A STUDY OF FUNCTIONAL OUTCOME OF FRACTURE NECK OF FEMUR MANAGED BY CANNULATED CANCELLOUS SCREWS

By

Dr. ABHIMANYU SINGH

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

In partial fulfillment of the requirements for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the Guidance of

Dr. NAGAKUMAR J.S., M.S.(Ortho),

ADDITIONAL PROFESSOR OF ORTHOPAEDICS

DEPARTMENT OF ORTHOPAEDICS,
SRI DEVARAJ URS MEDICAL COLLEGE, TAMAKA,
KOLAR – 563 101.

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Dr. ABHIMANYU SINGH
Postgraduate in Orthopaedics,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

Place: Kolar.

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Dr. NAGAKUMAR J.S.,

Additional Professor,
Department Of Orthopaedics,
Sri Devaraj Urs Medical College

Date:

Place: Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION

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Dr. ARUN H. S.

Professor & HOD
Department of Orthopaedics
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

Place: Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION

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ENDORSEMENT BY THE HEAD OF THE DEPARTMENT

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Dr. ARUN H. S.

Professor & HOD
Department Of Orthopaedics,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

Place: Kolar.

Dr. SREERAMULU P. N.

Principal,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

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, Kolar has unanimously approved

Dr. ABHIMANYU SINGH

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 FRACTURE NECK OF FEMUR MANAGED BY CANNULATED CANCELLOUS SCREWS"

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ABSTRACT

BACKGROUND

Hip fractures are common, they comprise about 20% of the operative workload of orthopedic trauma. Femoral neck fractures almost account for 50% of all the fractures around hip.Fracture neck of femur have always been a great challenge to surgeons and still are unsolved fractures. It is often a fracture of fragility due to osteoporosis in elderly, though in younger age group, it usually results from a high-energy trauma sustained commonly in a road traffic accident[2].

Regardless of age of the patient, or the fracture pattern, the primary goal of management of the fracture is to bring the patient back to a pre-fracture level of function. The ideal treatment of intra-capsular fractures of the femur neck is still anatomic reduction followed by stable bone fixation.

AIMS AND OBJECTIVE

To study the functional outcome in patients treated with cannulated cancellous screws for neck of femur fracture during 6 months of follow up.

MATERIALS AND METHODS

In this prospective study, 30 patients with neck of femur fractures were treated with cannulated cancellous screws at R. L. Jalappa Hospital, Kolar during a period of September 2016 to September 2018. All patients were hailing from surrounding rural area. Patients with pathological fractures, osteoarthritis of hip 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, 21 were males &9 females. Minimum age of patient included was 24 years and maximum of 65. Mean age of patients was 41.3 years. Road traffic accident was cause of injury in 70% of patients. 50% of patients had Garden type II fracture. In all patients closed reduction was achieved. Mean duration of union of fracture was 15

weeks. Most 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. 73.33% of patient showed excellent results while 20% showed good and 6.66% showed fair results.

CONCLUSION

At the end of the study we conclude that cannulated cancellous screws provide adequate fracture fixation, stability, strength, early mobility and excellent union rate of neck of femur fractures.

Key Words: neck of femur fracture, cannulated cancellous(cc) screws, osteosynthesis, non-union.

LIST OF ABBREVIATIONS

AD: Anno Domini

ADL: Activities of Daily Living

AO: Association of Osteosynthesis/ Arbeitsgemeinschaft fur oteosynthesefragen

AP: Antero posterior

AVN: Avascular Necrosis

BC: Before Christ

BW: Body Weight

CC: Cannulated Cancellous

CG: Centre of Gravity

DHS: Dynamic Hip Screw

DLC: Differential Leucocyte Count

ECG: Electrocardiograph

ESR: Erythrocyte Sedimentation Rate

FNF: Fracture Neck Femur

HIV: Human Immunodeficiency Virus

IM: Intramuscular

IV: Intravenous

Inj: Injection

JRF: Joint Reaction Force

K-Wire: Kirschner Wire SP: Smith-Petersen

NA: Not Applicable

OTA: Orthopaedic Trauma Association

RTA: Road Traffic Accident

TLC: Total Leucocyte Count

USFDA: United States Food and Drug Administration

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INTRODUCTION

Hip fractures are common, they comprise about 20% of the operative workload of orthopedic trauma. Femoral neck fractures almost account for 50% of all the fractures around hip. Lifetime risk of sustaining hip fracture is high and lies within a range of 40% to 50% in females and 14% to 22% in males. Life expectancy is increasing throughout the world, and the demographic changes is causing the hip fractures incidenceto increase[1].

Fracture neck of femur have always been a great challenge to surgeons and still are unsolved fractures. It is often a fracture of fragility due to osteoporosis in elderly, though in younger age group, it usually results from a high-energy trauma sustained commonly in a road traffic accident[2].

Regardless of age of the patient, or the fracture pattern, the primary goal of management of the fracture is to bring the patient back to a pre-fracture level of function. The ideal treatment of intra-capsular fractures of the femur neck is still anatomic reduction followed by stable bone fixation.

For displaced femoral neck fractures, reduction, compression, and rigid internal fixation is required if union is to be predictable. As nonunion and osteonecrosis develop frequently after internal fixation of displaced fractures of femur neck, many surgeons recommend primary prosthetic replacement as the treatment of choice in elderly ambulatory patients[3,4].

Internal fixation remains the treatment of choice for these fractures in all age groups, more so in displaced fractures in the younger patients, where preservation of femoral head is the priority. However, the optimal timing for surgical fixation of these fractures is still open to debate. It is advocated that fracture reduction and fixation should be performed as a surgical emergency in an attempt to restore the precarious

blood supply to the femoral head and prevent complications such as non-union and avascular necrosis, the incidence of these complications being 10-20% and 10-30% respectively. Avascular necrosis and non-union predisposes to future degenerative arthritis of hip joint involved[5,6].

The rationale behind the prompt treatment of fracture neck of femur is "preservation of the blood supply" to the femoral head, which is key for a good long-term result. The fracture is considered a vascular injury to the femur head blood supply[7,8]. The degree of vascular compromise is directly proportional and correlates with the fracture displacement, which affects healing of the bone and leads to complications. Hence, intra-capsular fracture neck of femur is considered an orthopaedic emergency[1] and needs prompt adequate reduction with rigid internal fixation which improves the femoral head blood circulation and prevents the troublesome complications.

Internal fixation with cannulated cancellous (CC) screws after good reduction is the ideal method of treating femur neck fractures, as there is less blood loss, shorter operative time and less duration of hospital stay. Thus parallel screw fixation at present, considered as the standard with which other implants have to be compared[1].

Therefore, we conducted this study in our institute to evaluate functional outcome of patients with neck of femur fracture treated with cannulated cancellous (CC) screws. We specially focused on the time lapse from injury to the surgery in relation to union and occurrence of complications such as non-union.

OBJECTIVES OF THE STUDY

- To assess the efficacy of cannulated cancellous screws in osteo-synthesis of femoral neck fractures.
- To determine the average time taken for union.
- To study the functional outcome of fracture neck of femur managed with cannulated cancellous (CC) screw fixation and assessing the results.

REVIEW OF LITERATURE

Femoral neck fractures description was there from the times of Hippocrates (460-380 BC). Ambrose Pare a French surgeon who first described hip fractures in 1564 but failed to differentiate between hip fracture and dislocation[9].

Sir Ashley Cooper gave first clear descriptions of femoral neck fracture in 1824. In his book “A treatise on dislocations and fractures of joints”, he clearly demarcated intra and extracapsular fractures. According to him, non-union was due to loss of blood supply to the proximal fragment. He postulated that union of incomplete fractures was by ossification and complete fractures heal by fibrous union[10,11].

Ward[12] described Trabecular pattern of femoral neck and head in 1838.

Philips in 1867 pioneered the treatment of femoral neck fractures by longitudinal and lateral traction. Maxwell later successfully used this method in his study done in 1867.

Nicholas Senn conducted animal experiments in 1883 and concluded that closed reduction of fracture and impaction of fragments would cause union of the fracture. According to Senn "The cause for nonunion in case of an intra-capsular fracture is the inability to maintain coaptation and immobilization of the fragments during the time required for the union to take place"[13].

Femoral head vascular anatomy description

- First by Trueta and Harrison[14]
- Later, in detail by Crock[15].

Kocher[7] was the first to put forward mechanism of injury of femoral neck fracture. He suggested two mechanisms:

- First, a fall with direct insult over the trochanter
- Second, external rotation of the limb

Closed reduction methods for conservative management were put forward by: Whitman[16,17] and Leadbetter[18].

Whitman also introduced closed reduction and Hip Spica application in 1902 but the results were not satisfactory.

First union of a non-united femoral neck fracture was reported in 1908 by Lexer[19] using an autologous bone graft.

In the same year, the use of wooden screws to fix femoral neck fractures was reported by Davis[20].

In 1916, Hey Groves[21] advocated the use of bone pegs instead of metal pegs in his textbook on "Modern methods of treating fractures" but the results were not satisfactory as many non-unions occurred due to breaking of bone pegs.

In 1931, the maiden successful method of internal fixation was established by Smith-Petersen[22]. He open reduced the fracture and inserted a tri-flanged nail into the neck. The shape of nail prevented rotation of fragments. The nail was subsequently named Smith-Petersen nail (SP) nail.

In 1932, Johannsson[23] simplified the SP nail technique by introducing a cannulated nail. This enabled nail insertion by closed methods. Westcott[24] in 1934 developed a similar system.

Johannsson also propagated low angle nailing to obtain 3-point fixation by using the nail on calcar, lateral cortex and femoral head.

Thronton[25] in 1937 added a side plate to the tri-flanged nail to secure lateral shaft fixation. Jwett[26] in 1941 added side plate to the nail and developed a solid one-piece nail but the nail failed as it did not allow fracture impaction.

Due to the failure of Jwett nail, various new systems were introduced:

- Pugh[27] used a sliding nail that had a side plate at 135-degree angle.
- Massie[28] used a tri-flanged telescopic nail with 150 degrees side plate but reported a high incidence of avascular necrosis (AVN) of femoral head.
- Schumpelickand Jhontzen introduced telescoping screws.
- Virgin and Mac Ausland introduced Dynamic Compression Screw in 1945.

Moore[29] in 1934 developed threaded pins, which had a beveled nut at a distal end, which prevented pin penetration into the head. Initially fixed with 3pins and later increased to 5pins.

Several other threaded pins were developed like Knowels pins, Hagie pins[30] for fixation of neck of femur fractures.

Hansson hook pins have been available and are being still used for better purchase into the subchondral bone the pins have a hook at the end.

Deyerle[31] inserted multiple pins into the femoral head at a preselected angle through a plate guide. He promoted valgus reduction during the surgery to get better results.

Sliding hip compression screw was introduced in 1970 by Richard. It is still used for fixation of trochanteric neck of femur fractures.

The differences between femur neck fractures in young adults and elderly were given importance by Protzman[4].

a. Neck of femur fracture in young adults is less common

b. A much more severe trauma is required to cause neck of femur fracture in young adults.

c. The results of treatment of femur neck fractures in young adults is considerably poorer than in the elderly.

Intra capsular pressures, to be higher in Un-displaced fractures as described by Crawfurd[32]and Stromqvist[33]. Swiontkowski[34] and Harper[35] demonstrated increased intraosseous pressures in the femoral head after femoral head fractures. Subsequent joint aspiration showed lowered intraosseous pressure within the femoral head.

In a study by Bradley[36], he concluded that a triangular screw configuration with the apical screw placed superiorly gave greater stability to fractures with 58 degrees or less and for fractures above 58-degree inferior apical screw gave better stability.

KBL Lee[3] in 2004 came to a conclusion in his study that cannulated cancellous screw fixation for femur neck of femur fractures is recommended for fixation of Undisplaced fractures in all age groups and for fixation of even displaced fractures in patients under 65 years of age.

Walker[37] et al conducted a study by fixing Pauwels type III neck of femur fractures with CC screws at different angles but did not find any difference in the outcomes.

In a retrospective study conducted by Cho MR[38], it was concluded that the bleeding from proximal screw holes is a precise perfusion assessment for prediction of possibility of AVN of femur head in the later stages. With this knowledge, he recommended that primary arthroplasty can be considered as the treatment of choice where scanty or no bleeding is observed from screw holes.

In a study by Thuan V L and Swiontkowski[6], it was concluded that a proper anatomic reduction should be achieved and when it is not possible, open reduction should be done. They also suggested capsulotomy to reduce intra-capsular pressure.

In a study of fixation of Garden Type IV fractures by cc screws in 88 patients by Filipov[39], all but 1 patient had union and only 1 patient had implant failure.

Christopher Koo Chee Han et al[40], treated 53 cases ranging from ages 30 to 59 years over a period of 5 years(2006-2010) with mean age of 42.1 years with cc screw fixation. He reported union in 52 patients with a mean time of union of 16 weeks and he thus concluded that neck of femur fracture fixation with cc screws is a viable option.

HS Sandhu[41] in 2008 in a study concluded that it is desirable to preserve the patient's natural hip joint. The extent of movements at the hip permissible in a natural hip joint is not possible in any artificial joint. He also stated that replacement arthroplasty should be done only when union is not possible or in elderly who should be ambulatory as soon as possible. These procedures should be offered to those who can afford and are capable of modifying their lifestyle.

Thierry Pauyo[42] et al in 2014 concluded that role of conservative management of femoral neck fracture is not recommended. He recommended urgent fixing of displaced femoral neck fractures and to reserve, conservative management for patients unfit for surgery.

David A. Forsch[43] conducted a study in 2012 and he came to a conclusion, that in the young patient, the goal is to preserve the native femoral head and avoid avascular necrosis as well as nonunion. Anatomic reduction and secure fixation are of paramount importance. In elderly, once the distinction, regarding the patient's physiologic age, the primary goals are optimization of medical comorbidities and surgical fixation with minimal delay to allow early mobilization.

Recent studies done by Mayank G[44] in 2016 and Jaiveer Y[45] in 2017 comparing the use of dynamic hip screw (DHS) fixation with CC screw fixation proved to have no significant differences in the clinico-radiological outcome but found CC screws to have an advantage in terms of blood loss, operating time and incision size.

Mohanlal N[46] in 2016 in his comparative study of fracture femoral neck fixation with DHS versus cannulated cancellous (CC) screws concluded that osteo-synthesis with DHS and CC screws fixation preserve living femoral head which is

better than a replacement. He further added that, though the blood loss, soft tissue damage, total length of surgery and cost of treatment are more in the DHS group than the CC screw group. As there was early weight bearing, lesser number of complications specially non-unions and a better Harris hip score as compared to CC screw group, he recommend DHS as a better and more stable implant for treatment of basi-cervical fracture neck femur.

Ruben Manohara[47] in 2014 concluded that cancellous screw fixation for un-displaced femoralneck fractures in elderly patients is a viable option and had good results in his study. Patient age did not affect postoperativepain, mobility, or rates of complication and revision and he recommended the use of internal fixation for all un-displaced fractures irrespective of age.

Sheodong Qui[48] in 2015 concluded in his study that internal fixation with cancellous bone screws reduces the blood loss during surgery, as well as the time used for surgery and fracture healing. In addition, it is effective in the treatment for neck of femur fractures by lowering the chances of AVN of femoral head.

VK Gupta[49] and Vijay V[50] concluded in their studies that CC screws allow excellent compression to occur atraumatically by the lag effect of CC screws, cannulated cancellous screw fixation represents a procedure with low operative mortality and morbidity and very high rate of fracture union and is thus a very viable option in the treatment of neck of femur fractures.

Dinçel YM[51] concluded in his study in 2017 that fracture neck of femur surgery is an emergency procedure. Earlier anatomic reduction and stable fixation are essentials of surgical treatment of FNF. Surgery to be done in less than 24 h, if possible in less than 12 h. Three-screw fixation with closed reduction is safe and still preferred option with minimal complication rates.

SURGICAL ANATOMY[52]

HIP JOINT ANATOMY

- It is a ball and socket synovial joint
- It is formed by the articulation of proximal femur(femoral head or 'BALL') with acetabulum(acetabular socket or 'CUP')
- It provides greater range of movements but is very stable
- Range of motion is relatively greater as the femoral neck is narrower than femoral head
- It connects the axial skeleton with lower extremity due to which some mobility is sacrificed for better stability and weight bearing.

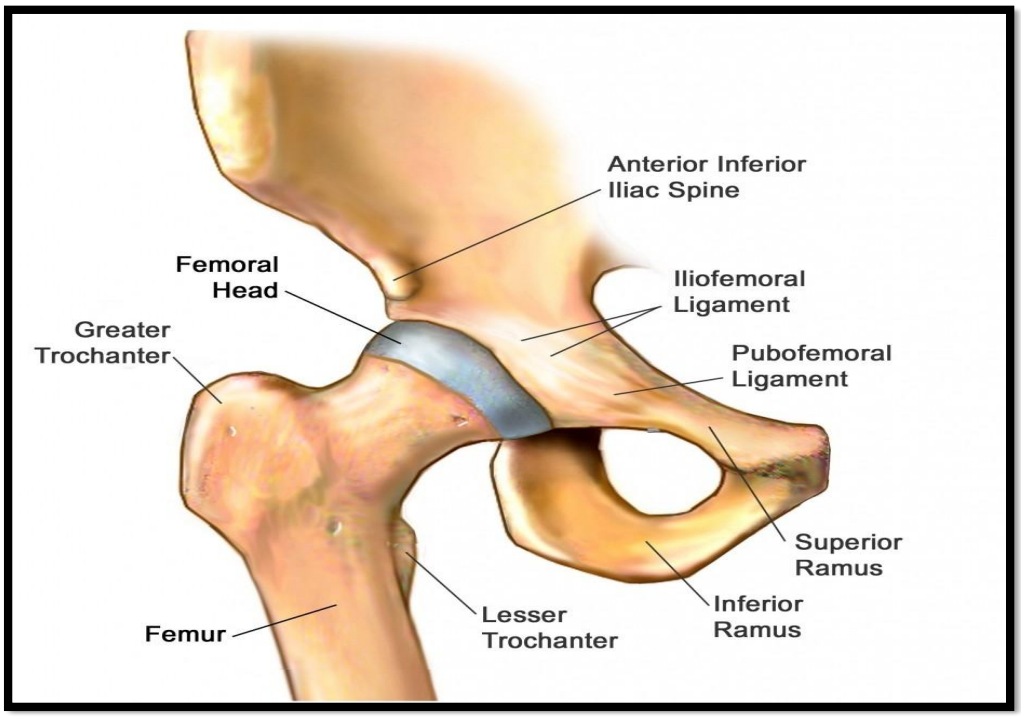


Fig No. 1: Hip Joint

ACETABULUM

- It is horse shoe shaped and is deficient at the center and inferiorly
- It is formed by conflux of ileum, pubic bone and ischium at the tri-radiate cartilage
- It covers roughly 2/5th of femoral head
- The acetabular cavity faces anteriorly, laterally, oblique and inferiorly
- It is, lined by articular cartilage (labrum) which is thick at the edges and extends across the deficient notch inferiorly called “Transverse acetabular ligament”.

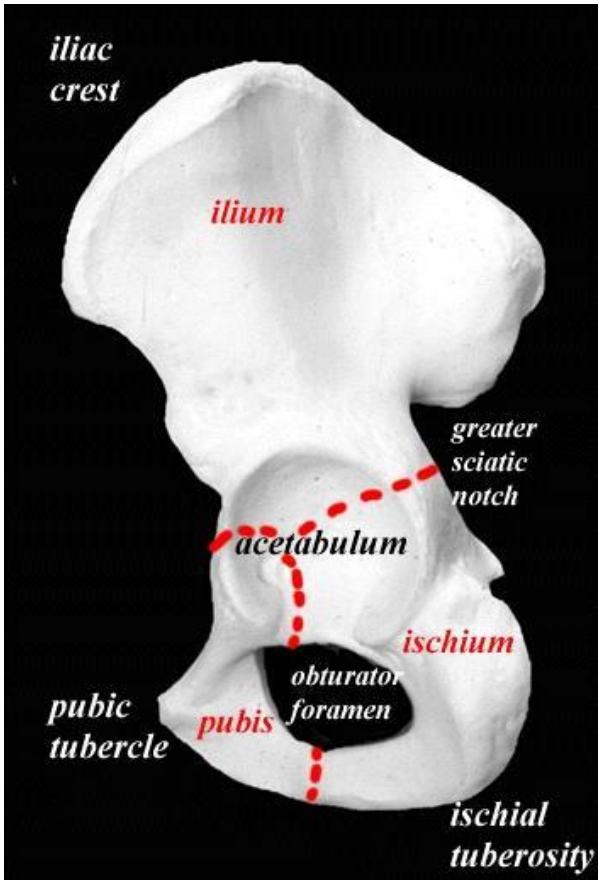


Fig. No. 2: Acetabulum

FEMORAL HEAD

- It is 2/3rd of a sphere and is covered by articular cartilage
- It is made up of dense trabecular bone and is directed medially, anteriorly and upwards
- Fovea centralis is a depression present just infero-medial to the centre of the head of femur where the ligamentumteres attaches

NECK OF FEMUR

- It is the region of femoral bone that connects femoral head to the shaft
- It is about 5cm long on average
- It forms an angle with the shaft of femoral bone which is about 120 degree to 140 degree in the antero-posterior plane called the caput collum diaphyseal (CCD) or Neck Shaft Angle
- In lateral plane it makes an angle of about 10-15degrees with the shaft called ante-version
- Its fat anterior surface joins the shaft at the intertrochanteric line and the curved posterior surface joins the shaft at the rough intertrochanteric crest
- It is reinforced postero-inferiorly by calcar femorale, which is a dense hard vertical plate of bone extending from the lesser to the greater trochanter

GREATER TROCHANTER

- It is quadrilateral shaped part of proximal femur present laterally on the upper end of shaft of femur
- It gives attachment to the abductors and short rotators

LESSER TROCHANTER

- It is a conical projection present postero-medially at the upper end of shaft where, femoral neck meets the shaft of femur
- It gives attachment to psoas muscle and iliacus muscle, which are the flexors of hip joint.

