al (1998) in an experimental study compared the loading ability of osteosynthesis of unstable per and subtrochanteric fractures and found that the PFN could bear the highest loads of all the devices.[18]

Fogagnolo F et al [34] in 2004 did a study to see the efficacy of intramedullary fixation of pertrochanteric hip fractures with the short AO-ASIF proximal femoral nail. They encountered a reoperation rate of 19.1% and mortality of 20.4%. Most of these were due to pre-existing co-morbidities. In our study, neither did we have any reoperation nor mortality.



Broken drill bit



Backing out of hip screw

Fig 30: Radioghraphic pictures of complication

MODIFIED HARRIS HIP SCORE

- **Pain scoring–**

66.67 % of patients in our study had slight pain that did not restrict his daily activities while 30% patient had no pain. This was superior to findings of Reddy N et al[30]and Batra A V et al [29]. Ahmed S et al[33] observed restriction of activity due to pain in 7.6% of patients compared to 3.33% patients in our study.

- **Functional ability scoring–**

70% of patients in our study could perform their daily activities without any restriction and most of the patients could use public transportation services independently. Reddy N et al [30]observed that 44.4% of patients needed no walking aids to perform their daily activities.

- **Range of motion scoring-**

All patients in our study had good range of motion compared to 80% patients that could achieve good range of motion in the study by Ahmed S et al[33].

Table no. 21 – comparison of general features of patients

	Jiang et al[20]	Batra A. V, et al[29]	Ekstrom et al[35]	Tiwari, et al[31]	Present study
Mean age (yrs)	53	53	82	40.16	**55**
Sex %	Male (77)	Male (70)	Female (76)	Male (83)	**Male (63)**
Mode of injury %	RTA (73)	RTA (67)	-	RTA (47)	**RTA (60)**
Affected side %	-	Right (57)	-	Right (63)	**R = L**
Fracture type %	IIIA (42)	IIIA (32.5)	V (9)	IIB (26.6)	**IIIA (40)**
Intra-op Reduction %	Closed (66)	Closed (90)	Closed (89)	-	**Closed (90)**
Average Operative time (minutes)	46	-	56± 21	80	**108**

" – " Parameter not mentioned in the study.

Table no. 22- Mechanical complications of PFN system

	Simmermacher et al [11]	C Boldin et al [18]	Dominigo et al [36]	Fogagnolo et al [34]	Present study
No. of patients	191	55	295	46	**30**
Cutout	1	2	4	5	**0**
Z effect	-	3	-	-	**0**
Reverse Z effect	-	2	-	-	**0**
Implant failure	1	-	-	2	**0**
Fracture below nail tip	-	-	1	1	**0**
Open reduction%	-	10	-	-	**10**
Re-operation%	7	18	3	19.1	**0**
Mortality %	-	-	-	20.4	**0**

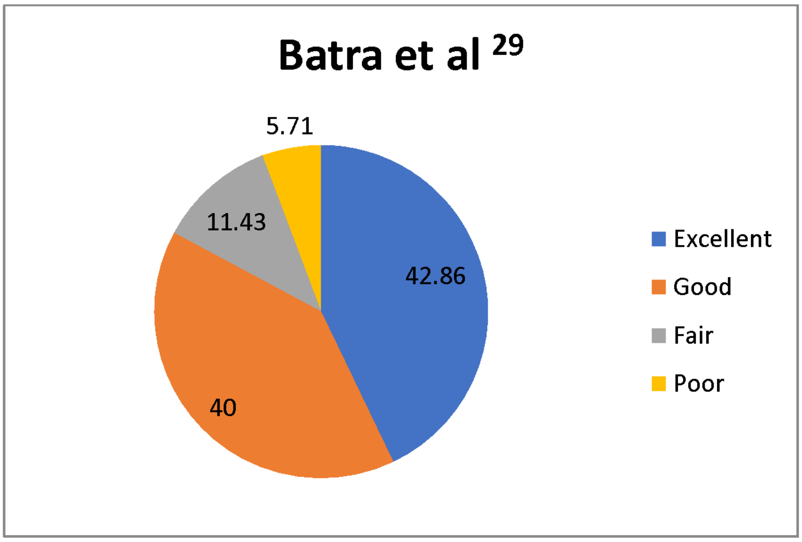
" – " Parameter not mentioned in the study.

