INTRODUCTION

Femoral neck fractures have been proven to be serious injuries that are associated with high mortality and significant morbidity in the elderly. The incidence increased since 1960s and is expected to increase more with increased life expectancy.[1,2] Despite advances in surgical hardware and techniques, these injuries still pose a significant challenge.[3]

There are many treatment options ،including parallel cancellous lag screws, sliding hip screw, Austin-Moore (AM) hemiarthroplasty, Thompson hemiarthroplasty, bipolar or unipolar modular hemiarthroplasty and THR.[4]

Bipolar prosthesis consists of a prosthesis-acetabular articulation and a femoral head–polyethylene articulation. It was introduced in the 1970s in an effort to avoid acetabular erosion. The prosthesis-prosthesis articulation theoretically decreases acetabular wear by shifting some hip movement away from the acetabulum to the internal prosthesis-prosthesis articulation.[5]

While there have been many changes in implant designs and biomaterials, surgical approaches have remained relatively unchanged over the years.[6,7]

A variety of surgical approaches have been utilized for the performance of hip arthroplasty; these include anterior, anterolateral, direct lateral, transtrochanteric, and posterior techniques. [6,7]

Von Langenbach first described the posterior approach for hip arthroplasty in 1874. According to Tronzo, at least 13 distinct variations of posterior approaches to the hip have been described (including those by Kocher, Gibson, and Moore). [8,9]

In response to the evolution of minimally invasive procedures such as angioplasty, laparoscopic abdominal surgery, and arthroscopy, orthopaedic surgeons have expressed an increased interest in minimally invasive surgical approaches (MIS) to hip arthroplasty more than 15 years ago, which had led to the appearance of specific instruments and surgical techniques. All of this has resulted in a reduction in the size of incisions, allowing at the same time sufficient exposure for appropriate component placement. Inspite of the advances made, there persists a controversy regarding the definition of this technique and the results it can afford.[10-12]

Minimally invasive approaches, defined as less invasive to the skin, muscles and bone, reduce complications and potentially improve recovery time. Benefits also include less bleeding, lower morbidity, less post-operative pain and more cosmetic. Minimally invasive surgery represents one of the most recent techniques to have emerged within hip hemiarthroplasty.[13-15]

Minimizing the recovery process is becoming increasingly desirable in a society that demands an individual to return to normal activities after a short recovery; with MIS-hip replacment techniques most patients (more than 80%) were discharged to their homes within 24 hours or less of their surgery, according to a report made at the annual meeting of the American Orthopedic Association (AOA).[16-20]

On the other hand, that reduced visibility can only increase the risk of early complications, which also makes implant positioning more haphazard. There have been few prospective and comparative publications to date.[21-26]

This thesis reported the results of a comparative and prospective study on a series of patients operated on via the conventional posterior approach and a series of patients operated on using a minimally invasive posterior approach.

REVIEW OF LITERATURE

Anatomy of the upper end of femur:

The hip joint is a multi-axial ball and socket joint (spheroidal joint). The femoral head articulates with the cup shaped acetabulum. The articular surfaces are reciprocally curved and are neither co-existent nor completely congruent. The surfaces are considered spheroid or ovoid rather than spherical, the proximal end of femur consists of femoral head, neck, greater trochanter and lesser trochanter.[27]

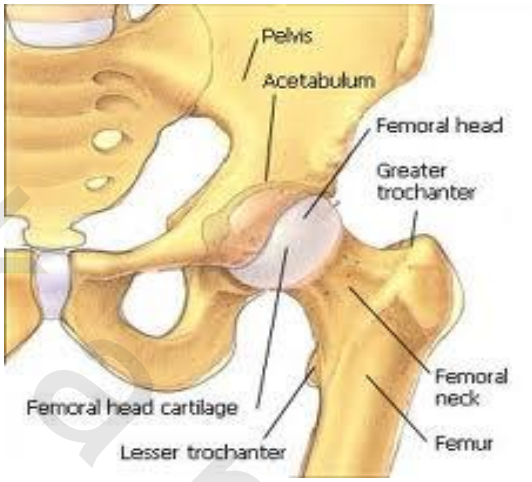

Fig. (1): Anatomy of the upper end of femur[27]

The head:

The femoral head forms two thirds of a sphere, arising from femoral neck. It is directed upwards medially and slightly forwards, and has an axis normally parallel to that of the neck. The surface of the femoral head is covered with articular cartilage, about 4 mm in thickness over the superior portion and 3 mm at the equator. The equatorial plane of the femoral head is virtually circular; however the radii of the meridians that are perpendicular to the equator are longer, differing in length according to their location. For example, the radius of the superior meridian is larger than the anterior and posterior meridians. This lack of roundness is greater in males than in females. The anatomic center of femoral head rotation in the hip joint is the center of the femoral head. It is usually located perpendicular to the axis of the femoral shaft on a line opposite the hip of the greater trochanter. [28]

The neck:

The neck is embryologically a continuation of the shaft. It has two rounded borders; the upper border is nearly horizontal and is gently concave upwards. The lower border is straight but oblique, and is directed downwards, laterally and backwards to meet the shaft near the lesser trochanter. The head of the femur overlaps the neck cortex but projects most prominently posteriorly as does the greater trochanter and its crest. The neck possesses a thick cortex anteriorly and laterally, posteriorly the calcar femorale reinforces the neck, a thin fragile angulated cortex is left at the junction of the head and neck medially and

laterally where the neck joins the trochanter crest, these are classic sites for femoral neck fractures. (28)