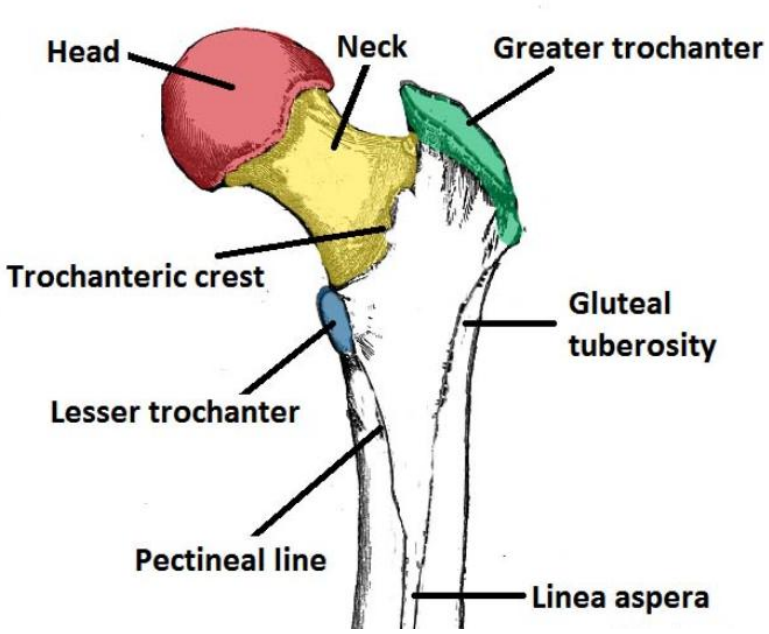


Fig. No. 3: Proximal femur

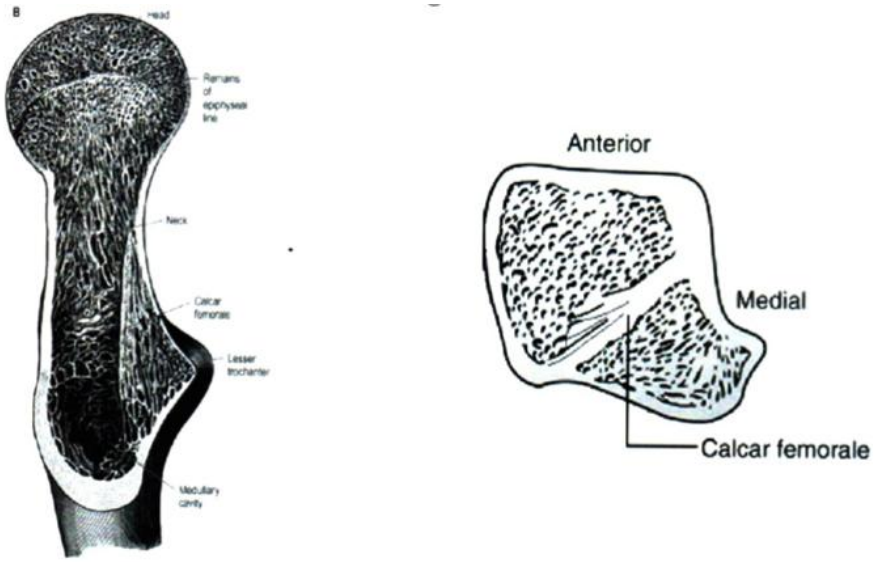


Fig No. 4: Calcar femorale

TRABECULAR PATTERN OF PROXIMAL FEMUR

- Proximal femur is characterized by its distinct trabecular patterns
- There are 2 systems of trabecular patterns
    - ✓ Medial or compressive groups
    - ✓ Lateral or tensile groups
- They form in response to joint reaction forces that the femoral head is subjected to.
- Medial or compressive groups form due to the compressive forces on the head of femur and make a right angle with the epiphyseal plate.
- Lateral or tensile group are responsible to resist the compressive forces on the head of femur

Wolff's Law: A bone in a healthy person will adapt to the loads or stresses under which it is placed.

- ✓ The trabecular pattern of proximal femur are thus directed along the lines of stress and if the stress direction changes, the orientation of pattern of trabeculae will change.

Trabeculae are divided into 5 groups:

1. Principal compressive group: they extend from upper part of head of femur to medial cortex of shaft of femur
2. Principal tensile group: they arch from the lower portion of the head to the lateral cortex of the shaft of femur via superior part of neck of femur
3. Secondary compressive group: They are present in the space between principal tensile and principal compressive group extending towards medial cortex of the shaft of femur.
4. Secondary tensile group: They are present in the space between the principal tensile and compressive groups and extend towards the lateral cortex.
5. Trochanteric group: It is present within the greater trochanter.

Ward's Triangle:

- It is the weakest area of the neck.
- It is an area in the neck of femur deficient of trabeculae.
- It is bounded by principal tensile, principal compressive and secondary compressive group.

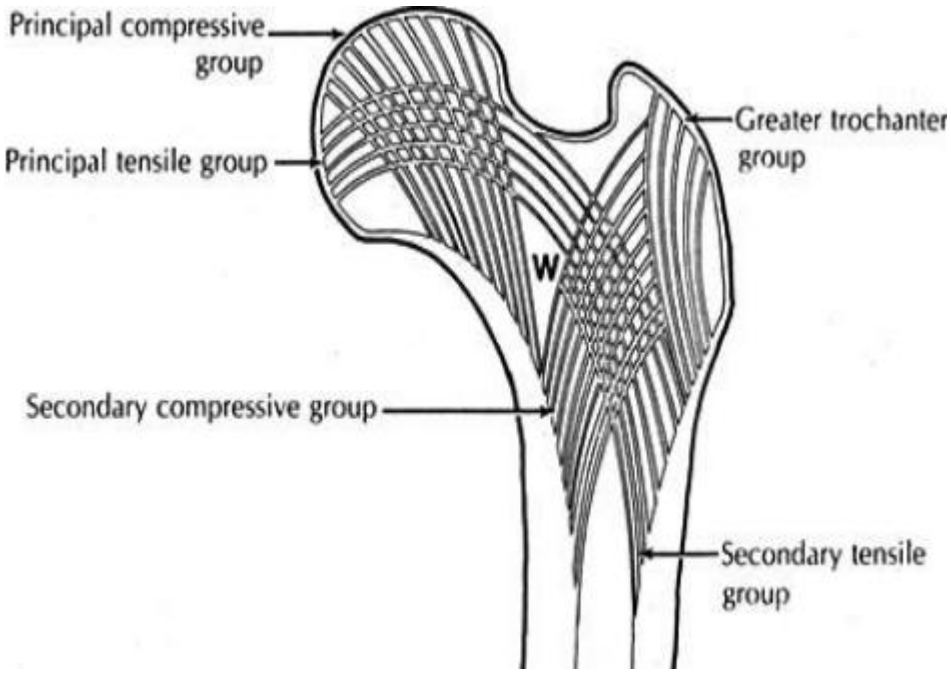


Fig No. 5: Trabecular pattern of proximal femur

SYNOVIAL MEMBRANE

- It lines the inside of the fibrous capsule.
- It is attached to the articular margins of proximal femur and acetabulum.
- It is reflected from the fibrous membrane onto the femur neck along with the capsule in the direction of long axis of the femur neck, thus forming ridges called ‘retinaculae’ in which the retinacular arteries run.

HIP CAPSULE

- It is a dense, strong structure that surrounds the hip joint.
- Attachments:
  - Proximally – Acetabulum and transverse acetabular ligament
  - Distally – Anteriorly to the intertrochanteric line

    Posteriorly, 1-1.5cm proximal to the intertrochanteric crest

- Hence the basicervical femur neck is extracapsular posteriorly
- From distal attachments it is reflected proximally along with synovial membrane along the longitudinal axis of femoral neck. These are calledretinacular fibres that contain retinacular arteries.
- It has 2 layers:
  - Zone orbicularis/Circular fibres. It is found in the postero-inferior part of the capsule.
  - Longitudinal fibres. It is found in the antero-superior part of the capsule.
- Capsule blends with iliofemoral, pubofemoral and ischiofemoral ligaments.

LIGAMENTS

1. 'Y' ligament of Bigelow / Iliofemoral ligament
   - Attachments:
     - Proximally – The antero-inferior iliac spine and acetabular rim
     - Distally – The ligaments split into an inverted 'Y' shape and one band attaches to the upper part and the other band attaches to the lower part of intertrochanteric line.
   - It is the strongest part of the capsule and the strongest ligament of the body.
   - Action: It prevents hyperextension of hip.

2. Ischiofemoral ligament

- Attachments: Ischial part of acetabular rim and supero-lateral neck of femur
- It reinforces the capsule posteriorly

3. Pubofemoral ligament

- Attachment:
  - Medially – Iliopectineal eminence
  - Laterally – Fibrous capsule and iliofemoral ligament

4. Ligamentumteres

- It is triangular in shape and flattened
- Attachments:
  - Apex attaches into the fovea capitisfemorale
  - Base is attached by two bands onto the either sides of acetabular notch
- It is surrounded by synovial membrane
- It contains artery of ligamentumteres which is a branch of obturator artery
- It is tensed on flexion/abduction/external rotation. It is relaxed in hip adduction.

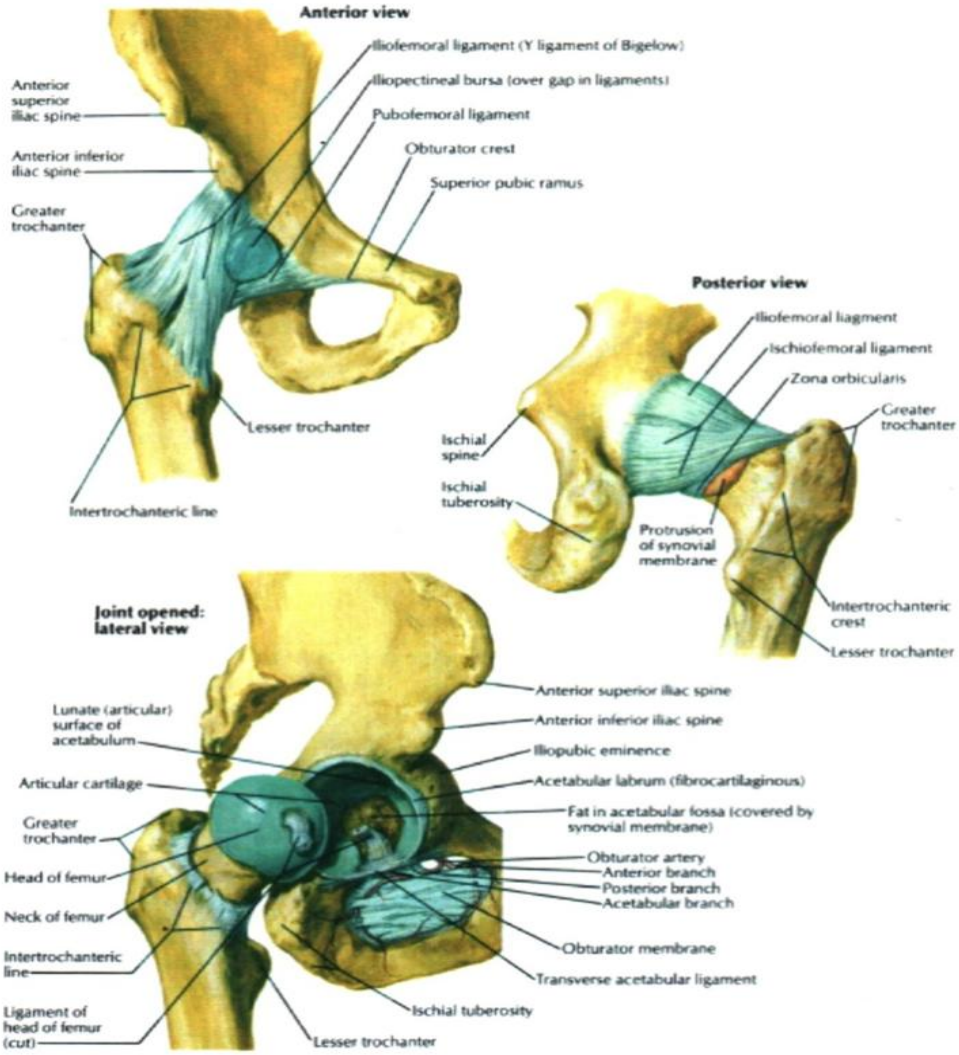


Fig No.6: Ligaments

BLOOD SUPPLY OF FEMUR HEAD AND NECK

- It was first described by Crock[15] as

a) An arterial ring outside capsule at the base of neck of femur

b) Ascending branches from the ring to the neck of femur

c) Artery of ligamentumteres

- EXTRACAPSULAR RING
    - Formation:
        - Anteriorly from the branches of lateral femoral circumflex artery
        - Posteriorly branch from the middle circumflex artery
    - Located at the base of femoral neck
    - It gives ascending cervical branches
- ASCENDING CERVICAL ARTERIES
    - These are branches of the extracapsular ring
    - They enter the capsule at the level of intertrochanteric line anteriorly, and pass underneath the zona orbicularis posteriorly
    - They course upwards in the retinaculae and are called "retinacular arteries of Weitbrecht"[53]
    - They lie in close conjunction with the femoral neck and are susceptible to damage when femur neck fractures, more so in displaced fractures.
    - They are divided into 4 groups based on where they lie on the femoral neck: anterior, medial, lateral and posterior groups.
- SUBSYNOVIAL ARTERIAL RING OF CHUNG[54]
    - It is formed by the anastomosis of branches from retinacular arteries at the level of junction of head and neck of femur.

- It gives epiphyseal branches that penetrate and supply the femoral head. These are the “lateral epiphyseal arteries” which contribute more than 80% blood supply to the femoral head.

- ARTERY OF LIGAMENTUM TERES
  - It is a branch of the obturator artery.
  - Enters the femoral head via the ligamentumteres.
  - It gives the “medial epiphyseal arteries” which contribute minor (less than 20%) blood supply to the femoral head.
- NUTRIENT ARTERY
  - The contribution of nutrient artery to the metaphyseal blood supply is variable.
  - The contribution is from superior nutrient artery's intramedullary branches.
- In fractures of femoral neck, the retinacular arteries and the nutrient artery contribution are interrupted, more so in displaced fractures and the blood supply to femoral head is subsequently dependent chiefly on the contribution from artery of ligamentumteres.
- As the contribution from the artery of ligamentumteres is less, it is not enough to keep the head viable, and if the revascularisation process is slow, it leads to avascular necrosis of head of femur.

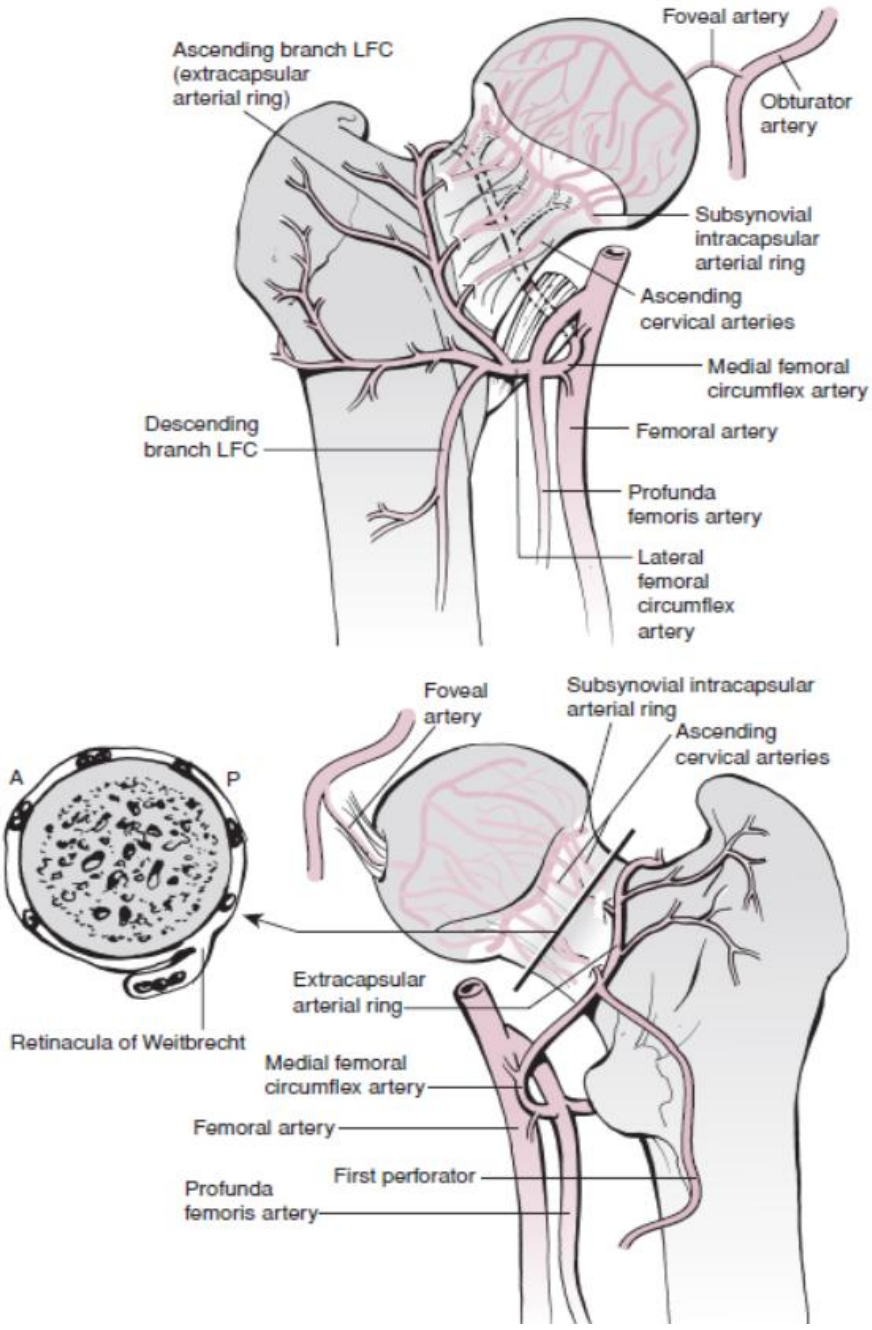


Fig. No. 7: Blood supply of head and neck of femur

NERVE SUPPLY OF HIP JOINT

- Hilton's rule: A joint is supplied by the nerves that supply the musculature acting across the joint. The same nerve also supplies the skin over the region.

- Nerve supply of hip joint varies from person to person.

Table No.: 1: Nerve Supply of hip joint

Location	Nerve supply
Anteromedial	Obturator nerve
Anterior capsule	Femoral nerve
Posterior aspect	Sciatic nerve
Posterolateral capsule	Gluteal nerve

MOVEMENTS OF HIP JOINT

- The movements occurring at hip joint include flexion, extension, abduction, adduction, rotations (internal and external) and circumduction.