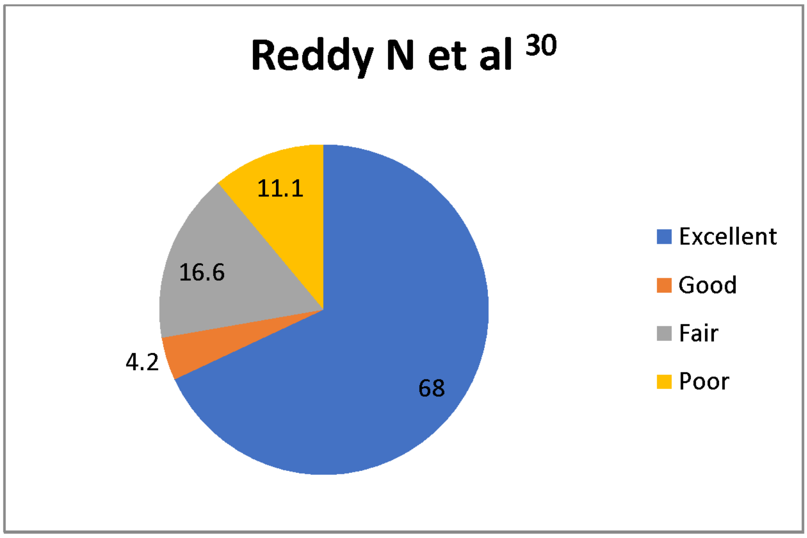
Table no. 23 - Comparison with other studies

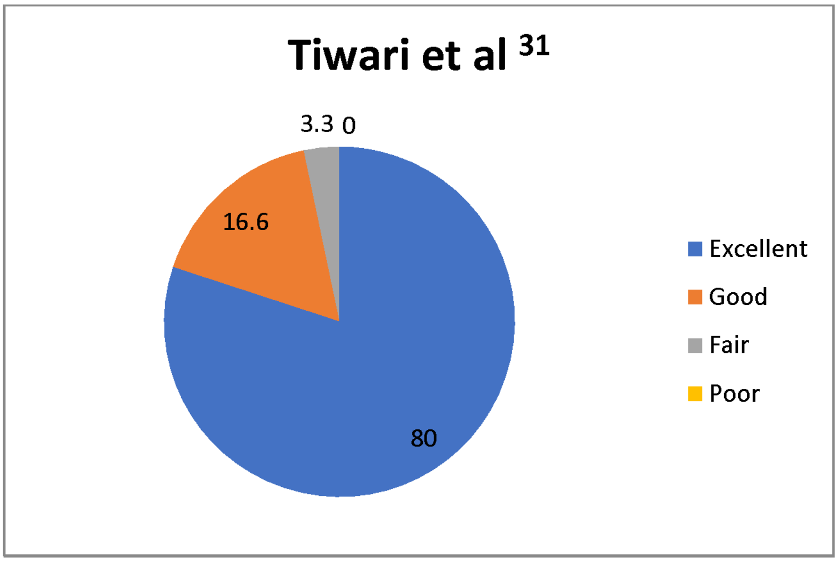
	Ekstrom et al [35]	Jiang et al [20]	Dominigo et al [36]	Tiwari et al [31]	Present study
Number of patients	105	49	295	30	30
Average blood loss (ml)	230±185	-	-	130	125
Duration of surgery (mins)	56±21	46	44	80	108
Average duration of union (weeks)	16	-	12	6-18	17.3
Union %	100 (9months)	98 (6months)	-	90 (6months)	100 (6months)
Fixation failure %	11	0	0	0	0
Delayed union %	-	2	-	10	6.66
Hospital stay duration (Days)	12	-	15.4	26.83	20
Reoperation rate %	0	0	3.38	0	0

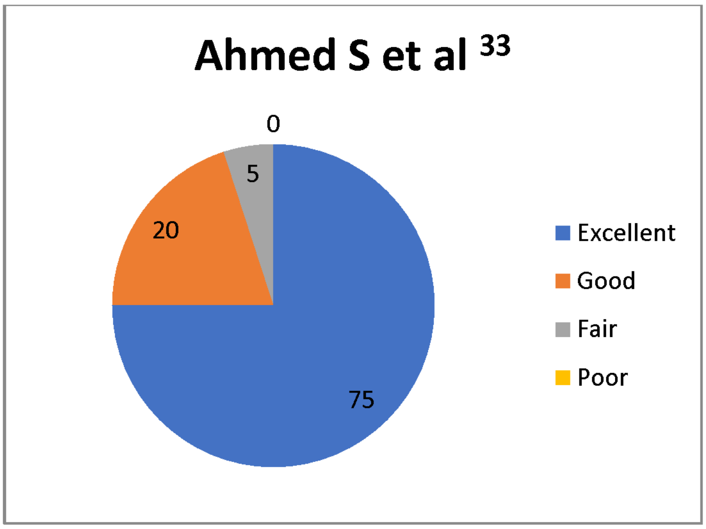
" – " Parameter not mentioned in the study.