Table No.: 2: Kinesiology of the hip joint

MOVEMENT	**MUSCLES (Prime Movers and Assisted)**	**AXIS**	**RANGE OF MOVEMENT**
Flexion	Psoas major, Iliacus, Pectineus, Rectus femoris, Sartorius, Adductor Longus (in early flexion from full extension)	Along the centre of femoral neck (pure spin)	130° with knee flexed, 90° with knee extended.
Extension	Gluteus maximus, Posterior hamstrings	Along the centre of femoral neck (pure spin)	10° to 15°

Abduction	Gluteus medius and minimus Tensor fasciae latae, Sartorius	Anteroposterior through femoral head	40°
Adduction	Adductors longus, brevis and magnus, Gracilis, Pectineus	Antero-posterior through femoral head	30°
Medial Rotation	Tensor fasciae latae and Anterior fibres of Gluteus, medius and minimus	Vertical axis through centre of femoral head and lateral condyle with foot stationary on the ground	30-40°
Lateral Rotation	Oburator Externus and Internus, Gemelli, Quadratus femoras, Assisted by Piriformis, gluteus maximus and Sartorius.	Vertical axis through centre of femoral head and lateral condyle with foot stationary on the ground.	30-45°

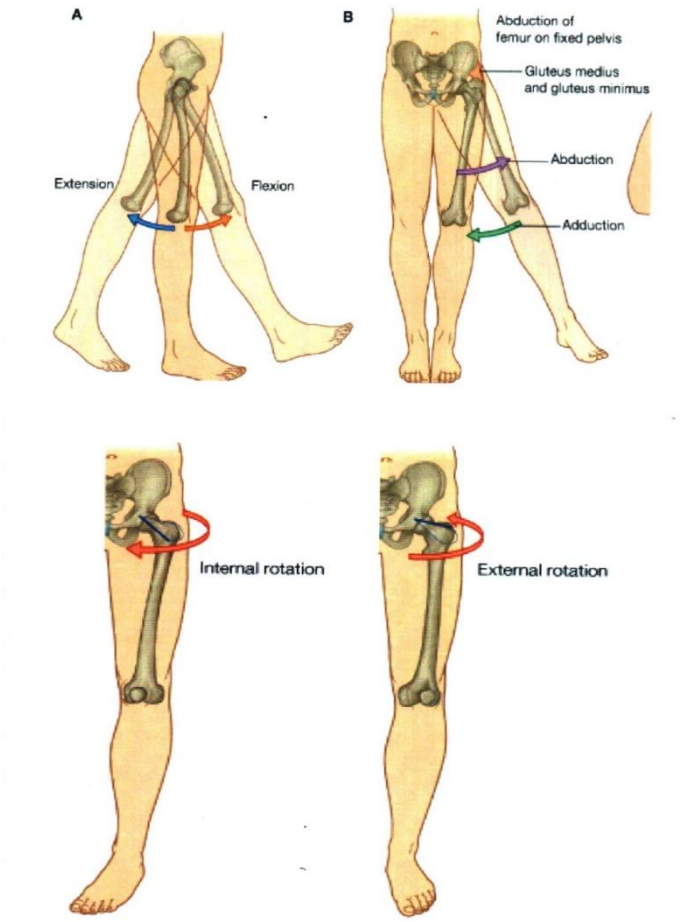


Fig No. 8: Hip movements

RADIOLOGY OF HIP JOINT[30]

Due to the anteversion of femoral neck in the anteroposterior (AP) radiograph with the limb in normal attitude (slight external rotation), the neck appears shortened due to the overlap of greater trochanter. Hence, to better visualise the proximal femur, the AP views are taken with toes directed symmetrically forward and heels slightly separated, ie. 10-15° of internal rotation.

The neck shaft angle is also seen in the AP radiograph with the limb in 10-15° of internal rotation. The lesser trochanter, in contrast, is more prominent on lateral rotation as it is located posteromedially.

SHENTON'S LINE

It is the line joining medial cortex of the femur shaft to the inferior surface of neck of femur and superior margin of obturator foramen. In normal individuals, it is a smooth curve on the AP radiographs.

A break in the line at the femoral neck region is definitive of fracture at the femur neck level.

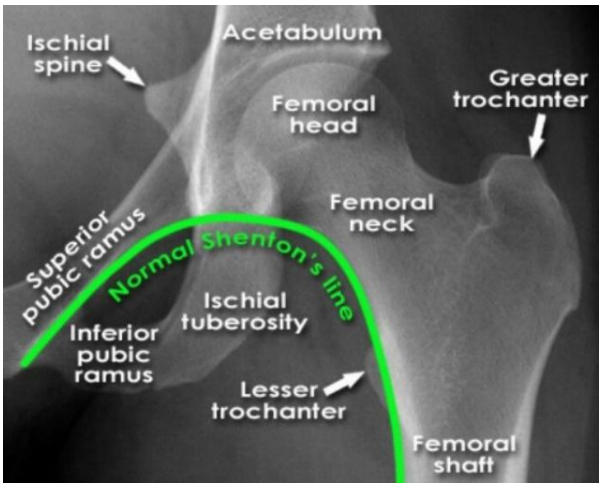


Fig No. 9: Shenton's line

SINGH'S INDEX[55]

- It is useful in assessing the bone quality as most femur neck fractures occur in elderly patients with osteoporotic bones.
- It is also useful in assessing fracture fixation quality as the stresses that can be condoned after fixation on the bone implant construct are dependent on the severity of osteoporosis.
- Proximal femur radiograph in AP view is required.
- Grade 3 and below are considered significant osteoporosis.

Table No.: 3: Singh's index

Singh's Index	Description
Grade I	Only a few compression trabeculae seen
Grade II	Loss of primary tension trabeculae is complete, marked reduction in compression trabeculae
Grade III	A break occurs in tension trabeculae
Grade IV	Secondary trabecular pattern is absent and primary trabecular pattern decreases
Grade V	Decrease in secondary trabecular pattern and ward's triangle becomes prominent
Grade VI	Normal trabecular pattern with primary compression and tensile trabeculae and secondary compression and tensile trabeculae

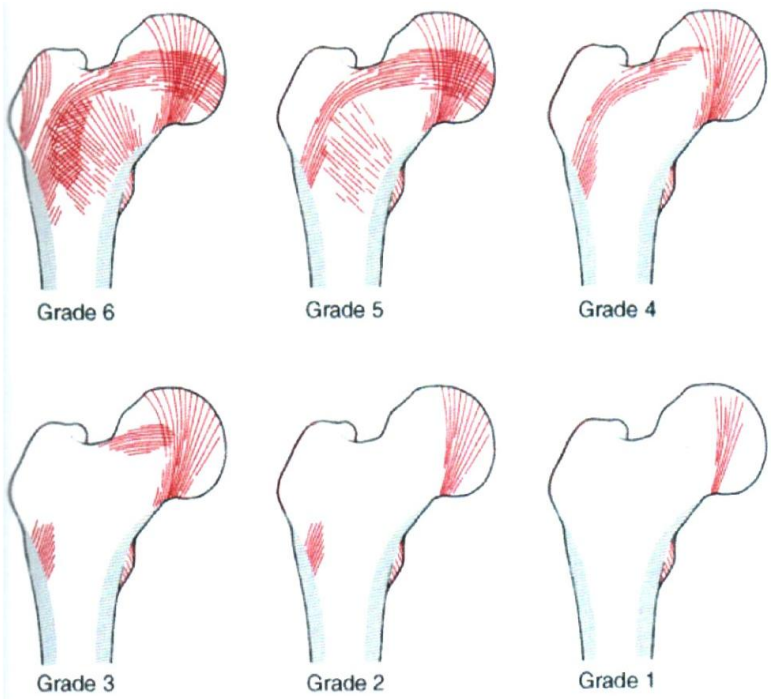


Fig No.10: Singh's Index

BIOMECHANICS OF THE HIP JOINT

- The ball and socket configuration of hip joint allows movements about all the three axes of flexion-extension, abduction-adduction and internal-external rotation.
- The most frequent motion that is required for walking is from 30° flexion to 10°extension accompanied by about 8° of pelvic rotation.
- The forces applied to the hip joint are normally quite large and much more than the body weight. These forces may be static or dynamic.
- The term static force refers to the application of external loads or forces so that they are balanced out and the joint is not subjected to acceleration.
- Dynamic forces on the other hand refer to unbalanced loads or forcesassociated with acceleration or deceleration in this case of lower extremity. Theforces include both gravity and forces generated by muscle activity.

ANALYSIS OF HIP BIOMECHANICS

Due to the various functions of hip and its dynamic forces involved the analysis of hip has been made in the different states of its utility

A) Gait analysis: Gait has been used as the primary activity to analyse kinematics of the hip joint. Most of the literature on biomechanics of hip focuses exclusively on hip joint forces during gait with a wide range of data available.

B) Activities of daily living (ADL): The hip joint is subjected to wide ranges of motion when performing common day to day activities which were not an important consideration during previous biomechanical studies. The studies involving hemi and

total hip replacement have highlighted functional demand as an important outcome measure for patient satisfaction and as such recent biomechanical studies have focused on ADL.

C) Sports activities: The hip joint is subjected to much higher and abnormal stresses in athletes than in general. Due to the complexities of motion associated with cutting and pivoting sports, the calculations are difficult and incredibly complex with most of the calculation based on mathematical models.

IN VITRO STUDIES

- Studies are done in laboratory conditions which exclude minor contributions from antagonistic muscles, elastic tension of the muscles, tendons and joint capsule.
- Almost all biomechanical studies are based on in vitro models.
- The initial studies involved 2D static analysis using free body diagrams for gait analysis and forces across hip joint in single leg stance. They are a simplified version of the actual hip biomechanics, with the assumption that the hip joint represents a uniform ball and socket joint with a single centre of rotation and a spherical head.

Static analysis criteria:

- Bones are rigid bars of a lever which can transmit force without deformation, joint are frictionless hinges and ignore rotational and translational movements, muscles are the only force producing tissues, all forces are to be taken as point loads.

- This oversimplifies the measurements but allows for better understanding the complex biomechanical interactions in joints.
- Motion capture in laboratory with infrared cameras capture movement and force plates to measure ground reaction forces have allowed for comprehensive analysis of gait.

The advantage of software simulation is that they are less invasive and allow for a fairly rapid acquisition of data, thus facilitating large datasets for a better statistical representation of variation within a given population.

IN VIVO MEASUREMENTS:

- In vivo studies have the advantage of measuring all forces acting on the hip by direct measurement of the hip joint forces including minor contributions from antagonistic muscles, elastic tension of the muscles, tendons and joint capsule.
- Theoretically, direct measurements of hip joint forces with surgical insertion of a force transducer will provide the most accurate data but it is fairly impractical.
- The forces acting on the hip are studied in various states of the human body and associated movement with importance given to gait analysis in most of the literature about hip biomechanics.
- The measurements are made with the assumption that the hip joint represents a uniform ball and socket joint with a single centre of rotation and spherical head.

BIOMECHANICS PRINCIPLE

The hip joint functions on the bio-engineering principle of moment of force with a fulcrum, lever arm and power arm.

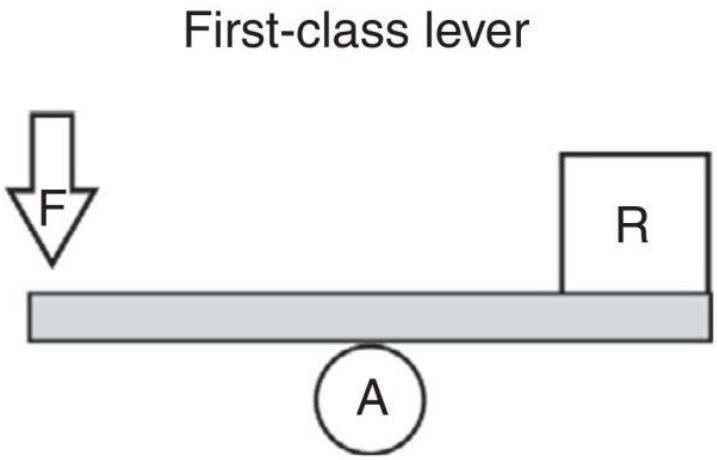


Fig No.11: First-class lever

Hip joint with the hemi-spherical femoral head articulating in the acetabular cup with abductor muscles acting at one end, the body weight on the other, and the joint itself being the fulcrum can be compared to a first order lever.

To describe the force acting on the hip joint, the body weight can be depicted as a load applied to a lever arm extending from the body's center of gravity to the center of the femoral head. The abductor musculature, acting on a lever arm extending from the lateral aspect of greater trochanter to the centre of the femoral head, must exert an equal moment to hold the pelvis level when in a one-legged stance, and a greater moment to tilt the pelvis to the same side when walking or running.

LEVER ARM RATIO: The ratio between the two lever arms of the fulcrum i.e. ratio between body weight moment arm “D1” and abductor muscle moment arm “D”

LEVER ARM RATIO = D1 : D

Typically this ratio corresponds to a ratio of 2.5. The abductor muscles have to exert a force that is three to four times the effective body weight on the hip joint in single leg stance. Variations do exist in the lever arm ratio and this is not a fixed value.

GAIT ANALYSIS

One single cycle of gait begins with heel strike and ending the next time same heel makes contact with the ground with toe off event at 60% of gait cycle. Latest measurements are based on in vitro studies using computational motion capture software.

Gait can be divided into stance and swing phase starting with heel strike followed by flat foot, mid stance, heel off and toe off to next heel contact and measurements have been made to decipher the stresses on hip at each level of ambulation to better implant design. Stance phase is between 0% to 60% of gait cycle and swing phase is from 60% to 100%.

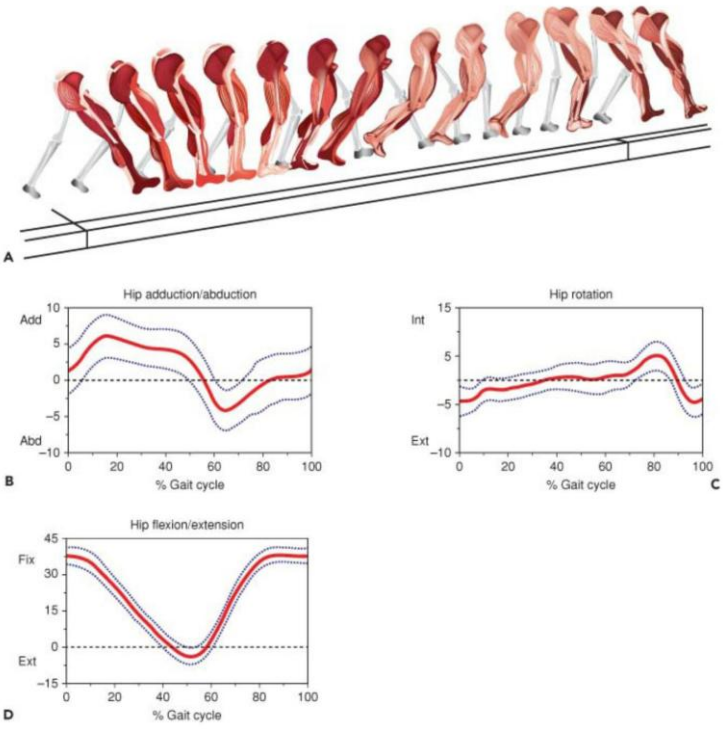


Fig No. 12: Gait cycle

PHASES OF HIP MOTION DURING GAIT CYCLE

The stress values calculated for straight line sprinting on a level surface:-

1. Slow walking: 300% BW after heel strike and 400% just before toe off

2. Speed walking: Increasing the speed of walking the initial peak joint load increases to 400% BW with less increase seen before toe off

3. Running: Forces increase by 700 to 800% BW during heel strike and slightly more during toe off.

Phase of Gait	Hip Position	Active Muscles	Occurrence During Cycle (%)
Stance			
Initial contact	30 degrees of flexion	Hamstrings and gluteus maximus	0-2
Loading response	30 degrees of flexion 5 to 10 degrees of adduction 5 to 10 degrees internal rotation	Hamstrings and gluteus maximus	0-10
Mid-stance	0 degrees of flexion-extension Neutral abduction-adduction	Gluteus medius, gluteus minimus, and tensor fascia lata	10-30
Terminal stance	10 degrees of extension	Iliacus	30-50
Pre-swing	0 degrees of flexion-extension	Iliacus and adductor longus	50-60
Swing			
Initial swing	20 degrees of flexion 5 degrees of abduction	iliopsoas, rectus femoris, gracilis, and sartorius	60-73
Midswing	20 to 30 degrees of flexion	iliopsoas, gracilis, and sartorius	73-87
Terminal swing	30 degrees of flexion	Hamstrings and gluteus maximus	87-100

IN VIVO MEASUREMENTS OF HIP JOINT FORCES

- 300% body weight during slow walking
- 350 to 400% body weight during quick walking
- 500% body weight during quick walking
- 800% body weight stumbling

FORCES ACTING ON THE HIP

The measurements are made with the assumption that the hip joint represents a uniform ball and socket joint with a single centre of rotation and spherical head. In vivo studies have the advantage of measuring all forces acting on the hip where as in vitro calculation on which most of the studies exclude minor contributions from antagonistic muscles, elastic tension of the muscles, tendons and joint capsule.

A) SYMMETRICAL STANDING / BOTH LEG STANCE:

In the human body, the centre of gravity (CG), in the resting standing state lies, in midline in front of the second sacral vertebrae in the coronal plane and is posterior to the axis of the joint in the sagittal plane. Based on in vitro studies, in this state the combined static and dynamic forces are exerted equally on both hips with the weight of the body minus the weight of both legs equally divided between them (femoral head) with the force vector directed vertically downwards towards the ground along the biomechanical axis of femur and lower limb. This equates to a compressive forces acting on each femoral head to be approximately one-third of total body weight i.e. 33%. No muscular forces required to maintain equilibrium position (in erect standing posture) with minimal muscle forces required for maintaining balance in static analysis.

The forces actually required for two-legged stance is approximately 80% to 100%, much more than anticipated (33% to 50%). This can be attributed to the persistent muscle tension that is required to maintain and erect two-legged stance.

B) SINGLE LEG STANCE

When a person stands on one lower limb, either during standing or during the stance phase of gait cycle, the hip joint experiences forces not only due to weight of the body but also muscle forces trying to maintain erect posture, equilibrium and correct for shift in the changing centre of gravity.

When standing on a single limb, the mass of the unsupported leg to is added to the body mass acting on the weight bearing hip. Only the mass of the supported leg below the femoral head is not acting upon the femoral head in this scenario. This causes the

centre of gravity to move away from the midline towards the unsupported leg and also distally based on the position of the unsupported limb. The in vitro calculations estimate 270% body weight acts upon the hip joint in single leg stance.

The supporting leg is eccentric to the line of action of centre of gravity. This also results in a rotatory force along the centre of the supported femoral head i.e. the body tries to fall on to the side of the unsupported limb due to gravity but this action is counteracted by pulling the entire trunk and levelling the pelvis (to horizontal plane) by the strong action of the hip abductor muscles.

In vitro calculations based on free body diagrams during single leg stance rely on frontal plane forces. Although limited in their design they help demonstrate the subtle changes in body position or hip anatomy can have on changes in forces across hip joint.

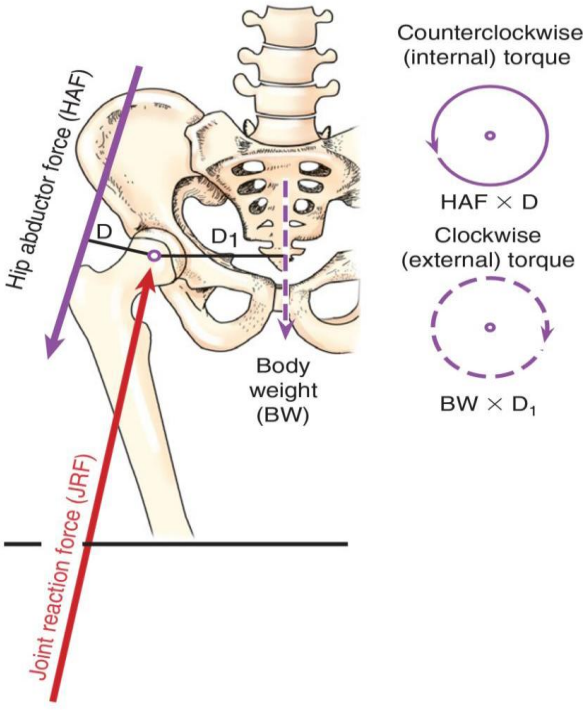


Fig. no. 13: Single leg stance

In the single leg stance the hip joint experiences a rotatory turning force (acting over the centre of the femoral head of supported leg) by the body weight (BW) on one side and its opposing counterpart forces offered by the combined abductor muscles action (HAF)

The rotational torque experience by the hip joint can be calculated by BW x D1 which is a counter clockwise torque. This necessitates the production of a counter force by the hip abductor muscles which is HAF x D a clockwise external torque. In a healthy individual these forces balance each other out and the pelvis and trunk remain levelled.

APPLIED ASPECTS

Various injuries and diseases can damage the tissues involved in the hip joint causing deformations associated with loading to be painful. The knowledge of the principals involved in the joint forces are to be used to management of various painful hip conditions aimed at reducing the joint reaction force (JRF).

The factors influencing magnitude and direction of compressive forces over femoral head are

1) Magnitude of body weight

2) Abductor lever arm (function of the neck-shaft angle)

3) Position of the centre of gravity

Reduction in total body weight (BW) reduces the overall mass effects of gravity thus reducing both the effective weight over the hip joint and the abductor power necessary to counter it bring in an overall reduction in JRF.

Lever arm ratio: Any parameter that changes the lever arm ratio will change the abductor muscle force. A shorter abductor lever arm as seen in coxa valga will lead to excessive abductor demand. This adds to the increase joint loading force with the abductor muscles being eventually overpowered. This will cause the pelvis and trunk to dip on the opposite unsupported limb and can be tested by Trendelenburg sign with the patient eventually developing a Trendelenburg gait i.e. pelvic tilting or gluteus medius lurch.

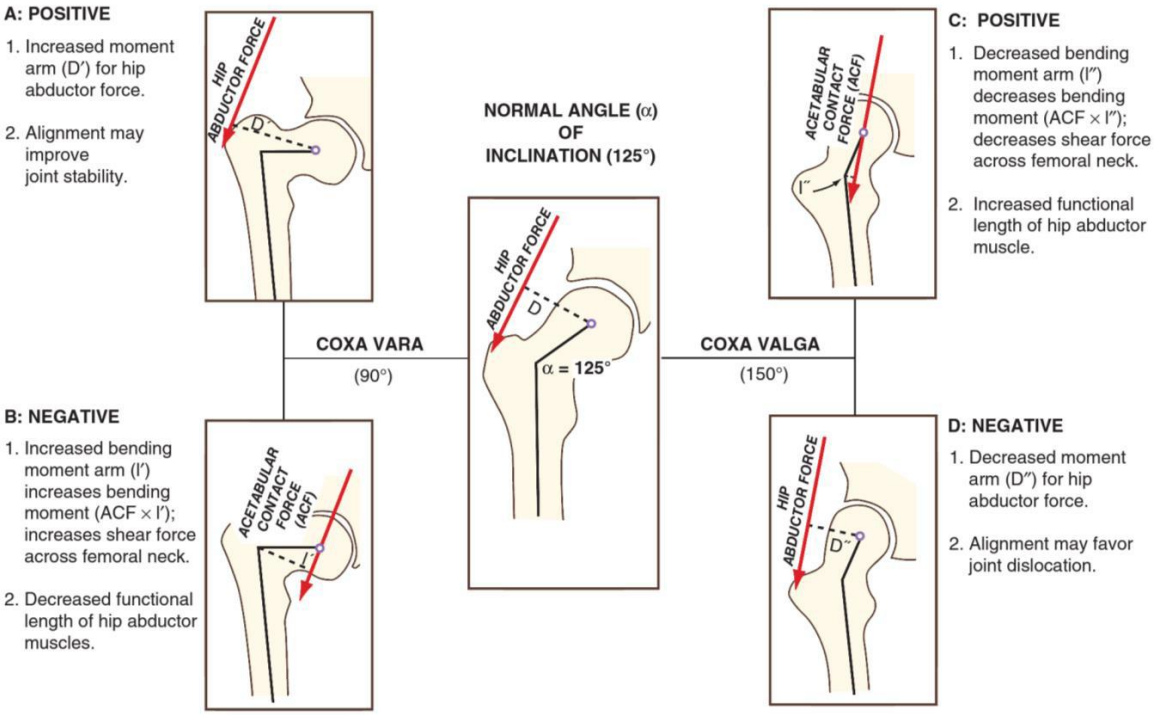


Fig No. 14: Lever arm ratio

TRENDELENBURG GAIT

A trendelenburg gait is observed when a patient bends in the coronal plane during the stance phase of walking, such that a greater proportion of his weight is centered over the standing leg. This is frequently seen in patients with hip pain, and is often thought to be representative of underlying hip pathology or abductor muscle weakness.

Although pure abductor weakness may be a rare clinical finding, an understanding of basic hip biomechanics helps explain why such a gait technique is advantageous in the setting of a painful hip. As the individual's weight is shifted over the standing leg and closer to the hip centre of rotation, the moment arm of the gravitational force "D1" is reduced, thus decreasing the force that must be generated by the abductor musculature to counteract the force of gravity on the pelvis. This results in an overall decrease in JRF, with the reduction being proportional to the extent of reduction in the moment arm of the gravitational force. In other words, the worse the trendelenburg ''lurch'', the greater reduction in load across the hip joint.

Compensation for Tredelenburg lurch can lead to contralateral knee going into a valgus position which is a risk of injury of knee and predisposes to arthritis due to excessive shear forces acting on the knee joint. Hence maintaining balance of the pelvis is an important consideration for protecting other joint along with the affected joint.

LIMPING:

One of the natural compensatory mechanisms to alleviate pain is by limping. Patient leans towards the painful hip with lateral movements to reduce the body weight moment arm "D1" by bringing the CG closer to femoral head centre and reducing the abductor muscle force required which is desirable.

However the cycle of lateral acceleration of the body mass and its deceleration (stance phase) and re-acceleration to other side (opposite leg stance) requires excessive energy consumption and also increased hip joint forces which is undesirable and prolonged limping can aggravate the pain.

WALKING AID

One of the simplest ways to alleviate pain and reduce compression forces over hip is the use of a walking stick or cane held in the hand opposite to the affected hip. This reduces the joint reaction force (JRF) caused by activating the hip abductor muscles.

The transfer of force to the walking aid reduces the effective load of body weight and produces a torque about the opposite hip in the same rotatory direction as the hip abductors.

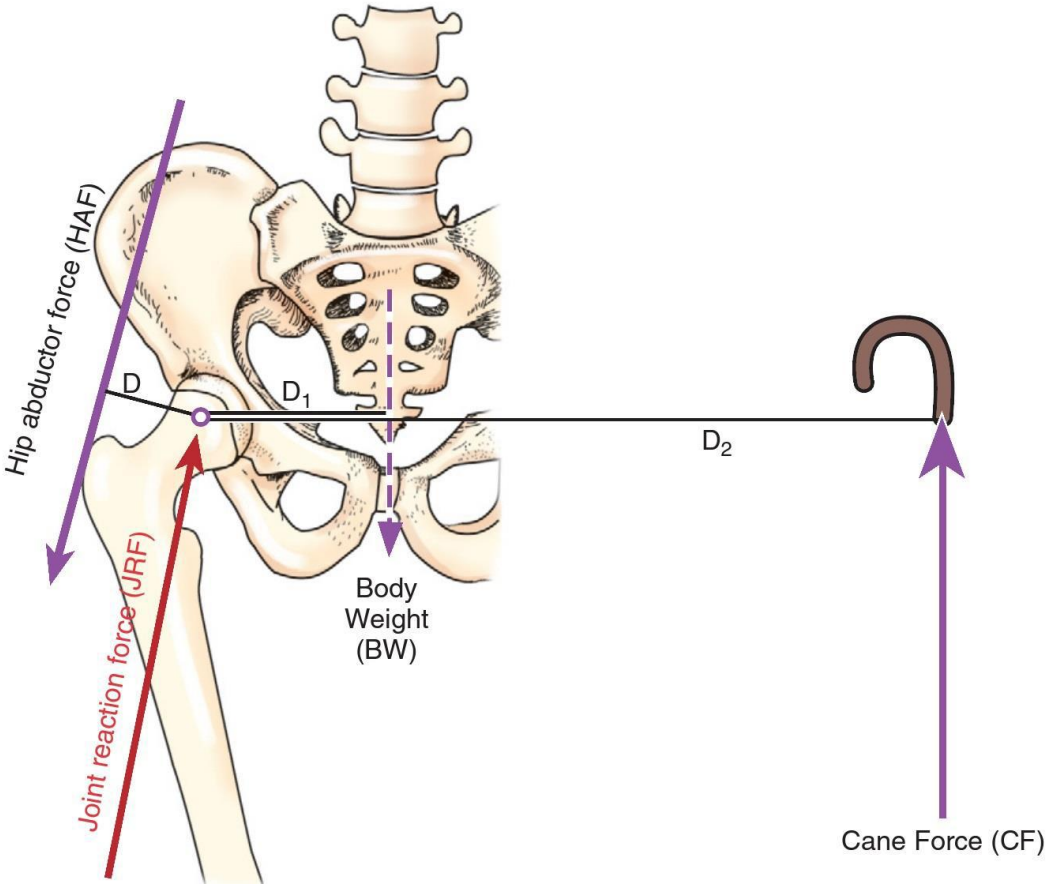


Fig No. 15: Walking aid

The cane force (CF) also acts over a large moment arm D2 as compared to the normal CG moment arm D1 thus even a small transfer of load to the cane can greatly reduce the combined JRF and this has been calculated to be 20% JRF reduction by some studies with as much as 42% when maximizing efforts to use cane.

BIOMECHANICS OF FEMORAL NECK FRACTURES

The load on the femoral neck can exceed 3-5 times the body weight when an individual is walking or running. Gravity acts on the center of the body mass, which results in torque on the medial aspect of the hip joint. This torque is counterbalanced by the contraction of the gluteus medius and minor. The total load on the femoral head is the sum of the forces producing these 2 torque forces. Then, these forces on the femoral head are transmitted through the femoral neck to the shaft, which create a significant amount of stress on the femoral neck as a result of compression and bending.

Minimal tension or compressive strains have been confirmed to occur in the superior aspect of the femoral neck during a normal single-leg stance. When tension increases, the inferior aspect of the femoral neck takes over the burden of damping the forces of compression. When a patient bends forward, stress is induced on the superior aspect of the femoral head, however, counter traction of the abductor muscles also occurs.

Hence, if the gluteus medius muscle is fatigued, the strain is placed entirely on the superior aspect of the femoral neck. This strain can predispose patients to femoral neck stress fractures. If the abductor muscles fatigue and are unable to provide normal tension, the tensile stress in the femoral neck increases.

Muscle fatigue has been implicated as a contributing factor in the development of stress fractures. Muscle imbalance leads to changes in the application of stress across the femoral neck that may exceed the bone's capability to respond appropriately to stress. Muscle fatigue secondary to repetitive activity can decrease its shock-absorbing capacity so that higher peak stresses occur in the femoral neck. This can lead to gait abnormalities, which, in turn, can alter the body's center of gravity and change the patterns of stress placed on the femoral neck.

Femoral neck fractures occur in the presence of a high ratio of axial load to bending load. Altered muscle balance may also increase the risk of a hip fracture. Another theory is that a fall onto the hip with a direct blow to the greater trochanter may generate an axial force along the neck, creating an impaction fracture. The combination of axial and rotational forces has also been proposed as a mechanism.

MECHANISM OF INJURY

- Fracture neck of femur is a common injury in the elderly with osteoporotic bones caused by low intensity trauma[56]
- According to Sir Ashtley Cooper[11], "the most frequent cause of intracapsular fracture is due to slipping at the edge of a pavement due to which the force is perpendicularly transmitted and the femoral neck acts as a level. The subsequent fall is the consequence of fracture and not its true cause."
- Two mechanisms were suggested by Kocher
    1. Fall with direct insult to the proximal femur perpendicular to the neck of femur.
    2. Lateral rotation of the limb. The femur head is immobile in the acetabulum and the neck rotates posteriorly.
- A third mechanism i.e. Cyclical loading was later on explained by Hirsch.
- In osteoporotic bone, physiological and in some cases, even subphysiological stress may cause a fracture[57]
- Fracture pattern[58] is determined by:

  a) Axial loading by the musculature along the femur neck longitudinal axis

  b) The external stress/force
- In young individuals, the fracture is caused by high intensity trauma mostly by a direct force and may or may not include a rotational component. Due to the high energy trauma, soft tissue damage is more and there is more comminution of fracture. This is the cause of higher treatment failure rates in young adults.

- Stress fracture:
    - These are common cause of hip/groin pain in young adults especially women.
    - It is caused due to sudden increase in stress subjected to a normal hip such as new long distance runners and military recruits.
    - They are mostly incomplete fractures occurring either on the compressive side of the neck or on the tensile side.
    - The incomplete compressive fractures can be managed conservatively but even in complete fractures of tensile side have to be prophylactically fixed as they will invariably progress to become complete fractures with grave prognosis.

CLASSIFICATION

- The classification systems help in selection of appropriate treatment modality and predicting the prognosis of outcome.
- Classification systems used today include:

1. Anatomical classification
    - Classified into 3 groups according to anatomical location of fracture on the femur neck:

      a) Subcapital

      b) Transcervical

      c) Basicervical

Table No. 4: Anatomical Classification

Anatomical classification	Description
Subcapital fracture	Fracture line immediately beneath the head along the old epiphyseal plate. It is usually associated with a beak
Transcervical fracture	Fracture line passing across the femoral neck between the femoral head and the greater trochanter
Basicervical fracture	These are extracapsular fractures occurring at the base of neck close to the trochanteric region

2. Pauwel's classification[57]

- It is based on the fracture line and the angle it makes with the horizontal plane in the AP radiograph.
- It was described by Pauwel in 1935.

Pauwel's classification	Description
Type I	Fracture line is < 30° from the horizontal
Type II	Fracture line is 30 - 50° from the horizontal
Type III	Fracture line is > 50° from the horizontal

Table No. 5: Pauwel's classification

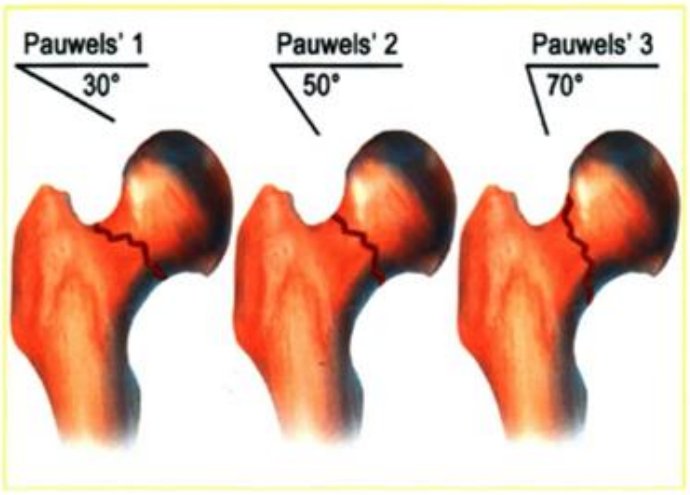


Fig No.16:Pauwel's classification

- Obliquity of fracture line increases from type I to III and thus shear force is also increased.
- Garden[59,60] later explained that it is the projection of X-ray line that differs in obliquity and not the actual fracture line as the femoral neck is spiral.
- The most accurate visualization of fracture line is possible when the neck is parallel to the X-ray film, ie. 10-15° of internal rotation.
- It is rarely used today because of findings of Garden who subsequently introduced a new classification system.

3) Garden's classification[58,59,60]

- It is based on fracture displacement.
- According to Garden, various types of femoral neck fractures were representations of the same displacing movement in different stages.

- He used the direction of compressive trabeculae from the femur head and neck to indicate the displacement and degree of rotation of the fracture in AP radiographs.

Table No.: 6: Garden's classification

Garden classification	**Description**
Garden type I	The fracture is incomplete, with the head tilted in posterolateral direction. It is valgus impacted fracture.
Garden type II	The fracture is complete, but there is no displacement. In this, the trabeculae of acetabulum, head and neck are in alignment.
Garden type III	The fractures are complete and partially displaced. The alignment of trabeculae between acetabulum, head and neck is distorted as a result of incomplete displacement
Garden type IV	Fracture fragments are completely displaced and the trabeculae of the femoral head realign themselves with the trabeculae within the acetabulum.

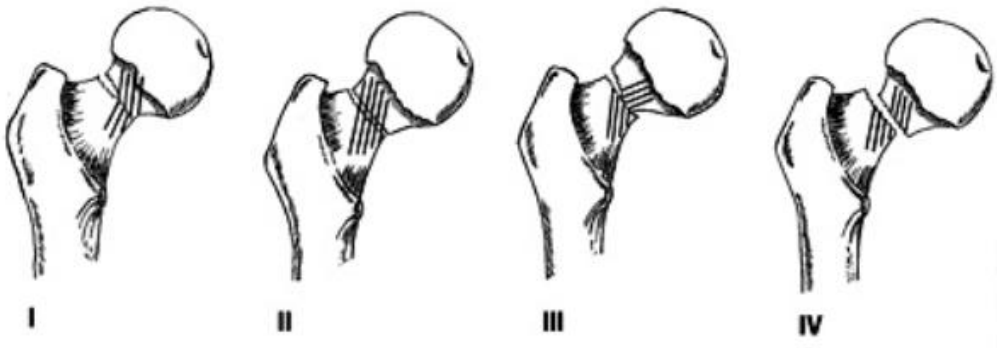


Fig. No. 17: Garden's classification

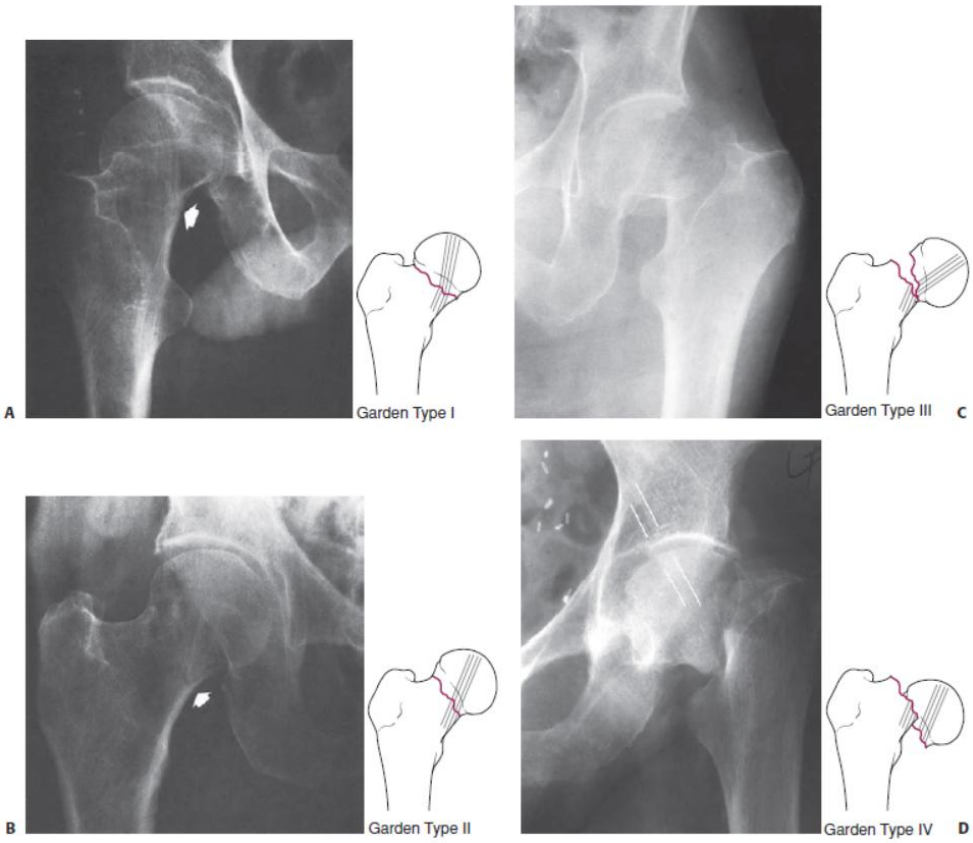


Fig No. 18: Garden's classification

- Kreder[61] in 2002 proved that the treatment and outcome is the same for Garden types I and II fractures and the treatment and outcome of types III and IV are also similar. Hence the treatment modalities for Garden types I and II (undisplaced) fractures in essence should be the same, and treatment modalities for Garden types III and IV (displaced) fractures should be along the same lines.

4) AO (ArbeitsgemeinschaftfürOsteosynthesefragen)/ Orthopaedic Trauma Association (OTA) classification[62]

- It is an alphanumeric fracture classification. Fracture femur neck is assigned type 31B where:
  - 3 denotes the femur bone
  - 1 denotes the proximal femur
  - B denotes the femur neck subgroup of proximal femur

Table no. 7: OTA classification

Orthopaedic Trauma Association (OTA) classification	**Description**	
Type B1	**Subcapital with no or minimal displacement**	
	Type B1.1	Impacted in valgus of 15 degrees or more
	Type B1.2	Impacted in valgus of less than 15 degrees
	Type B1.3	Non impacted
Type B2	**Transcervical**	
	Type B2.1	Basicervical
	Type B2.2	Midcervical with adduction

	Type B2.3	Midcervical with shear 40 degrees
Type B3	**Displaced sub capital fracture**	
	Type B3.1	Moderately displaced in varus and external rotation
	Type B3.2	Moderately displaced with vertical translation and external rotation
	Type B3.3	Markedly displaced

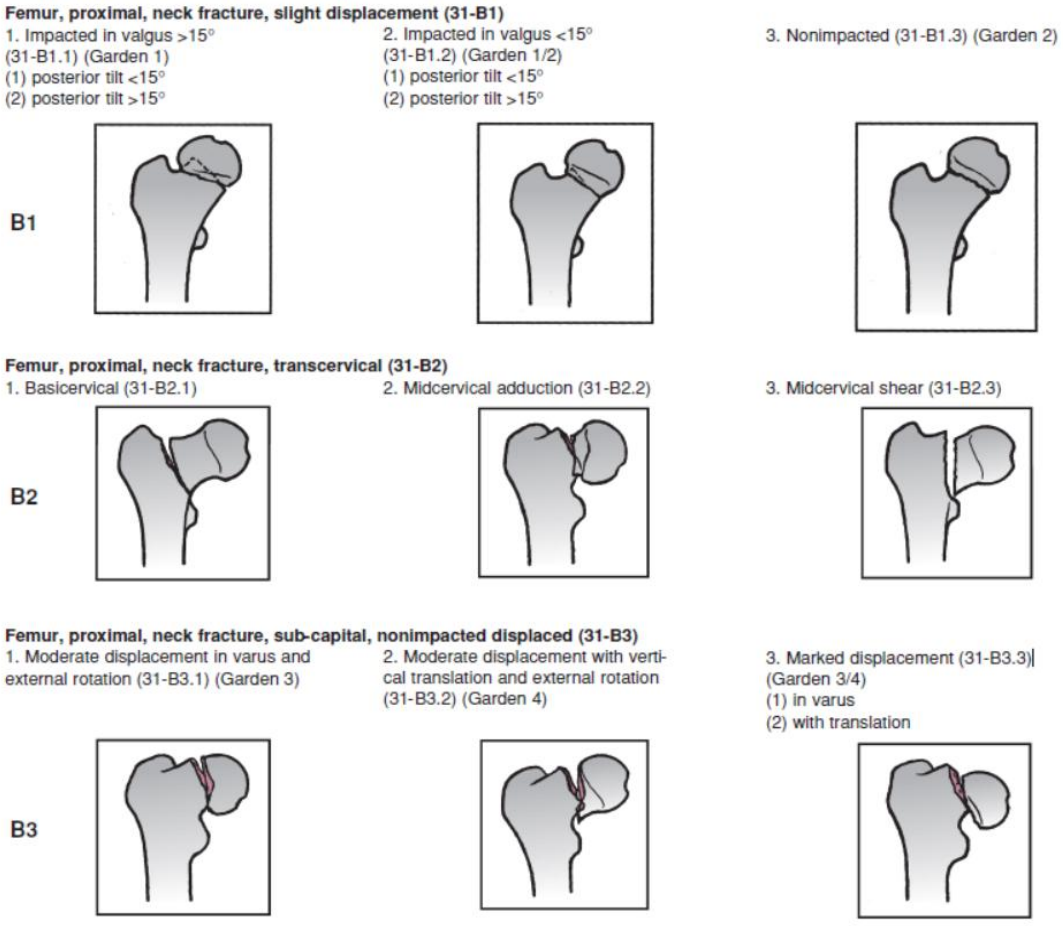


Fig No. 19: AO/OTA classification

TREATMENT

- Goals of treatment include[1,30]
    - Anatomical reduction
    - Maintenance of reduction till union
    - Return the functions to pre-injury level and give a painless, stable hip
- Outcomes depend on the restoration of anatomy

NON-OPERATIVE TREATMENT[1,30]

- It is reserved in cases where surgery cannot be done such as very old morbid patients with high risk of mortality if operated upon, patients not fit for surgery or terminally ill patients.
- Today, for most femur fractures, the treatment of choice is surgical as it reduces complications associated with prolonged bed rest by enabling early mobilisation.