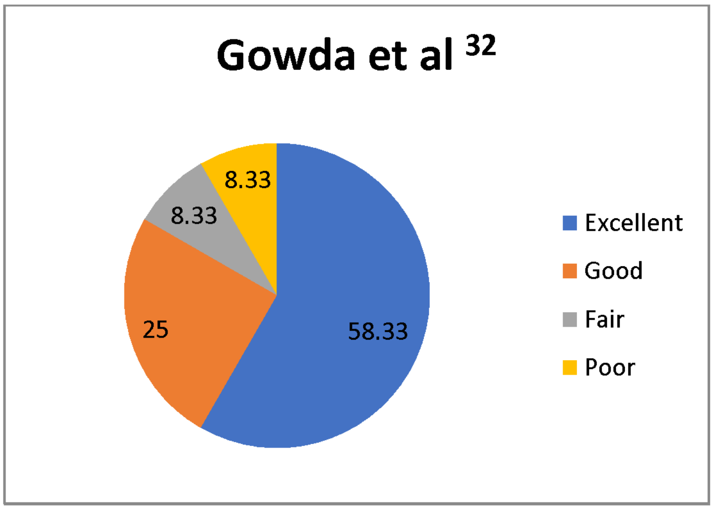
Comparison of functional outcome of different studies

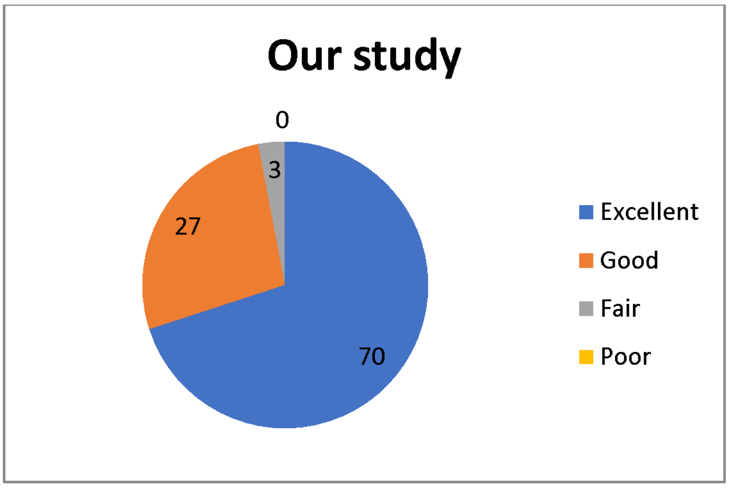












Graph 22: comparison of functional outcome of different studies

A series of 30 patients with subtrochanteric fractures treated with proximal femoral nail were assessed functionally, which showed 21 (70%) excellent, 8 (27%) good and 1 (3%) fair results.

CONCLUSION

In this study of 30 patients treated with proximal femoral nailing for subtrochanteric fractures of femur following conclusions were drawn.

A. Elderly males are more prone to subtrochanteric fractures due to trivial injury like self fall owing to the osteoporotic status of their bones. Whereas in young patients it is due to high velocity trauma like RTA.

B. Road traffic accidents are the major cause of subtrochanteric fractures in rural areas of Kolar district.

C. Co-morbidities should be taken into consideration and proper planning of the surgical procedure should be follow to avoid post surgical complications.

D. Primary and early internal fixation of the fracture makes the patient comfortable, facilitates early mobilization and faster rehabilitation to pre-fracture life.

E. Closed manipulation can provide good anatomical reduction.

F. Proximal femoral nail is a sound implant owing to it's ease of insertion and is biomechanically suitable owing to it's design.

G. Proximal femoral nail maintains neck length as it avoids excessive collapse at fracture site.

H. Deciding the entry point is most crucial step in using proximal femoral nail.

I. Two screws that are passed through the neck are anti-rotation screw which is proximal and the hip screw which is distal. Hip screw should be close to inferior margin in antero- posterior view and central in lateral view.

J. In cases of delayed union, dynamisation can be done by removing the dynamic screw.

K. In fractures of the elderly, where mortality and morbidity is high, a closed reduction and internal fixation surgery with proximal femoral nail is a life saver.

L. Blood loss, soft tissue dissection, radiation exposure and anesthetic complications are all reduced due closed nature of surgery.

M. Most of the complications are due to improper surgical skills or improper instrumentation which can be reduced with experience along with better understanding of the biomechanics of the subtrochanteric region.

It can be concluded that proximal femoral nailing provides stability, strength, early mobility and excellent union rate of subtrochanteric fractures in rural population where early return to hard working routine is required.

SUMMARY

Aim of this study is to evaluate the outcome of subtrochanteric fractures when treated with proximal femoral nail.

Subtrochanteric fractures are the price that humans are paying for fast transportation services, high rised towers and sedentary lifestyle. They are one of the most devastating injuries to bear and treat.

Though many other methods of treatment have been tried, beginning from conservative methods to use of implants such as dynamic hip screw and dynamic condylar screw, complications like non-union and delayed-union have haunted orthopedic surgeons for years.

We treated 30 patients with subtrochanteric fractures using proximal femoral nail, an intra-medullary nail. There were 19 males and 11 females with maximum age of 90 years and minimum of 20 years with mean of 55 years. 60% of cases were due to road traffic accidents and 40% due to self fall. 40% of cases had Seinsheimer type IIIA while 23% cases had type IIB fracture. 60% of the patients were mobilized between 3rd to 5th post operative day. Average hospital stay of patients was 17 days. 21 (70%) patients showed excellent functional results, 8(27%) showed good and 1(3%) patient showed fair functional results as per Modified Harris hip score.