OPERATIVE MANAGEMENT

- The accepted treatment for undisplaced impacted fractures include:
    1. Internal fixation with cannulated cancellous (CC) screws
        - It is the treatment of choice for undisplaced fracture internal fixation.
        - The fixation should be prompt to avoid displacement and further damage to femur head blood supply, and facilitate revascularisation of the injured blood supply.
        - At present, three parallel screw fixation is being practiced with one screw placed inferiorly in central position, and two screws placed

superiorly in the anterior and posterior parts of the neck, “inverted triangle pattern”.

2. Sliding hip screws

- Used more commonly for basicervical neck fractures as these fractures are extracapsular.
- The advantages include more biomechanical strength, support to the subtrochanteric region and avoidance of stress riser effect in subtrochanteric region.
- Disadvantages include more extensive surgical exposure and possibility of rotational malalignment while inserting the screw.

- Treatment for displaced neck femur fractures include[1,2]
  - CC screw fixation in patients <65 years of age.
  - For basicervical fractures, sliding hip screws with an antirotation screw.
  - Hemiarthroplasty in patients >65 years of age.
  - Total hip arthroplasty in patients with acetabular changes such as arthritis

Physiological Age (in years)	Functional Status	Type of Fracture	Treatment
<65	Community ambulator	Any	CRIF; ORIF if necessary
> 65	Community ambulator	Undisplaced	CRIF; ORIF if necessary
>65	Community ambulator	Displaced	Cemented bipolar arthroplasty
>75	Minimal household ambulator	Any	Unipolar arthroplasty
NA	Preexistent arthritis	Any	Total hip replacement
NA	Nonambulator	Any	CRIF or non-operative if extremely ill

Table No. 8: Treatment algorithm

- **Role of capsulotomy**[6,8,32,35]
    - The role of capsulotomy is still debatable
    - Various studies have demonstrated increased intracapsular pressures in femur neck fractures and decompression by capsulotomy in some studies has proved beneficial as blood flow to the femur head increases, reducing the femur head ischemia.

TIMING OF SURGERY

Fracture of femur neck is consideredorthopaedic emergency. Delayed fixation may lead to poor outcomes hence surgery is recommended in the first 6-12 hours, especially in young adults for preservation of femoral head. The delay of more than 24 hours leads to poor results. There are exceptions to the protocol as several patients present late.[1]

Intracapsular pressures are highest in hip extension and medial rotation and are lower in hip flexion and external rotation hence the limb should not be moved much from its presented position which is usually lateral rotation and slight flexion.

REDUCTION TECHNIQUES FOR FEMUR NECK DISPLACED FRACTURES

- Risk of AVN femur head decreases with a proper anatomical reduction[6]
- When reduction is not proper, the actual bony contact is less than 50% of what appears on X-rays as demonstrated by Moore[29,63]
- This reduced contact leads to lesser area for blood vessels to grow towards the femur head thus increasing chances of AVN femur head and non-union.
- The methods of closed reduction are:

1. Whitman's technique[17]
    - In this technique, traction is applied to the injured limb with hip in extension followed by medial rotation and abduction.
    - On failure of the technique, reduction is done with hip in 90° flexion and lateral rotation of limb with traction along the long axis of femur followed by gradual extension and medial rotation of hip.
2. Leadbetter technique[64]
    - In this technique, the reduction is done in hip flexion. The idea being that in 90 degrees of hip flexion all the muscles around the hip are maximally relaxed.

- First the hip is flexed to 90° followed by traction along the long axis of femur in slightly adducted limb. It is then followed by medial rotation.
- Limb is then gradually moved into abduction and extension while maintaining the medial rotation.

3. Smith-Petersen technique[22]
    - Smith-Petersen recommended reduction in slight hip flexion by applying gentle traction along the line of femur shaft long axis with counter pressure on the pelvis followed by medial rotation, abduction and gradual extension while maintaining traction.
4. Flynn method[65]
    - In this technique, a lateral traction is applied in the axis of femur neck with 90° hip flexion followed by gradual extension and medial rotation while the lateral traction is maintained.
    - It is claimed to be superior to Leadbetter and Whitman techniques.

Open reduction of femur neck fractures

- It should be considered if closed reduction fails after 1 or 2 tries.
- It often proves to be a tricky procedure as it can instill more damage to the remainder blood supply and it is difficult to control the "spinning femoral head", as observed by Cave and Scheck[66,67].
- It has been demonstrated that open reduction is associated with lesser incidence of both non-union and aseptic necrosis as compared to improper

closed reduction. Hence, it is safe to proceed with open reduction if closed reduction fails.

RADIOGRAPHIC EVALUATION OF REDUCTION

- Studies on effect of quality reduction on both early and late results were done by Garden[59,60].
- He found that the proper reduction decreased the incidence of AVN femur head and non-union.
- To standardize the acceptable reduction, he developed an "alignment index" to evaluate the quality of reduction.
- It is called "Garden's alignment index" [68].
- It is measured on both the AP and lateral X-rays taken after reduction.
- The X-ray quality must be good enough to identify the bony trabeculae.
- On the AP view, the angle formed by the central axis of principal compressive trabeculae is seen from the proximal to distal fragment and the medial cortex of shaft. Normally, this angle is about 160°.
- On the lateral view, the central axis of the head and neck are normally in a straight line, i.e. 180°.
- According to Garden, after reduction, the angle on both views must range between 155-180°.

COMPLICATIONS

1. Non-union

- According to US FDA (United States Food & Drug Administration), non-union is “established when a minimum of 9 months has elapsed since injury and the fracture has shown no visible signs of healing for the previous 3 months.”

- Non-union of femur neck can be established in as early as 3 months but a fairly precise prediction of healing can be usually made only after about 6 months.

- Non-union incidence is lesser in undisplaced fractures but occurs in about 20-30% of the neck fractures that are displaced. The rate of non-union also increases with age, increased synovial fluid, comminution of posterior cortex, non-anatomical reduction.[1,2,9,30]

- The lack of cambium layer in femur neck periosteum makes it more vulnerable for non-union.

- As the retinacular arteries are in close proximity to femur neck, displaced fractures pose a higher risk of damage to them and thereby increasing the risk of non-union.

- Synovial fluid prevents union as it causes lysis of hematoma and it also contains inhibiting factor for angiogenesis which prevents neovascularisation.

- The union is completely dependent on endocallus and creeping substitution.

2. Avascular necrosis

- It is the death of bone caused by ischemia.

- The phenomena starts early at a microscopic level but is evident on imaging only late.
- The effects are considered to be reversible in the initial stages, that is, when the changes are only microscopic by restoring the blood supply to the head.
- There is late collapse of the subchondral bone that lies over the infarcted bone, which causes articular incongruity and degenerative changes in the joint. This collapse is a late event and may not be present in all patients. It may occur as late as 17 years after fractures but in most patients, it is evident in almost 2 years radiographically. It occurs in 15-35% of displaced fractures[68,69].
- During the revascularisation across the fracture, the neovascularised buds can get repeatedly torn off if there is motion at the fracture site in cases of poor stabilization. In poorly reduced fractures, the surface area for blood vessels to grow at the remaining neck is less, which reduces the efficacy of revascularisation and thus increases the chances of avascular necrosis of femur head[63].
- Excessive rotation or excessive valgus at the time of reduction may damage blood supply through the ligamentumteres. This rotation may also be caused while inserting screw for fixation. An implant that is placed superiorly and laterally can cause disruption of lateral epiphyseal vessels and therefore increases the risk of avascular necrosis of femur head[1].

METHODOLOGY

- A prospective study on about 30 consecutive patients with fracture of femoral neck meeting the inclusion and the exclusion criteria admitted to RL Jalappa hospital attached to Sri DevarajUrs Medical College and research centre were taken up for the study after obtaining the informed consent between the period of September 2016 to September 2018.

➢ **INCLUSION CRITERIA:**

- Undisplaced (Garden type I and II) neck of femur fractures in all age groups.
- Displaced (Garden type III and IV) fractures in patients below 65 years of age.

➢ **EXCLUSION CRITERIA**

- Osteoarthritis of hip joint
- Pathologic fracture
- Rheumatoid arthritis
- Patients with acetabulum fractures
- Ipsilateral shaft of femur fracture
- Fracture neck of femur with dislocation.

METHOD OF COLLECTION OF DATA

- It is a prospective study.

- Collection of data from 30 cases admitted between September 2016 and September 2018 with fracture neck of femur as follows:

✓ History by Verbal communication with the patient and/or informant.

- ✓ Clinical examination, both local and systemic
- ✓ Base line investigations.
- ✓ Basic Radiological Examination
- Admitted patients were evaluated for fitness, routine pre anesthetic check-up was done and informed written consent was taken before surgery.
- ✓ The fractures were classified according to the Garden's classification based on radiological findings.

On admission, detailed history was taken and recorded and a thorough physical examination was done. In majority of the cases the findings were:

Gait: inability to walk or bear weight on the affected limb.

Attitude: Patient lying supine on bed with affected limb in slight flexion and external rotation. In some patients the rotation was not marked.

Inspection:

a. No significant contusion
b. Fullness over Scarpa's triangle

Palpation:

a. Local rise of temperature.
b. Tenderness in the groin region and Scarpa's triangle.

Measurements: limb length discrepancy.

Movements:

a. Active movements absent or painful.

b. Passive movements restricted because of pain.

PRESENCE OF ANY OTHER INJURIES:

Head injury

Injury to chest/abdomen/pelvis

Any other fractures

- On admission, skin traction with 3-4 kg weight was applied till surgery.

INVESTIGATIONS:

The following investigations were done on the patients, both male and female, being admitted with fracture neck of femur and satisfying the inclusion criteria prior to the surgery after taking the consent:

- X rays of the pelvis with bilateral hips with both limbs in 10-15 degree of internal rotation on AP view.
- X-ray of the affected femur – both AP and Lateral views
- Chest X-ray AP view
- Blood investigations- haemoglobin ,TLC, DLC, ESR , blood urea, serum cretinine, blood grouping and typing ,serum sodium and potassium, HIV, HbsAg, random and fasting blood glucose
- ECG

Post operatively:

- Check x rays pelvis with both hips AP view and operated hip lateral view were done. The same radiographs were taken on subsequent follow-ups.
- Blood investigations: haemoglobin

PREOPERATIVE PREPARATION OF PATIENTS:

- ✓ Patients were kept nil per oral eight hours before surgery.
- ✓ Parts preparation – whole extremity, groin/private parts/lower back
- ✓ Tetanus toxoid 0.5ml IM, lignocaine test dose were given
- ✓ Informed written consent was taken
- ✓ IV antibiotics were given prior to surgery after test dose
- ✓ Adequate amount of compatible blood was kept reserved, for any eventuality for patients with hemoglobin 10gm/dl or under.

INSTRUMENTS AND IMPLANTS:

- ✓ 6.5 mm cannulated cancellous screws
- ✓ 2 mm threaded guide wires.
- ✓ Cannulated hexagonal screw driver
- ✓ 3.2 mm drill bit
- ✓ 5.0 mm cannulated drill bit
- ✓ 6.5 mm Cannulated tap
- ✓ Washers (Optional)
- ✓ Power drill
- ✓ Drill sleeve.

In our study, spinal anaesthesiawas given to all 30 cases. Patient secured to a radiolucent fracture table. The pelvis was rested on the perineal supports and the unaffected limb was secured to a leg gutter with hip in flexion and abduction and knee in flexion. This facilitated convenient use of c-arm fluoroscopy.

The fracture was then reduced using Whitman's/Leadbetter technique. The adequacy of reduction was evaluated clinically by the heel-palm test and radiologically by Garden's alignment index. In heel-palm test, the heel is placed in the palm of an outstretched hand and when the reduction is adequate the leg does not rotate spontaneously externally.

Garden's alignment index:

- ✓ Assessed on AP and lateral radiographs/ C-arm flouroscopy. In A.P. view, the angle formed by the principle compressive trabeculae passing from the head to the medial cortex of upper femur shaft is normally 160 degrees.
- ✓ In the lateral view central axis of femur head and neck is at 180 degrees.
- ✓ Acceptable reduction: 155-180degrees on lateral views

The foot of the affected limb was then held in the foot holder of the fracture table. The affected limb was scrubbed with betadine(7.5%), savlon followed by spirit from abdomen to below knee joint and was subsequently painted with betadine(10%) solution and then limb was draped with the lateral aspect of the affected limb and the anterior superior iliac spine exposed.

Exposure:

A lateral incision of about 4.6cm was given in the line with greater trochanter, starting at the level of flare of greater trochanter and extending distally.

In the line of skin incision, the superficial fascia, vastuslateralis and tensor fascia latae were split.

PROCEDURE

- Following reduction of fracture, patient's foot on affected side were secured in the foot plate.
- Reduction was confirmed under C-arm fluoroscopy
- After skin incision and exposure, just below the level of vastuslateralis ridge, a drill hole was made in the lateral cortex midway between the anterior and posterior cortices using a 3.2mm drill bit.
- A 2mm threaded guide-pin was inserted through the hole and its position was checked under C-arm fluoroscopy in AP and lateral views.
- This is the inferior pin located centrally.
- Second guide wire was placed in the postero-superior and antero-superior neck and their position was confirmed under C-arm fluoroscopy in AP and lateral views.
- All the guide-wires were passed upto the subchondral bone of femoral head.
- The insertion depth of the guide wires was determined.
- 5.0mm cannulated drill was inserted along the guide wire and drilling was done 10mm lesser than the guide wire insertion depth and confirmed under C-arm fluoroscopy.

- 6.5mm cannulated tap was used to tap the near cortex (lateral cortex) over the guide wire.
- Partially threaded screws of appropriate size were selected (5mm shorter than the guide wire insertion depth).
- The screws were inserted along the guide wires with the help of cannulated hexagonal screwdriver. The final purchase of screws into the subchondral bone was done under C-arm guidance. The screws were selected and positioned such that the threaded part of the screws crossed the fracture site.
- The screw position was confirmed under C-arm fluoroscopy in AP and lateral views.
- Thorough wound wash was given and the wound was closed in layers. Skin sutured with silk or stapled. Sterile dressing was done.

POST OPERATIVELY:

- Patients were shifted to high dependency surgical ward and monitored.
- Check X-ray of pelvis and both hip in AP and operated hip in lateral views were done.
- Appropriate analgesics (Inj. Diclofenac or Inj. Tramadol) were given intramuscularly.
- IV antibiotics (Inj. Cefotaxime) was given for 2-3 days.
- IV fluids in high dependency ward as appropriate were given.
- Stitches were removed 2 weeks after surgery.

The patients were mobilized with strict non-weight bearing ambulation post-operatively with the help of a walker. They were discharged with a strict advice of non-weight bearing ambulation and to do active quadriceps exercises and were called for follow up after 4 weeks. On subsequent follow up, the next date of follow up was given.

FOLLOW UP:

Follow up was done on 4^{th}, 8^{th}, 12^{th}, 16^{th} and 24^{th} weeks. At all follow ups, symptoms like pain or swelling were noted and a detailed clinical examination was done, and looked for tenderness, active range of movements of hip and limb length discrepancy. Subjective assessment of functional outcome was done using Modified Harris Hip Score at each follow up.

X-rays were repeated on 4^{th}, 12^{th} and 24^{th} weeks (ie. 1^{st}, 3^{rd} and 5^{th}follow ups) and were observed for signs of union (trabecular continuity across fracture site), neck-shaft angle, screw backing out or breaking of screws.

Patients were advised non-weight bearing ambulation for first 8 weeks, followed by foot touch down (partial weight bearing) ambulation from 8^{th}-12^{th} week and full weight bearing after 12 weeks if radiographs showed signs of union.

STATISTICAL METHODS APPLIED

Descriptive statistics

The Descriptive procedure displays univariate summary statistics for several

variables in a single table and calculates standardized values (z scores). Variables can be ordered by the size of their means (in ascending or descending order),

alphabetically, or by the order in which you select the variables (the default).

Cross-tabs procedure

The Crosstabs procedure forms two-way and multiway tables and provides a variety of tests and measures of association for two-way tables. The structure of the table and whether categories are ordered determine what test or measure to use. Observations are presented as number and percentages with corresponding different characteristics. Since the present study is purely descriptive observational study. No statistical analysis in necessary.

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)

a. 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)

b. SHOES AND SOCKS

   i. With ease (4)

   ii. With difficulty (2)

   iii. Unable (0)

c. SITTING

   i. Comfortably in ordinary chair one hour (5)

   ii. On a high chair for half an hour (3)

   iii. Unable to sit comfortably in any chair (0)

d. 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 (140^0)

b. Abduction (40^0)

c. Adduction (40^0)

d. External rotation (40^0)

e. Internal rotation (40^0)

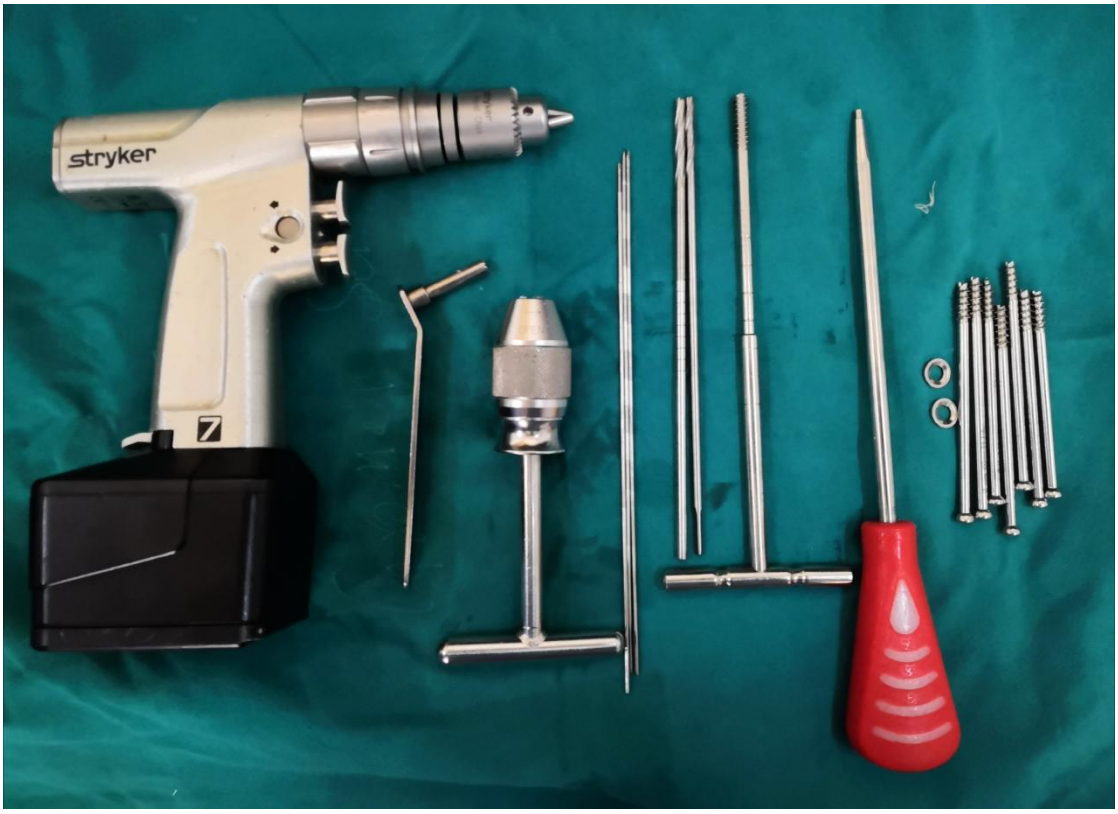
RANGE OF MOTION SCALE

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

TOTAL MODIFIED HARRIS HIP SCORE

Score	**Rating**
90 – 100	Excellent
80 – 89	Good
70 – 79	Fair
< 70	Poor

OPERATIVE PHOTOGRAPHS



IMPLANTS AND INSTRUMENTS

From left to right:

1) Power drill
2) Drill sleeve
3) Universal chuck with T-handle
4) Guide wires
5) Cannulated drill bits
6) 6.5 mm cannulated tap
7) Cannulated hexagon screw driver
8) 6.5 mm cannulated cancellous screws

Patient positioning on fracture table and parts painting

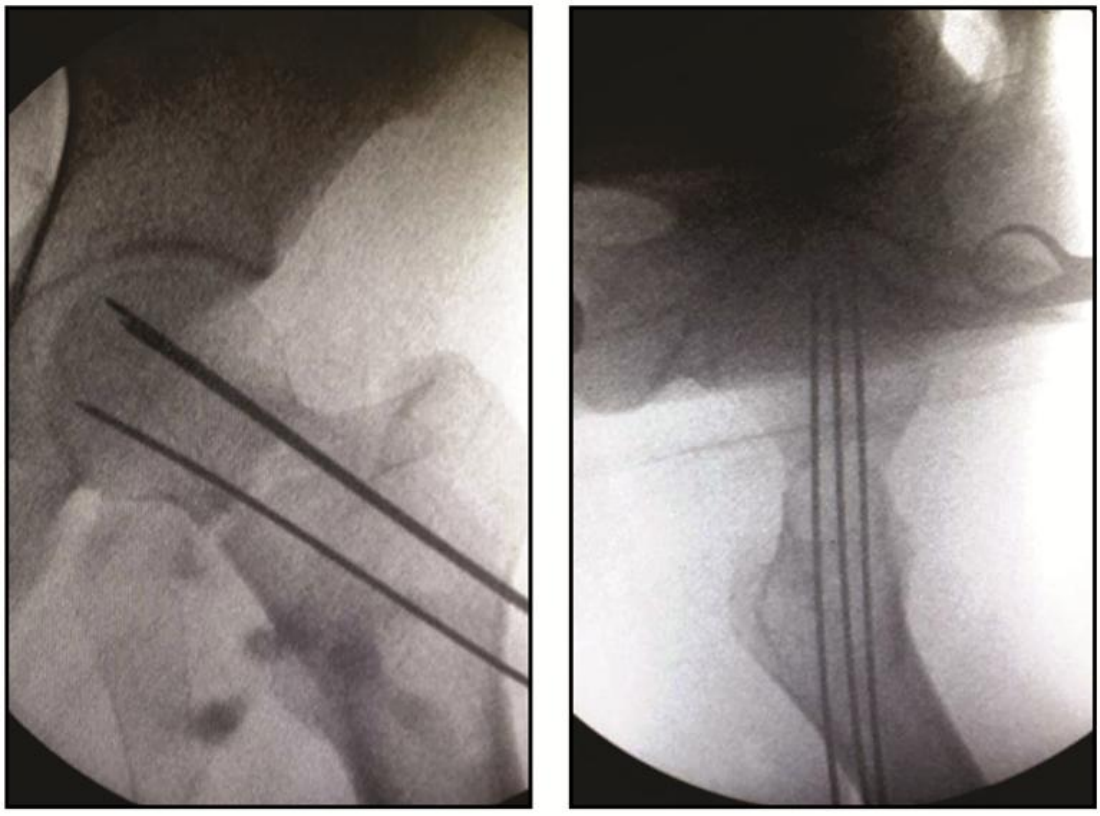
Draping and final positioning

Skin incision site confirmed under c-arm fluoroscopy

Lateral Incision

Guide wire insertion

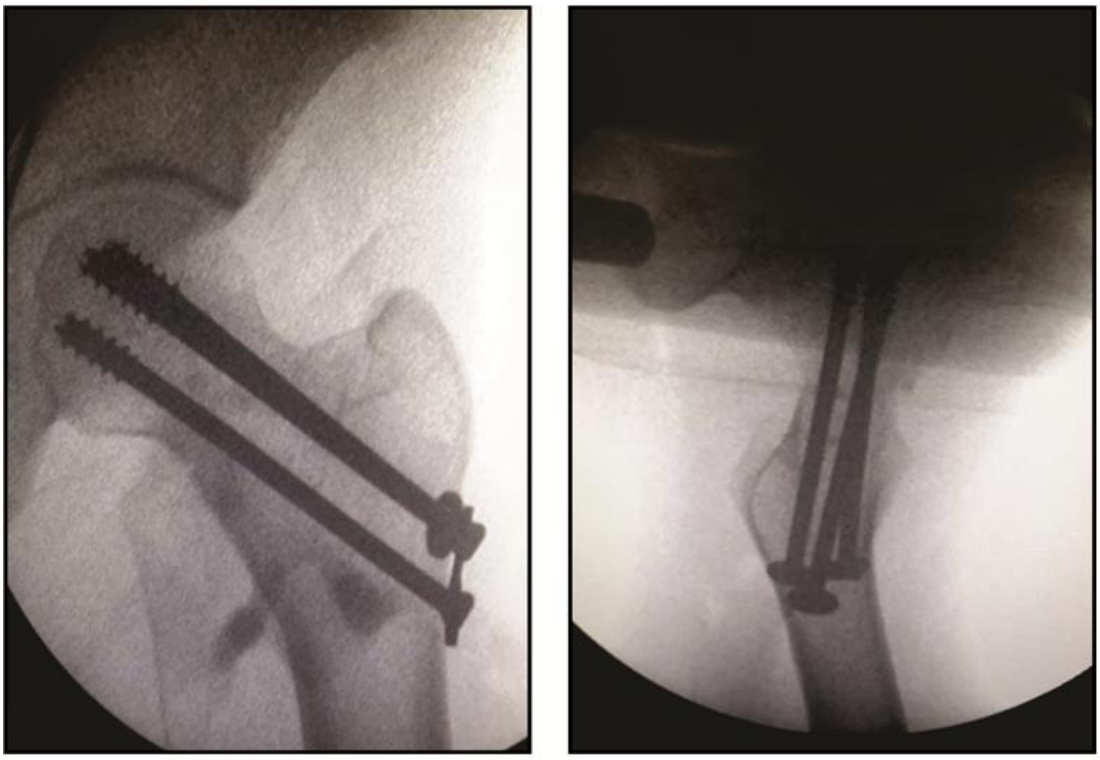
Three parallel guide wire insertion



Guide-wire position confirmation under c-arm fluoroscopy

Use of cannulated drill bit over the guide wire

Cannulated screw driven by hexagonal screw driver



Final screw positions under c-arm fluoroscopy

Wound closure

Sterile dressing and adhesive plaster

RESULTS

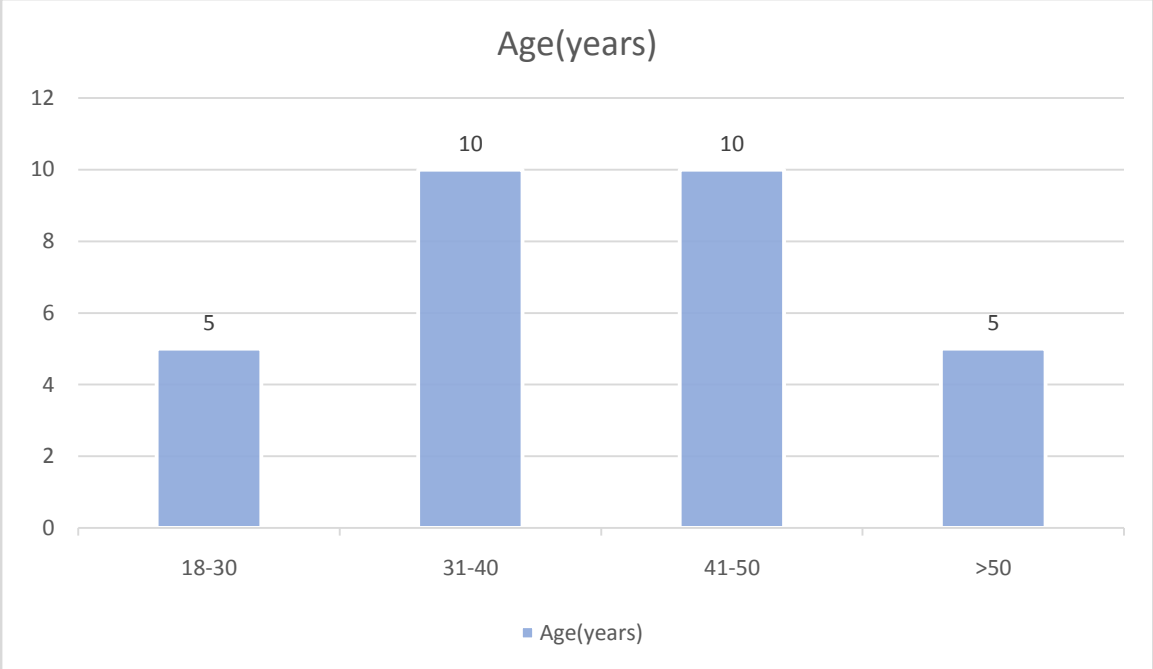
In our study 30 cases of fracture neck of femur treated surgically by internal fixation with cannulated cancellous screws at R.L. Jalappa Hospital attached to Sri Devaraj Urs Medical College and Research Centre, Kolar during the period from September 2016 to September 2018 were studied. Following were the observations made and the available data were analyzed as follows.

1) Age distribution:

In this study , majority of cases, 20 (66%) were in 31-50 years age group, followed by 5 (17%) each in the age group of 18-30 and above 50. The youngest patient's age was 24 years and eldest was 65 years old. The mean age was 41.3 years

Table 9 : Age distribution

Age (in years)	**18-30**	**31-40**	**41-50**	**>50**
No. of cases	5	10	10	5
Percentage	17	33	33	17



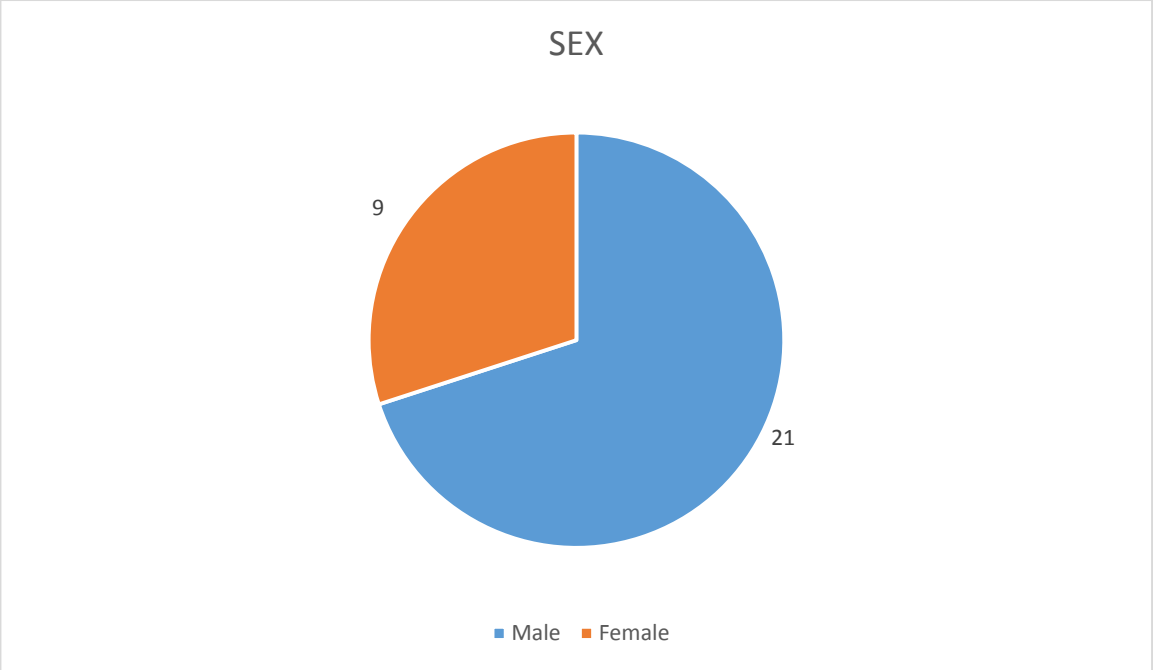
Graph -1 : Age group

2) Sex distribution:

In our study, majority 21(70%) of cases were males, and females were 9(30%) cases , with Male: Female ratio of 3:1.

Table 10 : Sex distribution

Sex	No. of cases	Percentage
Male	21	70
Female	9	30



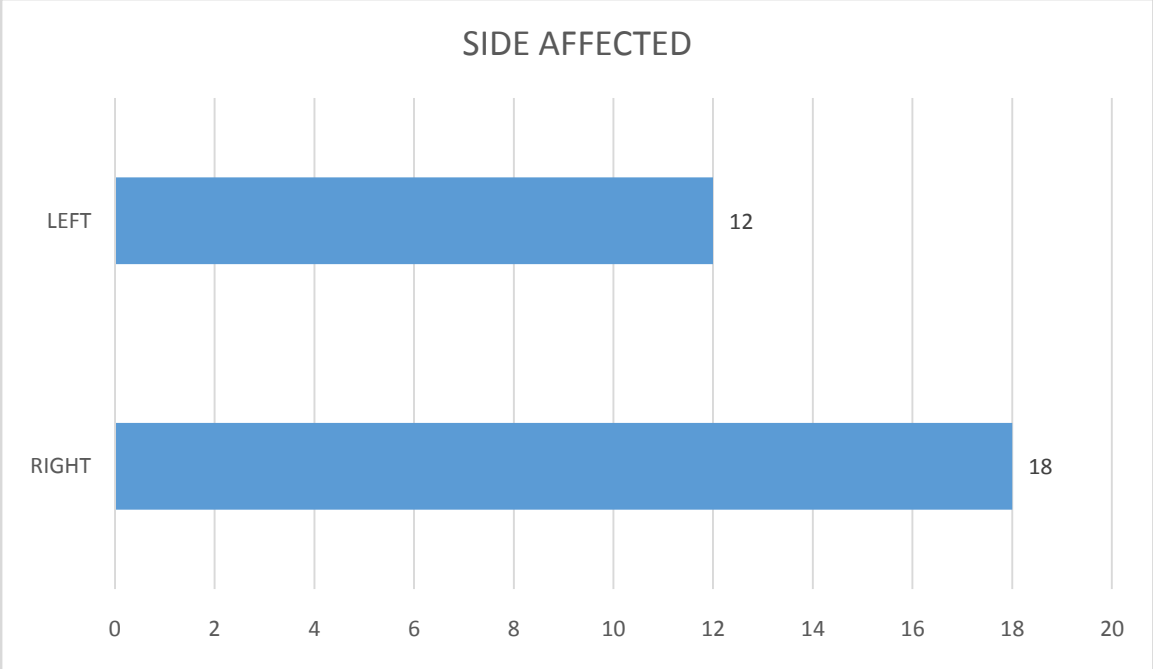
Graph -2 : Sex distribution

3) Side involvement:

Right side was involved in 18(60%) cases and left side in 12(40%) cases.

Table 11 : Side involvement

Side	No. of cases	Percentage
Right	18	60
Left	12	40



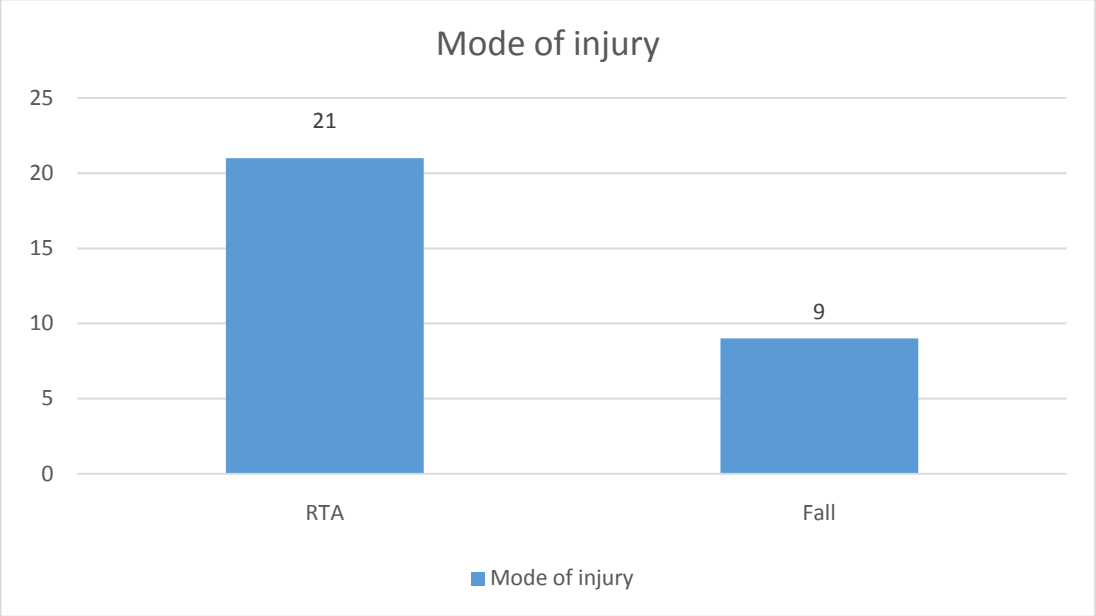
Graph -3 : Side involvement

4) Mode of injury:

the most common mode of injury was road traffic accident. 21 cases (70%) out of 30 cases were affected due to road traffic accident and rest 9 cases (30%) were due to fall.

Table 12 : Mode of injury

Mode of injury	No. of cases	Percentage
Road traffic accident (RTA)	21	70
Fall	9	30



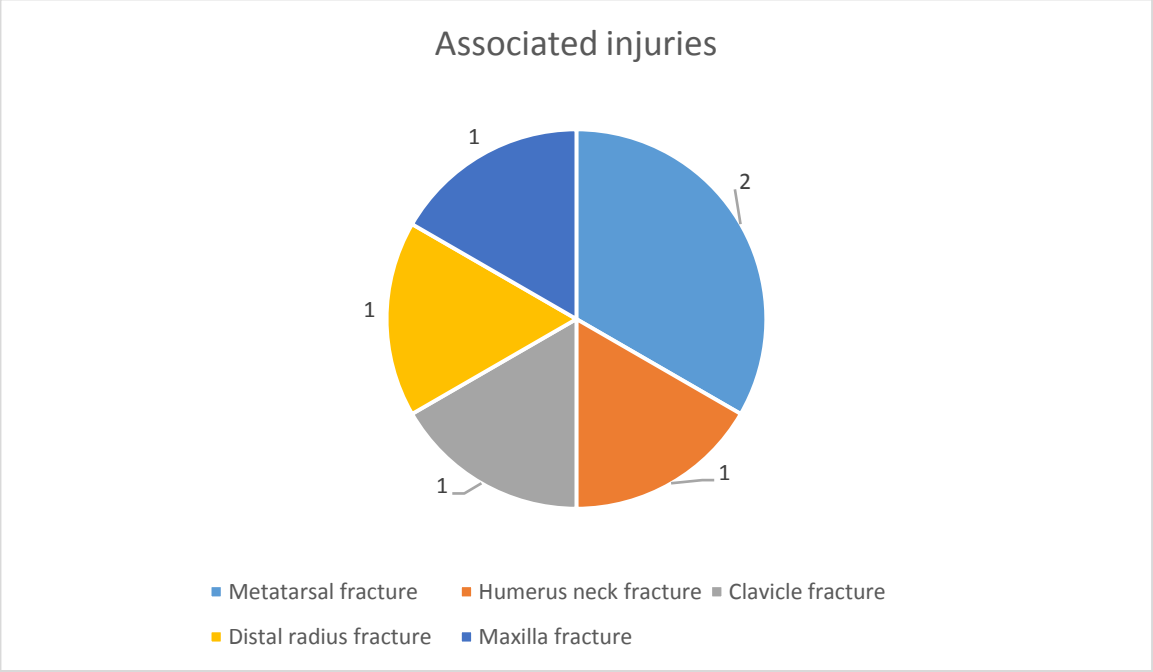
Graph 4 : Mode of injury

5) Associated injuries:

6 patients had associated injuries. 2 patients had metatarsal bones and 1 patient each had a clavicle, humerus surgical neck distal radius and facial bone(maxilla) fractures.