With experience and evidence of this study, we consider that PFN is a reliable and strong implant for subtrochanteric fractures. With good surgical skills and instrumentation, patients with subtrochanteric fractures can be helped to return to their pre-fracture life.

BIBLIOGRAPHY

1. LaVelle DG, Canale ST, Beaty JH. Campbell's Operative Orthopaedics., 11thed. Philadelphia: Mosby. 2008; 3(3):3237-862
2. Hibbs RA : The management of the tendency of the upper fragment to tilt forwards in fractures of the upper third of femur. New York Med. J. 1902; 75: 177-179.
3. Shelton ML. Subtrochanteric fractures of the femur. Arch Surg. 1975; 110:41-48
4. Heygrooves EW. Ununited fractures with special reference to gun shot injuries and the use of bone grafting. Br. J. Surg 1918;6:203-245
5. Aronoff PM, Davis PM, Wickstrom JK. Intramedullary nail fixation treatment of subtrochanteric fractures of the femur. J Trauma 1971; 11:637-650
6. Hinton RY, Smith GS. The association of age, race and sex with the location of proximaJ femoral fractures in elderly". JBJS 1993; 75(5):752-9
7. Boyd HB, Griffin LL. "Classification and treatment of trochanteric fractures" Arch surgery 1949;58:853-866
8. Watson HK, Campbell RD, Wade PA. Classification, treatment and complications of the adult subtrochanteric fracture. J Trauma 4: 457 – 480, 1964
9. Hanson GW, Tullos HS: Subtrochanteric fractures of the femur treated with Nail-Plate devices. A retrospective study. Clin. Orthop 1978; 131: 191-194
10. Templeton T, Saunders EA. A review of fractures in the proximal femur treated with the Zickel nail. Clin Orthop 1979;14:213–216
11. Simmermacher RK, Bosch AM, Van der Werken C. The AO ASIF-proximal femoral nail (PFN): a new device for the treatment of unstable proximal femoral fractures. Injury 1999;30:327-32.
12. Sudan M et al. Peritrochanteric fractures: Is there an advantage of intramedullary nail? ; J Orthop Trauma 2002; 16 : 386 – 393

13. Fielding JW, Magiliato HJ. Subtrochanteric fractures. Surg. Gynec. and Obstet. 1966;122: 555-560
14. Zickel, R.E. An intramedullary fixation device for the proximal part of the femur. J Bone Joint Surg Am 1976;8:866–872
15. Seinsheimer F. Subtrochanteric fractures of the femur. J Bone Joint Surg Am 1978; 60:300–306
16. Srinivas K et al. A study on surgical management of intertrochanteric and subtrochanteric fractures of femur by proximal femoral nail. J of Evidence Based Med & Hlthcare, 2015; 2(3): 2349-2570
17. Halder S C.: The Gamma Nail for peritrochanteric fractures.; JBJS (Br) 1992.74:340–344
18. Boldin et al. The proximal femoral nail (PFN)—a minimal invasive treatment of unstable proximal femoral fractures. Acta Orthop Scand 2003; 74(1): 53 - 58.
19. Sidhu AS, Brar BS, Mann HS, Kumar A. Proximal femoral nail – A minimally invasive method for stabilization of pertrochanteric and subtrochanteric femoral fracture. Pb Journal of Orthopedics 2010; 12(1).
20. Jiang LS, Shen L, Dai LY. Intramedullary fixation of subtrochanteric fractures with long proximal femoral nail or long gamma nail; technical notes and preliminary results. Ann Acad Med Singapore 2007;36:821-6
21. Ballal MSG, Emms N, Thomas G. Proximal femoral nail failures in extra capsular fractures of the hip. J of Orthopaedic Surgery 2008; 16(2): 146 -149
22. . Park SY, Yang KH, Yoo JH, Yoon HK, Park HW. The treatment of reverse obliquity intertrochanteric fractures with the intramedullary nail. J Trauma 2008; 65: 852 – 857.

23. Brar BS, Mann HS, Sidhu AS, Kumar A. Proximal femoral nail – A minimally invasive method for stabilization of pertrochanteric and subtrochanteric femoral fracture. Pb J Orth 2010; 12(1).

24. Kuzyk et al. Intramedullary versus extramedullary fixation for subtrochanteric femur fractures. J Orthop Trauma 2009; 23: 465–470.