Table 13 : Associated injuries

Nature of injury	No. of cases	Percentage
Humerus neck fracture	1	3.33
Metatarsal fracture	2	6.66
Facial bone fracture	1	3.33
Clavicle fracture	1	3.33
Distal radius fracture	1	3.33



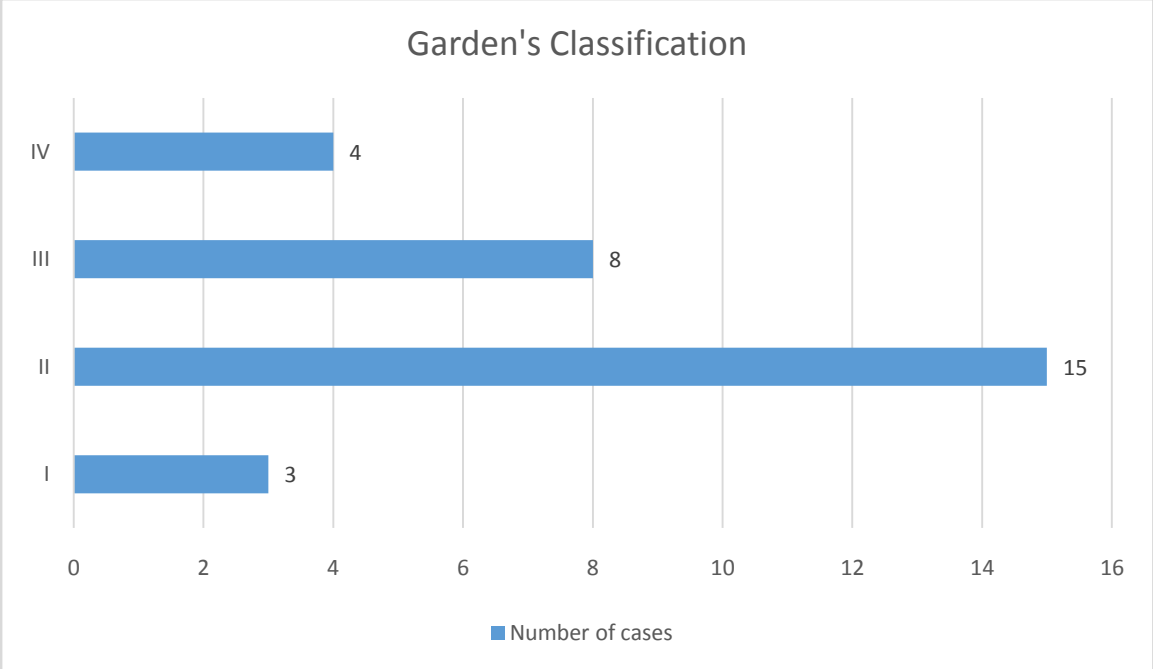
Graph -5 : Associated Injuries

6) Fracture type – Garden's classification :

In our study out of 30 cases, majority were Garden's type II – 15(50%) cases followed by Type III , 8(26.66%) cases, Type IV, 8(13.33%) and Type I, 3(10%) cases.

Table 14 : Fracture type – Garden's classification

Garden's classification	No. Of cases	Percentage
I	3	10
II	15	50
III	8	26.66
IV	4	13.33



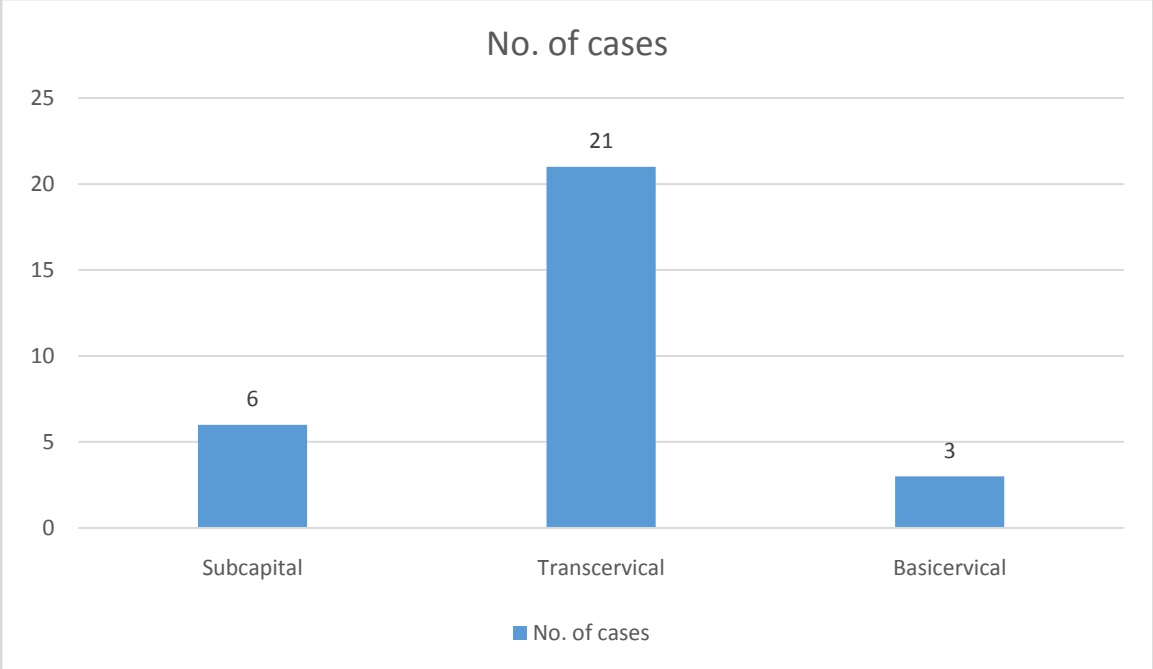
Graph -6 : Garden's Classification

7) Anatomical Location:

In our study, most cases had fracture in the transcervical region of the neck of femur, 21(70%) cases followed by subcapital fractures, 6(20%) and the least cases had basicervical fracture(10%).

Table 15: Anatomical location

Anatomical location	No. Of cases	Percentage
Subcapital	6	20
Transcervical	21	70
Basicervical	3	10



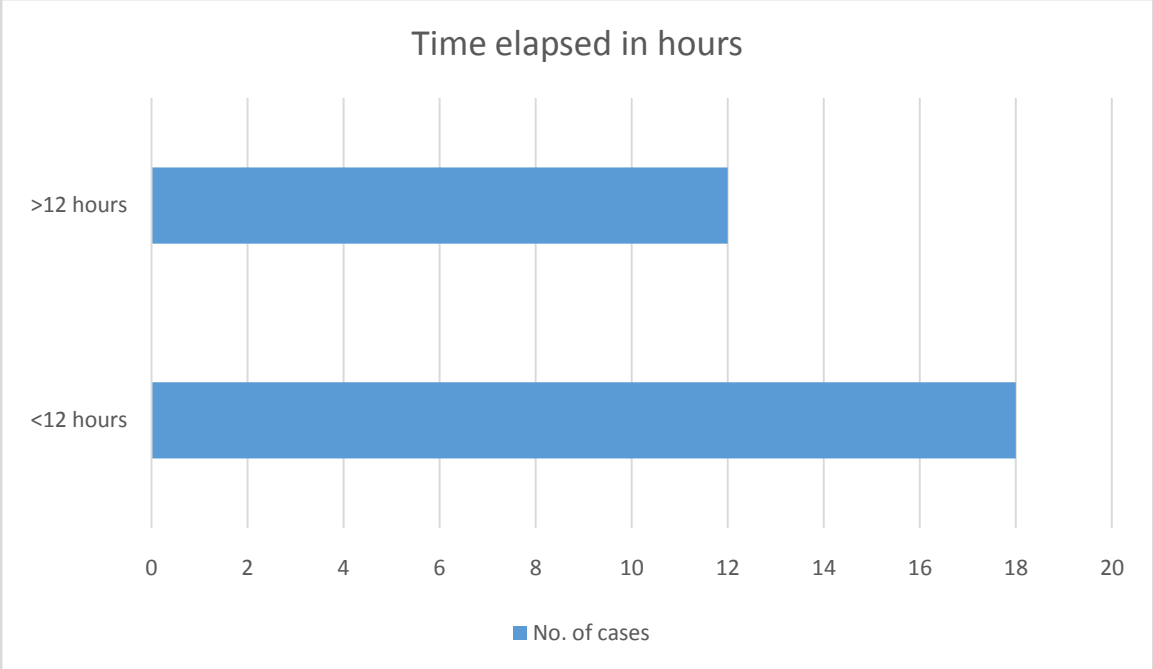
Graph -7 : Anatomical Classification

8) Time interval between injury and surgery:

In our study, 18(60%) cases were operated within 12 hours of trauma and 12(40%) cases were operated within 12 -48 hours.

Table 16 : Time interval between injury and surgery

Time elapsed	<12 hours	>12 hours
No. of cases	18	12
Percentage	60	40



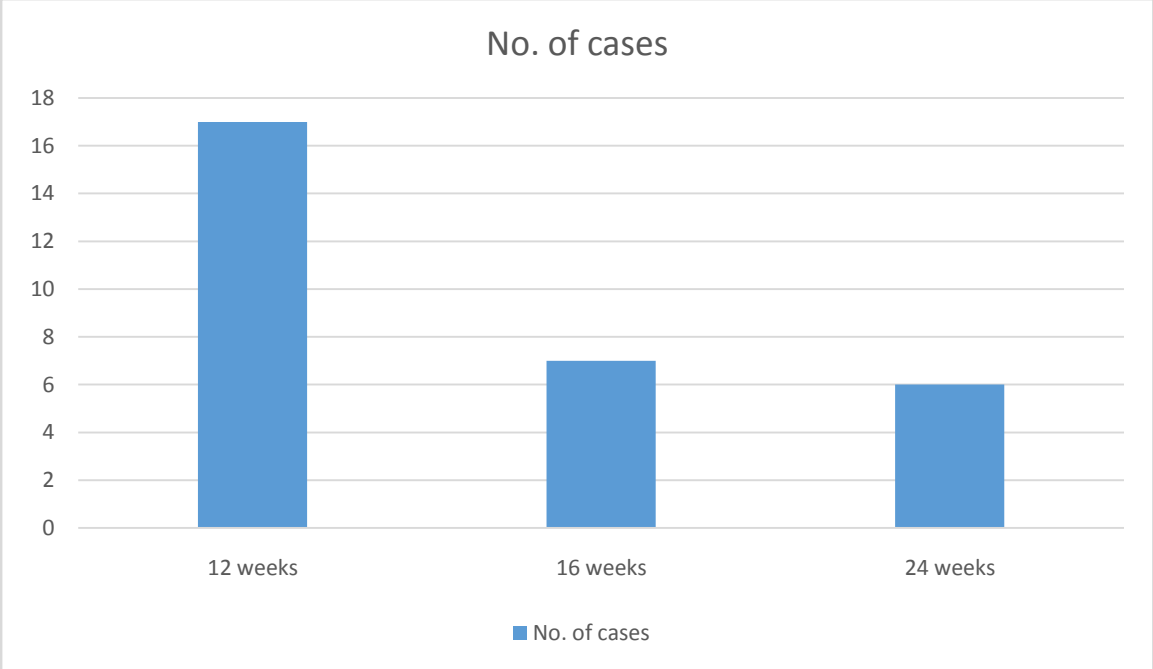
Graph -8 : Time Elapsed

9) Time taken for union:

In our study, the average time taken for union was 15 weeks. Most of the cases showed union in 12weeks, 17 patients followed by 16 weeks in 7 patients and 24 weeks, 6 cases.

Table 17 : Time taken for union

Union (weeks)	**Twelve**	**Sixteen**	**Twenty four**
No. of cases	17	7	6



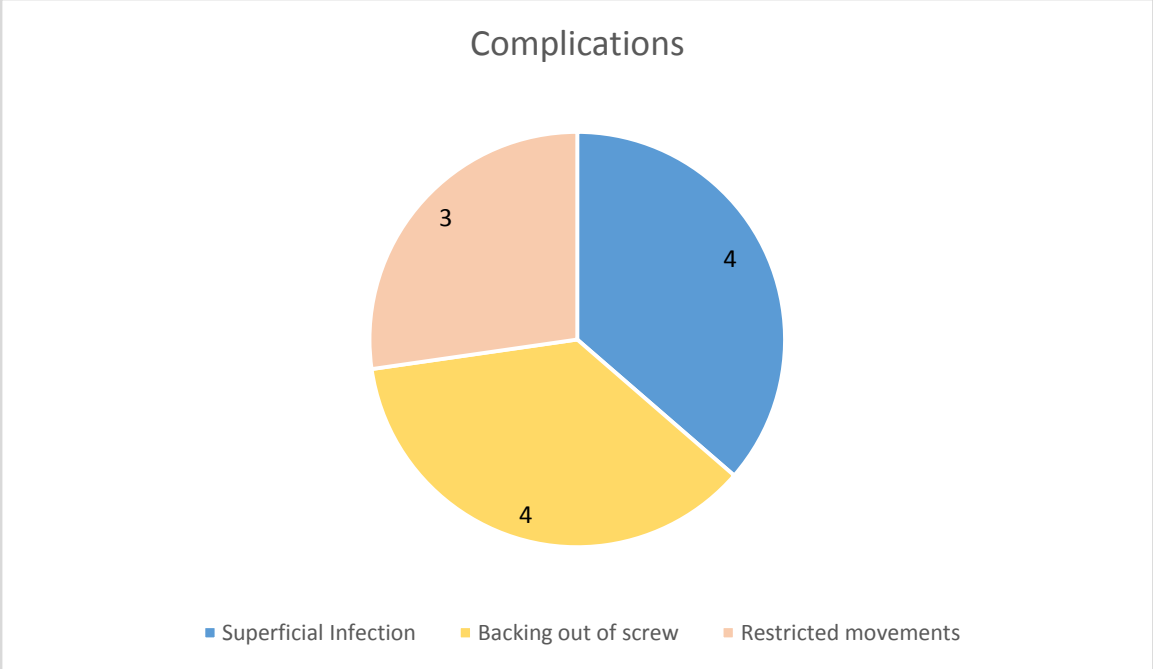
Graph -9 : Time of Union

10) Complications :

In our study , 6(20%) cases had complications. The most common complication were superficial infection and backing out of screws, 4 cases(13.33%). There were no implant failure or non-union.

Table 18 : Complications

Complications	No. of cases	Percentage
Superficial infection	4	13.33
Backing out of screw	4	13.33
Restricted movements	3	10



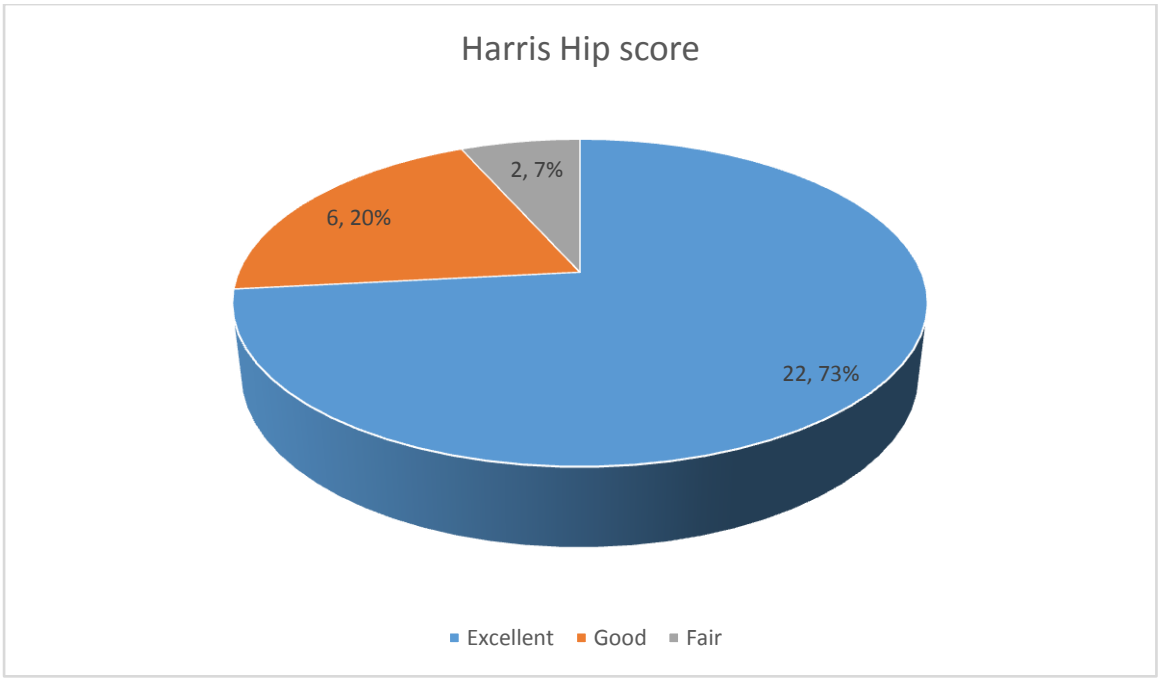
Graph -10 : Complications

11) Results – According to Modified Harris Hip score

In the present study, 30 patients with fracture neck of femur were treated surgically. The results were satisfactory in 93.33% cases by the subjective Modified Harris Hip scoring system. The functional outcome was Excellent in 22 cases (73.33%), Good in 6 cases (20%) and in 2 cases(6.66%) Fair. Excellent results were observed equally irrespective of timing of surgery in our study i.e within 2 days. No patient had a poor outcome at their final follow up.

Table 19 : Results – According to Modified Harris Hip score

Results	No of cases	Percentage
Excellent	22	73.33
Good	6	20
Fair	2	6.66
Poor	0	0



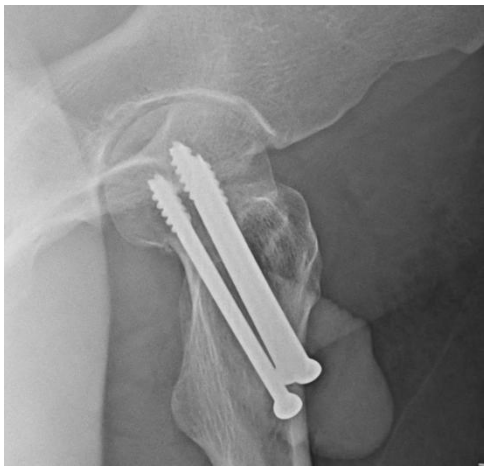
Graph -11 : Results

CASE – 1

Pre op x-ray (AP view)

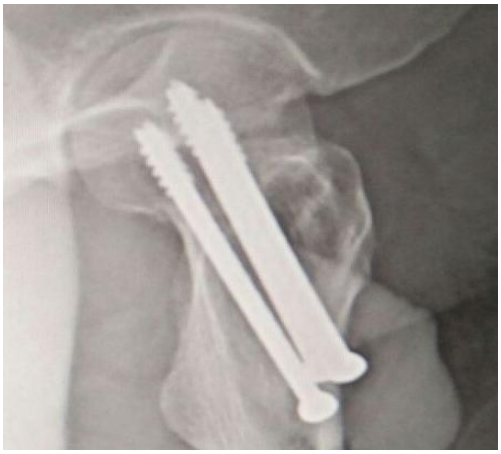
Pre op x-ray (Lateral)

Post op x-ray



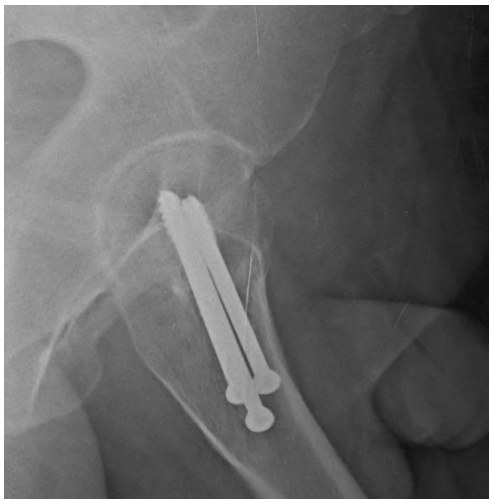
Post op x-ray

3 months follow up



3 months follow up

6 months follow up



6 months follow up

Follow up clinical range of motion photographs

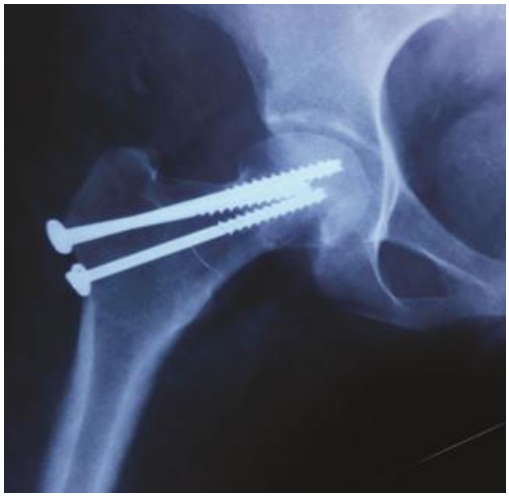
CASE – 2

Pre op x-ray

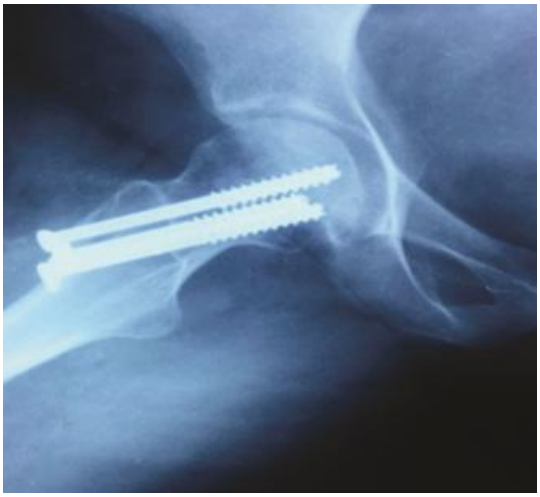
Pre op x-ray

Post op X-ray

Post op X-ray



6 months follow-up

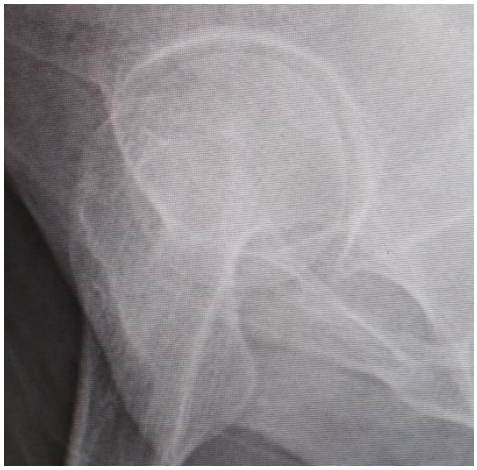


6 months follow-up

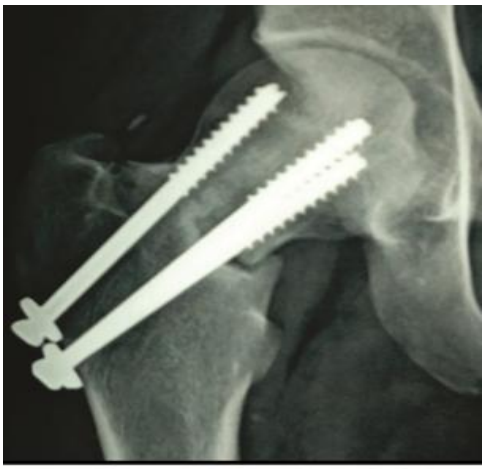
Follow up clinical range of motion photographs

CASE – 3

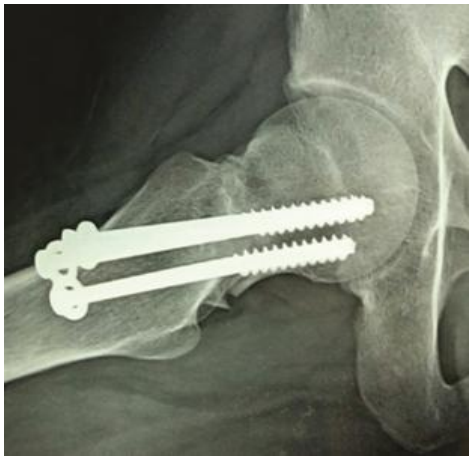
Pre op xray



Pre op xray



Post op xray



Post op xray

6 months follow up

6 months follow up

Follow up range of motion photographs

DISCUSSION

The femoral neck fracture is the most common skeletal injury, occurring with minor trauma in the osteoporotic bone of elderly patients. In younger patients, usually with a high energy trauma.

The management of this fracture has evolved significantly

- Closed reduction and immobilization in POP hip spica in abduction and internal rotation (Whitman abduction plaster) in the early part of 20th century [16,17]. High incidence of non-union, AVN, bedsores and respiratory complications led to exploration of methods of internal fixation.

- The introduction of SP Nail brought a new aspiration of solving the problem, but high failure and complication rates disappointed many surgeons.

- Further improvement in implant designs brought a newer designs like SP nail plate and McLaughlin nail plate which did not the withstand the test of time.

- The modern concepts of fixation under compression led to the use of partially threaded cancellous screws and placement over preliminary wires led to the development of cannulated variety of screws, which are now the standard of care in adults. Smooth pins (Moore or Knowles pins) are still the choice for children.

The presentation at different ages possess different problems related to the management. The issues are fixation failure in osteopenic bone of the elderly, marked displacement of fragments, posterior comminution and disruption of blood supply in young adults and a higher incidence of AVN and non union young adults.

The blood supply to the femoral head is derived from from primarily from three sources, medial femoral circumflex artery and lateral femoral circumflex artery through the extracapsular arterial ring formed at the base of neck of femur and subsequently through intracapsular terminal branches which run parallel to the neck and obturator artery via the artery of ligamentum teres. A femur neck fracture is considered a vascular injury to the femoral head as it disrupts the terminal vessels(the retinacular arteries) which lie in close conjunction to the femoral neck. It is an intracapsular fracture which exposes it to synovial fluid which had factors neovascularization. Moreover sue to action of theses surrounding musculature and fracture pattern a high degree of sheering strain is subjected to it. Hence, proper anatomical reduction and secure internal fixation are of paramount importance in its treatment.

The treatment of fracture neck of femur with anatomical reduction, early and stable fracture fixation using cannulated screws has been found to give a high proportion of excellent and good results [6,8,40]. This study supports these conclusions.

In the current study, we have 30 adults with fracture neck of femur who were operated upon. Follow up was done for 6 months for all patients.

STATISTIC RESULTS OF SURGERY:

- Most of the cases (70%) were operated in the first 12 hours.
- All the cases were operated under spinal anaesthesia.
- On an average the duration of surgery was one hour.

1. **AGE DISTRIBUTION:** In our study fractures were commoner (55%) in the 31-50 age group with mean age being 41.3 years. The findings in our stuidy are comparable to those in a study by Christopher Koo Chee Han et al[40].

Table 20 : Age distribution comparison

Study	No. of cases	Mean age (in years)
Vijay V et al[50]	25	50(20-90)
Dincel Y M et al[51]	67	46.5(18-75)
Christopher Koo Chee Han et al[40]	53	42.1(6-91)
Present study	30	41.3(24-65)

2. **SEX DISTRIBUTION:** Our series had a male predominance with 70% and male:female ratio of 2.33:1. The findings are comparable to the studies by Christopher Koo Chee Han et al and Vijay V. The male preponderance in our series can be accredited to the cause of fracture mainly being RTA.

Table 21: Sex distribution comparison

Study	No. of male:female	Male:Female
Vijay V et al[50]	30:34	2.57:1
Dincel Y M et al[51]	39:28	1.3:1
Christopher Koo Chee Han et al[40]	39:14	2.7:1
Present study	21:9	2.33:1

3. **GARDEN'S TYPE OF FRACTURE:** In our study, Garden's classification system was used for operative evaluation. The most common type of injury was type II, 15 cases (50%) followed by type III , 8 cases(26.66%).

Table 22: Fracture type comparison

Study	Garden type I & II	Garden type III & IV
Vijay V et al[50]	11	14(56%)
Dincel Y M et al[51]	30(44.7)	37(55.3)
Christopher Koo Chee Han et al[40]	17(32.1)	36(67.9)
Present study	18(60)	12(40)

4. **FUNCTIONAL RESULTS:** The functional results in our study were calculated using the Modified Harris Hip Score. The score was calculated at each follow-up and the functional result was based on the score at the final follow-up. The functional results of the present study were comparable with that of Vijay V et al with 73.33% excellent results, 20% having good results and fair results in 6.66%.

Table 23: Functional results comparison

Study	Excellent (%)	Good (%)	Fair (%)	Poor (%)
Vijay V[50]	18(72)	4(16)	2(8)	1(4)
Christopher Koo Chee Han et al[40]	41(93.2)	0	2(4.5)	1(2.27)
Present study	22(73.33)	6(20)	2(6.66)	0

5. **UNION DURATION AND RATE:** In our study, the average time taken for union was 15weeks. Most of the case showed union in 12weeks (17 patients). No patient had non union. The findings of the present study were comparable with that of Christopher Koo Chee Han et al.

Table 24: Union duration and rate comparison

Study	Weeks	No. of union(%)	Non union
Vijay V et al[50]	-	24(96)	1
Dincel Y M et al[51]	24	64(95.52)	3(4.47)
Christopher Koo Chee Han et al[40]	14.96	52(98.11)	1(1.89)
Present study	15	30(100%)	Nil

6. **TIME INTERVAL BETWEEN INJURY AND SURGERY:**

In our study, most of the cases were operated within the first 12 hours of the trauma, 18 cases(60%).

Table 25: Time elapsed between trauma and surgery comparison

Study	<12 hours(%)	>12 hours(%)
Vijay V et al[50]	Nil	25(100)
Dincel Y M et al[51]	67(100)	Nil
Christopher Koo Chee Han et al[40]	25(47.17)	28(52.83)
Present study	18(60)	12(40)

7. **COMPLICATIONS:** The complications seen superficial infection and backing out of screws. In our study further follow up is necessary to evaluate the incidence of AVN. All patients were able to carry out their daily activity with minimal or no discomfort. 4(13.33%) patients in our study had screw backout and superficial infections.

Table 26: Complications comparison

Study	AVN(%)	Non union(%)	Superficial infection (%)
Vijay V et al	2(8)	1(4)	1(4)
Dincel Y M et al	3(4.477)	3(4.477)	0
Christopher Koo Chee Han et al[45]	9(16)	2(3.7)	0
Present study	-	0	4(13.33)

Preservation of the femoral head with internal fixation is desirable in younger and more active patients with a femoral neck fracture. A healed femoral neck fracture, without the development of osteonecrosis, leads to a good functional outcome[40,70]. Eventual good outcomes after fixation are dependent on:

- The factors under surgeon's control such as quality of reduction, stable fixation and timing of surgery
- Factorts not under surgeon's control such as initial fracture displacement and disruption of femur head blood flow and patients presenting late[71].

Swiontkowski[6,8] stated that early fixation, ideal reduction the most important factors for successful surgery, and should be done in 12 h. In our study most of the fractures(60%) were fixed within 12 hours and the final results in all but one case were excellent. The other case had a good result at last follow up.

Jain et al[5], in their study compared the functional outcome of femur neck internal fixation within 12 hours and after 12 hours in patients under 60 years of age over a follow up period of 2 years and they did not find any significant difference in the outcome. Our study confirmed the same as there was no difference in the outcome of patients operated early(<12 hours) and late (>12 hours). Functional results are similar in both groups.

Placement of the screw is also of paramount importance. Inverted triangle with apex inferior is preferred as there will be less stress raiser affect and decreases the subsequent chances of subtrochanteric fracture. The screws should be placed as far as possible from one another close to the cortical bone of femoral neck. Screws should be parallel with unacceptation of not more than 10 degree angulation between them. Screws tips should be within 5mm of subchondral bone.[43]

In our study early non weight bearing ambulation was allowed with the help of a walker strictly for 8 weeks. Partial weight bearing was allowed following 8 weeks and full weight bearing was allowed once radiological signs of union were seen. The normal hip range of motion was restored in almost all cases.

The superior rate of fracture healing in the study was attributed to the good bone quality and healing potential of the femoral head and neck of most young patients and due to early fracture fixation.

The limitations of our study include small size of the study group, short follow up which was not enough to evaluate and comment on the incidence of AVN. The study require further follow up to comment on incidence of AVN.

The treatment of fracture neck of femur in adults with anatomical closed reduction stable internal fixation using cannulated cancellous screw was found to give a satisfactory proportion of excellent and good results [6,8,40]. This study supports these conclusions and the results were comparable with those in the other studies.

CONCLUSION

In the study, 30 cases of fracture neck of femur were treated surgically by closed reduction and internal fixation with cannulated cancellous screws.

Conclusions of our study are:

- These injuries are common in middle aged men attributed to RTA
- Age groups between 31-50 years were most commonly injured. The mean age of present study was 41.3 years
- Majority of them were Garden's Type II fractures.
- Osteonecrosis of femoral head and nonunion are the two most challenging complications as reported. In our study, there were no cases with non-union and the follow-up period was too short to evaluate for AVN. The factor that plays an important role is the initial fracture displacement causing disruption of femur head blood supply.
- The other factors that play a role include early diagnosis, proper anatomical reduction and stable fixation.
- Early diagnosis, prompt fixation with proper reduction and internal fixation with cancellous screws gave excellent results in this study.
- In our study, open reduction was not done for any case.
- Early non-weight bearing ambulation was allowed for all cases followed by partial weight bearing ambulation after 8 weeks and full weight bearing

ambulation when radiological signs of union were visible following 12th week follow up.

- The functional outcomes were satisfactory in 93.33% cases with Excellent in 73.33% and Good in 20% as per the Modified Harris Hip scoring system.
- We had only two cases of fair results (6.66%) at the final follow-up.
- Our study had superficial infection and backing out of screws in 4 patients(13.33%) and most patients had satisfactory functional outcome at their final follow up.
- There was no significant difference in the outcome between patients operated within 12 hours and those operated between 12-48 hours.

Hence we could conclude that, fracture neck of femur in young adults treated surgically by closed reduction and fixation with cannulated cancellous screw fixation gave excellent to good functional outcome in 93.33%. Hence this would be the best procedure for management of fracture neck of femur in adults under 65 years of age even for displaced fractures and the review of data and our study all point to the fixation of fracture as early as possible to avoid poor results.

SUMMARY

30 patients of fracture neck of femur in young adults were treated surgically by CRIF with cannulated screws at RL Jalappa Hospital attached to Sri Devaraj Urs Medical College and Research Institute, Kolar. All the patients were evaluated with follow up period of 6 months.

1. The anatomy, classification, clinical features, review of literature and methods and surgical management have been described out.

2. The age distributions was 24 to 65 years (average – 41.3 years), majority of them were in the age group 31-50 years.

3. More common in male (70%) compared to females (30%). This is attributed to the more activity and indulgence in RTA among men.

4. There was difference in the laterality of fracture. Right side were more common than left side.

5. Most common mode of injury was Road traffic accident (70%) followed by fall (30%).

6. According to Garden's classification, Type I is seen in 3(10%) and Type II is seen in 15 cases (50%), Garden Type III in 8 cases(26.66%) and TypeIV in 4(13.33%).

7. Timing of surgery in our study did not affect the overall outcome in our short period of follow up. Most of the cases (60%) were operated under 12 hours.

8. We used 3 screws in all 30 patients.

9. Average time taken for fracture union was 15 weeks.

10. There were 6 patients with associated injury that were treated appropriately with good results.

11. The operative results were excellent to good in most of the cases.

12. Our study had complications namely superficial infections, backing out of screws and restricted movement. Infection was treated with proper antibiotics and hip range of motion physiotherapy was given to patients with restricted movements.

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PROFOMA

Name : Case no :

Age : Ip no :

Sex : Doa :

Address : Dos :

Occupation : Dod :

Diagnosis :

Chief complaints :

History of presenting illness :

- Mode of the injury- Road traffic accidents , fall , assault ,sports injuries

Past history :

Family history:

Personal history:

General physical examination:

Vital signs	Systemic examination
BP	CVS
RR	RS
PR	CNS
Temperature	PA

Local examination:

- Inspection-

1. Attitude
2. swelling
3. deformity
4. wounds
5. others

- Palpation-

1. Local rise of temperature
2. tenderness
3. abnormal mobility
4. crepitus

.

- Measurements –

- Length of the lower limb Right Left

- Movements - HIP

1. flexion
2. extension
3. adduction
4. abduction

5. internalrotation
6. external rotation

- Distal neuro vascular status – femoral artery

  -Sensory disturbances -Motor disturbances

- Associated injuries

Investigations:

Blood :

Haemoglobin	TLC
ESR	DC
RBS	Blood urea
S.creatinine	HIV
Sodium	HbsAg
Potassium	

Urine: Albumin, Sugar

ECG:

Radiography: X-raysof hip and femur Antero-posterior and Lateral views

Treatment:

Preoperative-skin traction
-Antibiotics:
-Analgesics:

Type of anaesthesia: general /spinal

Surgical procedure-
-Duration of surgery

Additional procedures

Intra-operative complications

Postoperative
- Antibiotics
-Check x-rays
-Complications

Revision procedures
-Secondary procedures

FOLLOW UP:

	Radiographs	Modified Harris Hip Score
AT 1 MONTH		
AT 3 MONTH		
AT 6 MONTH		

CONSENT FORM FOR SURGERY

Chief researcher/ PG guide‘s name: Dr. NAGAKUMAR J.S.

Principal investigator: Dr. ABHIMANYU SINGH

Name of the subject:

Age:
Address:

I_____ in my full senses here by give my complete consent for cannulated cancellous screw fixation for ____ femur neck fracture,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

PATIENT INFORMATION SHEET

Study title: A study of functional outcome of fracture neck of femur managed by cannulated cancellous screws.

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

Aim- To record the functional outcome of fracture neck of femur using cannulated cancellous screws.

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

Patient with fracture neck 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, radiological 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. ABHIMANYU SINGH

Mobile no: 8077075535

E-mail id: rusty7mac.as@gmail.com

KEY TO MASTER CHART

SI- serial

No- number

Hosp: hospital

RTA: Road traffic accident

b/w: between

int: interval

F: female

M: Male

R: Right

L: Left

Sx: Surgery

COMPLICATIONS:

1: Superficial infection

2: Backing out of screws

3: Restricted movements

MASTER CHART

Sl.no	Hosp no	age	sex	Mode of injury	Side affected	Garden's classification: Type	Anatomic location of fracture	Time int b/w trauma and SX (in hours)	Reduction	Time of union (in weeks)	Complications	Harris Hip Score at 1 month	Harris Hip Score at 3 months	Outcome by 3 months	Harris Hip Score at 6 months	Outcome by 6 months
1	309742	35	M	RTA	R	3	Transcervical	14	closed	12	Nil	78	84	Good	92	Excellent
2	349759	30	M	RTA	L	4	Tanscervical	17	closed	16	1,2	72	78	Fair	86	Good
3	380737	26	M	RTA	L	3	Transcervical	9	closed	12	Nil	84	92	Excellent	100	Excellent
4	436694	55	M	RTA	R	2	Subcapital	22	closed	24	1,3	72	70	Fair	76	Fair
5	249099	24	M	FALL	R	2	Subcapital	6	closed	16	Nil	86	92	Excellent	100	Excellent
6	468785	34	F	FALL	R	2	Transcervical	7	closed	12	Nil	82	90	Excellent	96	Excellent
7	472012	41	M	RTA	L	4	Transcervical	20	closed	12	Nil	76	82	Good	90	Excellent
8	471906	60	F	FALL	R	2	Transcervical	36	closed	24	2,3	68	74	Fair	78	Fair
9	485046	38	M	FALL	L	2	Transcervical	14	closed	24	Nil	84	98	Excellent	100	Excellent
10	531007	46	M	RTA	R	2	Transcervical	9	closed	12	Nil	88	94	Excellent	100	Excellent
11	536430	41	F	RTA	L	2	Subcapital	12	closed	16	Nil	74	80	Good	88	Good
12	537762	55	F	FALL	R	2	Transcervical	48	closed	24	2,3	88	92	Excellent	100	Excellent
13	520340	34	M	RTA	L	3	Basicervical	12	closed	12	Nil	86	94	Excellent	100	Excellent
14	543738	34	F	RTA	R	3	Transcervical	17	closed	12	Nil	74	82	Good	88	Good
15	546420	28	M	RTA	R	2	Subcapital	18	closed	16	Nil	90	96	Excellent	100	Excellent
16	480967	48	M	RTA	R	3	Transcervical	12	closed	12	Nil	90	94	Excellent	100	Excellent
17	578648	65	M	FALL	R	2	Subcapital	6	closed	12	1,	88	94	Excellent	100	Excellent
18	626277	40	F	RTA	R	2	Transcervical	5	closed	12	Nil	92	96	Excellent	100	Excellent
19	627203	48	M	RTA	R	1	Transcervical	17	closed	16	Nil	74	78	Fair	86	Good

20	609378	40	M	FALL	R	3	Transcervical	12	closed	12	Nil	88	92	Excellent	100	Excellent
21	619163	49	M	RTA	L	2	Basicervical	6	Closed	24	Nil	90	96	Excellent	100	Excellent
22	627758	53	M	FALL	L	2	Transcervical	14	closed	12	Nil	80	84	Good	88	Good
23	641702	45	M	RTA	L	2	Transcervical	12	closed	16	Nil	86	90	Excellent	100	Excellent
24	643081	32	F	RTA	R	1	Transcervical	6	closed	12	Nil	84	92	Excellent	100	Excellent
25	650601	46	M	FALL	L	3	Transcervical	6	Closed	16	Nil	88	94	Excellent	100	Excellent
26	650715	46	F	RTA	R	4	Transcervical	10	closed	12	Nil	90	94	Excellent	100	Excellent
27	653345	38	M	RTA	L	1	Basicervical	26	closed	12	1,2	72	74	Good	86	Good
28	653406	30	F	RTA	R	3	Transcervical	10	Closed	12	Nil	86	94	Excellent	100	Excellent
29	654923	41	M	RTA	R	2	Subcapital	9	Closed	12	Nil	90	96	Excellent	100	Excellent
30	655011	37	M	RTA	L	4	Transcervical	9	closed	24	Nil	92	96	Excellent	100	Excellent