25. Shetty N, Shah HM, Suranigi SM. Study comparing the advantages of proximal femoral nail over dynamic hip screw among patients with subtrochantric fracture. JMT 2013; 1(2)

26. Yadkikar SV, Yadkikar VS, Prasad DV, Marawar A. Prospective study of proximal femoral nail in management of trochanteric and subtrochanteric fractures of femur. IJBAR 2015; 6(4)

27. Ozkan K et al. A biomechanical comparison of proximal femoral nails and locking proximal anatomic femoral plates in femoral fracture fixation- A study on synthetic bones. IJO 2015;3(49):347-351

28. Codesido P, Mejía A, Riego J, Ojeda-Thies C. Subtrochanteric fractures in elderly people treated with intramedullary fixation: quality of life and complications following open reduction and cerclage wiring versus closed reduction. Arch Orthop Trauma Surg. 2017;137(8):1077-1085

29. Batra AV et al. Our experience of management of sub trochanteric fractures of femur by proximal femoral nail. Int J Res Med Sci 2015;3(9):2164-2168

30. Reddy DN, Anand A, Raviteja Y. Evaluation of results in intramedullary fixation of subtrochanteric fracture of femur with proximal femoral nailing (AO type of design). J Evolution Med. Dent. Sci. 2016;5(64):4547-4551

31. Tiwari et al. A prospective study of functional & radiological outcomes of subtrochanteric femur fractures treated by proximal femur nailing. IJOS 2016;2(4):278-284

32. Gowda PR et al. A prospective comparative study in the clinical outcome of trochanteric and subtrochanteric fracture femur with proximal femoral nail versus dynamic hip screw. Int J Res Orthop. 2017;3(5):986-990.

33. Ahmed S et al. Complications of internal fixation by a short proximal femoral nail (PFN) in Subtrochanteric fractures. Int J Cur Res Rev. 2017;9(9):14-19

34. Fogagnolo F, Kfuri M, Paccola Ca. Intramedullary fixation of per trochanteric hip fractures with short AO ASIF PFN. J Arch Orthop Trauma Surg 2004;124(1):31-7.

35. Ekstrom W, Thur CK, Larsson S, Ragnarsson B, Alberts KA. Functional outcome in treatment of unstable trochanteric and subtrochanteric fractures with the proximal femoral nail and the medoff sliding plate. J Orthop Trauma 2007;21:18-25.

36. Domingo LJ, Cecilia D, Herrera A, Resines C. Trochanteric fractures treated with a proximal femoral nail. Int Orthop. 2001;25(5):298–301.

37. Min WK et al. Proximal femoral nail for the treatment of reverse obliquity intertrochanteric fractures compared with Gamma nail.J Trauma 2007;63:1054–1060

38. Medoff RJ, Maes K. A new device for the fixation of unstable pertrochanteric fractures of the hip. J Bone Joint Surg Am1991;73:1192–1199. .

39. Hildebrand F, Giannoudis P, Krettek C et al. Damage control: extremities. Injury 2004;35:678–689.

40. Koch JC. The laws of bone architecture. Am Janat 1917;21;177-298

41. Nuber S, Schoweiss T, Ruter A. Stabilization of unstable trochanteric femoral fractures; dynamic hip screw with trochanteric stabilization plate vs proximal femoral nail. Journal of Orthopaedic trauma 2003;17(4):316-317.

42. Michael R. Baumgaertner and Thamos F.Higgins. Rockwood And Green's Fractures In Adults. vol-2,5th Ed. 1579-94 &1665-1681.

43. Edwards, S.A.; Pandit, H.G.; Clarke, H.J. The long gamma nail: A DGH experience. Injury 2000;31:701–709.

44. Rybicki EF, Simonen FA, Weis EB. On the mathematical analysis of stress in the human femur. J Biomech 1972;5:203–215.

45. Browner BD, Levine AM, Jupiter JB, Trafton PG. Skeletal trauma, Basic science, Management, and Reconstruction. 3rd ed. Philadelphia: Saunders; 2003.

46. Muller ME, Allgower M, Schneider R. Lower Extremity. Manual of Internal Fixation, 2nd ed. Berlin;Springer-Verlag:1979.1878

PROFORMA

NAME AGE SEX IP NUMBER-

ADDRESS- DOI-

OCUUPATION- DOA-

INFORMANT DOS-

DOD-

HISTORY-

PRESENTING COMPLAINTS-

1) PAIN R L
THIGH

LEG

2) SWELLING R L
THIGH

LEG

3) DEFORMITY R L
THIGH

LEG

4) RESTRICTION OF MOVEMENTS R L
HIP

KNEE

5) MODE OF INJURY
RTA

SELF FALL

FALL FROM HEIGHT

6) **ASSOCIATED INJURIES**

7) **PAST HISTORY**

8) **FAMILY HISTORY**

9) **PERSONAL HISTORY**

SOCIOECONOMICSTATUS

BOWEL AND BLADDER HABITS

DIET

APPETITE

SLEEP

EXAMINATION-

General physical examination

a)BUILT

b)NOURISHMENTWELLMODERATE POOR

c)WEIGHT
d)PENCIL

e)PR- BP- RR- TEMP.-
GCS

2.SYSTEMICEXAMINATION
CVS-
R.S.-
P/A-
CNS-

3) LOCALEXAMINATION-
A) ATTITUDE

1) B) SWELLING R L
THIGH

LEG

2) DEFORMITY R L
THIGH

LEG

3) RANGE OF MOVEMENTS R L
HIP

KNEE

4) TENDERNESSANDCREPITUS

THIGH R

Proximal1/3rd

Middle1/3rd

Distal1/3rd
LEG R L

Proximal1/3rd

Middle1/3rd

Distal1/3rd

SHORTENING R L

STAL NVD YES NO

DIAGNOSIS-

MANAGEMENT-

A. PRELIMINARY IMMOBILIZATION

THOMAS SPLINT

ABOVE KNEE POP SLAB

B.SURGICALMANAGEMENT

DURATIONBETWEENTRAUMAANDSURGERY:A

NAESTHESIA--SPINALGENERAL

PROCEDURE:

DURATIONOFSURGERY:

C.SIZEOFTHENAILMED

IAL

LATERAL

D.POSTOPERATIVEMANAGEMENT

a)ANTIBIOTICSINTRAVENOUS-

ORAL-

b)WOUNDINSPECTIONANDDRESSING

c)DATEOFSUTUREREMOVAL

INVESTIGATIONS

1.BLOOD	**2.URINE**	**3.ChestX-ray**	**4.EC**
Hb	**Albumi**		
TC	**Sugar**		

ESR

Urea

Creatinine

HIV

HBsAg

VDRL

5) X–ray full length – thigh with hip and knee -- AP and lateral views

OR

X–rayfulllength–legwithkneeand ankle --APandlateralviews

6) SIDE AFFECTED R L

SITE OF FRACTURE

PROXIMAL 1/3RD

MIDDLE 1/3RD

DISTAL 1/3RD

7) TYPE OF FRACTURE

TRANSVERSE

OBLIQUE

SPIRAL

COMMUNITED

SEGMENTAL

MODIFIED HARRIS HIP SCORING SYSTEM:

Maximum points possible - 100

1. Pain relief-44
2. Function- 47
3. Range of motion- 5
4. Absence of deformity- 4

(1) PAIN (44 POSSIBLE)

a. None or ignores it (44)

b. Slight, occasional, no compromise in activities (40)

c. Mild pain, no effect on average activities, rarely moderate pain with usual activity; may take aspirin (30)

d. Moderate pain, tolerable but makes concessions to pain, some limitation of ordinary activity or work; may require occasional medicine stronger than aspirin (20)

e. Marked pain, serious limitation of activities (10)

f. Totally disabled, crippled, pain in bed, bed ridden (0)

(2) FUNCTION (47 POSSIBLE)

A) GAIT (33 POSSIBLE)

1. LIMP

i. None (11)

ii. Slight (8)

iii. Moderate (5)

iv. Severe (0)

2. SUPPORT

i. None (11)

ii. Cane for long walks (7)

iii. Cane most of the time (5)

iv. One crutch (3)

v. Two canes (2)

vi. Two crutches (0)

vii. Not able to walk (0)

3. DISTANCE WALKED

i. Unlimited (11)

ii. Six blocks (8)

iii. Two or three blocks (5)

iv. Indoors only (2)

v. Bed and chair (0)

B) ACTIVITIES (14 POSSIBLE)

1) STAIRS

i. Normally without use of railing (4)

ii. Normally use of railing (2)

iii. In any manner (1)

iv. Unable to do stairs (0)

2) SQUATTING

i. With ease (4)

ii. With difficulty (2)

iii. Unable (0)

3) SITTING CROSS LEGGED

a. With ease (5)

b. With difficulty (3)

c. Unable (0)

4) ENTER PUBLIC TRANSPORTATION (1)

(3) ABSENCE OF DEFORMITY (All yes = 4; Less than 4 = 0)

a. Less than 30 degrees of fixed flexion contracture.

b. Less than 10 degrees of fixed adduction.

c. Less than 10 degrees of fixed internal rotation in extension.

d. Limb length discrepancy less than 3.2 cm.

(4) RANGE OF MOTION (5 POSSIBLE) (NORMAL)

Total degree measurements, then check range to obtain score

a. Flexion (1400)

b. Abduction (400)

c. Adduction (400)

d. External rotation (400)

e. Internal rotation (400)

RANGE OF MOTION SCALE

□ 210 – 300 (5)

□ 161 – 210 (4)

□ 101 – 160 (3)

□ 61 – 100 (2)

□ 31 – 60 (1)

□ 0 – 30 (0)

TOTAL MODIFIED HARRIS HIP SCORE

Score Rating

90 – 100 Excellent

80 – 89 Good

70 – 79 Fair

< 70 Poor

CONSENT FORMFOR SURGERY

Chief researcher/ PG guide's name: Dr. P.V.Manohar.

Principal investigator: Dr.WayalUtkarsha Ashok 1

Name of the subject:

Age :

Address :

I________________________________ in my full senses here by give my complete consent for Proximal femoral nailing ,which is a surgical procedure (operation) to be performed on my son/daughter/___________ aged________.

The nature and risks involved like intra-operative haemorrhage, neurovascular injury, wound scarring during and after the procedure have been explained to me in my own vernacular language , to my satisfaction.

For academic and scientific purpose, the operation/ procedure may be television or photographed, or used for statistical measurements.

Date : Signature/Thumb Impression/
Of the Patient/Guardian:

Name:

Full Address:

PATIENT INFORMATION SHEET

Study title: A study of functional outcome of subtrochanteric femur fracture using proximal femoral nail in rural population.

Study site: R.L Jalappa hospital, Tamaka, Kolar.

Aim- To record the functional outcome of subtrochanteric femur fracture using proximal femoral nail in rural population.

To study the outcome of procedure with respect of early mobilization and return to pre fracture ambulatory status.

Patient with subtrochnteric facture of femur will be selected. Please read the following information and discuss with your family members. You can ask any question regarding the study. If you agree to participate in this study we will collect information (as per proforma) from you. Routine (CBC, CRP,Urine Routine) and Relevant blood investigations,radilogical investigation will be carried out if required. This information collected will be used for dissertation and publication only.

All information collected from you will be kept confidential and will not be disclosed to any outsider. Your identity will not be revealed. This study has been reviewed by the Institutional Ethics Committee and you are free to contact the member of the Institutional Ethics Committee. There is no compulsion to agree to this study. The care you get will not change if you don't wish to participate. You are required to sign/ provide thumb impression only if you voluntarily agree to participate in this study.

For any further clarification you can contact the study investigator:

Dr. Wayal Utkarsha Ashok

Mobile no: 8408899880

E-mail id: utkarssssh@gmail.com

MASTER CHART KEYS.

GENDER	CODE
Male	1
Female	2

SIDE AFFECTEED	CODE
Right	1
Left	2

DETAILS	CODE
Road traffic accident	1
Self fall/sports injury/weight fall	2

MEDICAL CONDITION	CODE
Hypertension	1
Diabetes	2
Bronchial asthma	3

Interval between trauma and hospital admission	CODE
$\leq$ 24 hours	1
24 – 48 hours	2

≥ 48 hours	3

Days from trauma to surgery	CODE
1 - 5	1
6 -10	2
11- 15	3
16-22	4

TYPE OF REDUCTION	CODE
Closed	1
Open	2

INTRA-OP COMPLICATIONS	CODE
Failure to put anti-rotation screw	1
Broken drill bit	2
Superficial surgical site infection	3

POST OPERATIVE MOBILIZATION	CODE
3^{rd} – 5^{th}	1
6^{th} – 10^{th}	2
≥ 10	3

LATE POST OP COMPLICATIONS	CODE
Broken distal locking screw	1
Backout of hip screw	2
Delayed union	3
Limb shortening of 1 cm	4

RANGE OF MOTION AS PER MODIFIED HARRIS HIP SCORE	
210 – 300	5
161- 209	4
101- 160	3
61-100	2
31-60	1
0-30	0

DEFORMITY	
Present	0
Absent	4

FUNCTIONAL OUTCOME AS PER MHHS	CODE
Excellent	1

Satisfactory	2
Poor	3

SR. NO.	NAME	AGE	GENDER*	ADDRESS	HOSPITAL NUMBER	SIDE*	MODE OF INJURY*	MEDICAL CONDITION*	ASSOCIATED INJURIES	INTERVAL BETWEEN TRAUMA TO HOSPITAL ADMISSION*	DAYS FROM ADMISSION TO SURGERY	DAYS FROM TRAUMA TO SURGERY*	DATE OF SURGERY	REDUCTION*	HOSPITAL STAY	SEINSHEMER TYPE	NAIL SIZE (MM)	UNION(WEEKS)	OPERATIVE TIME(MINUTES)	INTRA AND IMMEDIATE POST OPERATIVE COMPLICATIONS*	POST OPERATIVE MOBILIZATION*	LATE POST OP COMPLICATION*	PAIN RELIEF	FUNCTION	RANGE OF MOTION*	ABSENCE OF DFORMITY*	MODIFIED HARRIS HIP SCORE	FUNCTIONAL RESULTS*	
1	Basvachari	62	1	Beerandahalli	181481	1	2	1, 2		1	16	4	27/8/2015	1	31	2A	8x360	20	58		2	1	40	43	5	4	92	1	
2	Sanjappa	60	1	Bangarapete	194238	1	1			1	2	1	16/9/2015	1	4	3A	10X250	20	106		2		40	38	5	4	87	2	
3	Chinnamma	82	2	Patrapalli	359841	2	2			2	6	2	28/9/2015	1	25	2B	11X320	24	101	1	3		40	38	5	4	87	2	
4	Shyamsundar	75	1	Muddenahalli	237977	1	2			1	2	1	26/12/2015	1	16	3A	11X250	24	108		3		30	37	5	4	76	3	
5	Muniswamy	60	1	Chikkakasapanahalli	249656	1	1			1	1	1	29/1/2016	1	13	5	10x250	16	102		2		40	36	5	4	85	2	
6	Mensamma	70	2	Maddinahalli	249527	2	2			1	1	1	29/1/2016	1	24	2B	11x250	17	78		1		40	42	5	4	91	1	
7	Gopal Reddy	68	1	Vadaguru	250985	2	2			1	2	1	4/2/2016	1	19	3A	9X250	14	104		1		40	44	5	4	93	1	
8	Kubra Begum	75	2	Chinnasandra	252176	1	2	1, 2		2	20	4	25/2/2016	1	46	4	10X250	24	80		3		40	39	5	4	88	2	
9	Salamma	50	2	Chenduti	287217	1	1		Fracture dislocation of proximal phalynx of left 5th finger	1	1	1	11/5/2016	1	14	2B	9X380	14	80		1		44	43	5	4	96	1	
10	Zabiulla	20	1	Narasapura	299604	1	1		Right mandible fracture	1	4	1	14/6/2016	2	17	4	9x360	12	100		1		40	42	5	4	91	1	
11	Mangamma	61	2	Kolar	303593	1	1			1	1	1	24/6/2016	1	20	3A	11 X 250	14	106		1		44	42	5	4	95	1	
12	Munirathnam	67	1	Appenahalli	301012	1	2		Right maxilla fracture	1	9	2	23/6/2016	1	26	3A	12X250	15	90		1	2	40	42	5	4	91	1	
13	Narayanappa	90	1	Doddasapenahalli	304491	2	2	1, 2		1	4	1	25/6/2016	1	35	5	12X250	24	112		3	4	40	37	5	4	86	2	
14	Nagamma	88	2	Srinivasapura	306970	1	2	1		3	5	2	1/7/2016	1	37	2C	12X250	23	96		1		40	40	5	4	89	2	
15	Venkat Reddy	60	1	Avani	216088	1	1			1	6	2	12/7/2016	1	12	3A	10X360	16	59		2	2	40	38	5	4	87	2	
16	Krishna Reddy	80	1	Ebbata	336242	2	2	1, 2		1	2	1	10/9/2016	1	12	2B	11X250	20	111		2		40	43	5	4	92	1	
17	Nanjamma	70	2	Muduvadi	337655	1	1	1, 3		1	5	1	16/9/2016	1	36	2B	10X400	20	105		2		40	42	5	4	91	1	
18	Parvathamma	60	2	Ajjapanahalli	343616	2	1		Fracture distal phalynx of 5th finger of left hand	1	1	1	26/9/2016	1	24	2B	10X400	14	95		1		44	41	5	4	94	1	
19	Venkatswamy	75	1	Vkote	342554	2	2	1	Fracture neck of right femur	3	4	2	29/9/2016	1	21	3A	11X250	18	107		1		40	44	5	4	93	1	
20	Fatima	42	2	Vadaguru	345811	2	1			1	1	1	1/10/2016	1	13	3B	9X250	14	100		3	3	40	40	5	4	89	2	
21	Padmamma	45	2	Kupahalli	369039	2	1			1	1	1	29/11/2016	1	17	3A	10X250	13	94		1		40	44	5	4	93	1	
22	Gangappa	70	1	Bangarapete	370406	2	1	1	Right 6,7 rib fracture	1	1	1	2/12/2016	1	19	3A	9X250	18	112		1		40	43	5	4	92	1	
23	Mehboob pasha	32	1	Srinivaspura	381372	1	1		3,4,5 metacarpal fracture	1	1	1	29/12/2016	2	31	5	10x400	13	102		1		44	41	5	4	94	1	
24	Vasu	43	1	Agara	374781	2	1		Right 5,6,7th rib fracture	1	15	3	27/12/2016	1	13	2C	11X250	16	107		1		44	41	5	4	94	1	
25	Shiva	25	1	Dalasanuru	382753	1	1		Right patella fracture	1	1	1	1/1/2017	1	18	2B	10X380	13	98		1	3	40	46	5	4	95	1	
26	Prasanna Kumar	25	1	Kondanahalli	394771	2	1			1	1	1	31/1/2017	2	18	3B	11X420	15	99		1		44	43	5	4	96	1	
27	Chinnappa	66	1	Srinivaspura	412320	2	1	2		2	4	1	22/3/2017	1	18	3A	10x380	18	97	2	1		44	44	5	4	97	1	
28	Changalarayappa	80	1	Thimmaravathahalli	428950	2	2	1		2	1	1	5/5/2017	1	18	3A	10X360	18	111		3		40	42	5	4	91	1	
29	Ashraf pasha	30	1	Chintamani	440856	2	1			1	1	1	1/6/2017	1	40	3A	10X420	19	110	3	1		44	43	5	4	96	1	
30	Chandrakala	42	2	Kendalli	463225	1	1			1	1	1	26/7/2017	1	17	3B	9X360	14	109		1		44	42	5	4	95	1	
* ' Please refer master key																													