The longitudinal rotatory axis of the femur passes from the center of the head to the region of the intercondylar notch when the proximal femur is intact, the course of the axis is outside the upper two thirds of the shaft. Dissolution of the femoral neck displaces the axis of rotation laterally into the marrow cavity of the shaft. This immediately converts all muscles passing from the pelvis to the linea aspra and lesser trochanter into uninhibited external rotators. They unwind the femoral shaft into external rotation. Compression forces on this axis, whether due to muscle action or direct contact will collapse and comminute the posterior cortex at its two weak area(at the junction of the head and neck and laterally where the neck joins the trochantric crest) after failure of the thick anterior cortex. (28)

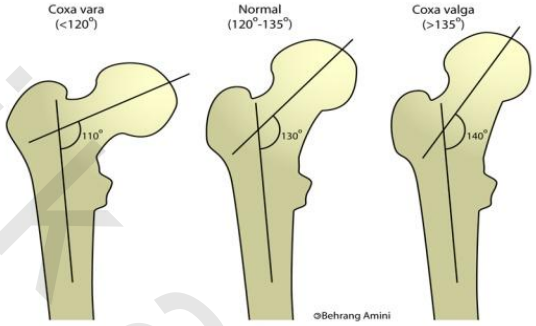

Fig. (2): Femoral neck shaft angles**.** (28)

The greater trochanter:

The greater trochanter is the site of insertion of abductors. Both femoral head and the greater trochanter are originally part of the same epiphyseal mass in which two separate secondary centers of ossification form. Growth disturbances at the capital femoral epiphysis causes a coax vara, while growth arrest of the growing greater trochanter produces coax valga. It projects up and back from the convexity of the junction of the neck and shaft. Its upper border is projected into the apex posteriorly; this carries the upper part of the attachment of gluteus medius. Piriformis is attached here and spreads forward along the upper border deep to gluteus medius. More anteriorly the medial surface of the upper border shows smooth facets for the tricipital tendon of the obturator internus and gemelli. The apex of the trochanter overlies a deep pit, the trochantric fossa. The bottom of the pit is smooth for the attachment of obturator externus tendon. The anterior surface of the greater trochanter shows a J-shaped ridge for the gluteus minimus tendon. The lateral surface shows a smooth strip, 1 cm wide for the tendon of gluteus medius. Posteriorly the apex of the greater trochanter is continued down as the prominent trochantric crest to the lesser trochanter. Quadratus femoris is attached here and vertically down to a level that bisects the lesser trochanter. (29)

The lesser trochanter:

The lesser trochanter lies back on the lowest part of the neck. Its rounded surface facing medially is smooth for reception of the psoas tendon. Iliacus is inserted into the front of the tendon and into the bone below the lesser trochanter. (30)

Internal architecture of the upper end of femur:

It has long been recognized that the cancellous bone of the upper end of the femur is composed of bone trabeculae disposed into two arches intersecting each other at right angles. These trabeculae correspond in the position of trajectories of maximum compression and tension stresses in Fairbank crane (a curved cantilever approximating the shape of the upper end of the femur). The transmission of weight from the head of the femur to the shaft determined the arrangement of trabeculae in the upper end of the femur. Thus it can be concluded that the trabeculae in the upper end of the femur of a normal individual are arranged along lines of compression and tension stresses produced in the bone during weight bearing. This arrangement ensures maximum strength with the available material. [31]

The trabeculae are divided into the following 5 groups: [31]

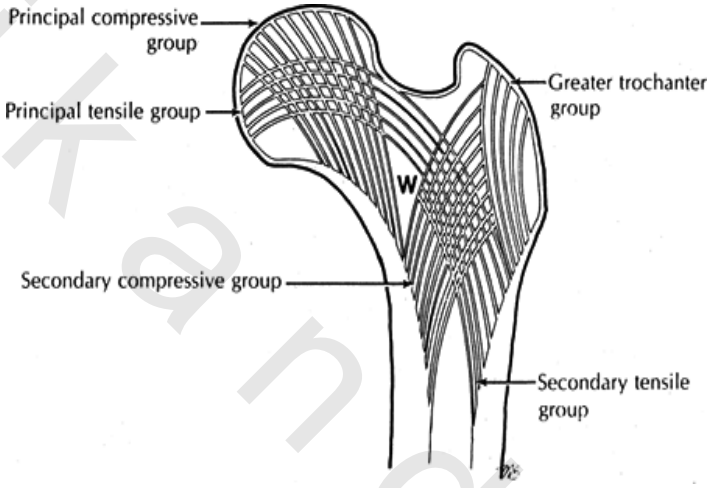

Fig. (3): Trabeculae of the upper end of femur. [31]

1. Principal compression group:

The upper most compression trabeculae that extend from the medial cortex of the shaft to the upper portion of the head of femur, in slightly curved radial lines these are some of the thickest and most closely packed trebeculae in the upper end of femur.

2. Secondary compressive group:

The rest of compression trabeculae that arise from the medial cortex of the shaft. These arise below the principal compressive group and curve upwards and laterally towards the greater trochanter and the upper position of the neck. The trabeculae of this group are thin and widely spaced.

3. Greater trochanter group:

Some slender and poorly defined tensile trabeculae which arise from lateral cortex just below the greater trochanter and sweep upwards to and near its superior surface.

4. Principal tensile group:

Trabeculae which spring from lateral cortex immediately below the greater trochanter group. These trabeculae, which are the thickest amongst tensile group, curve upwards and inwards across the neck of the femur, to end in the inferior portion of the femoral head.

5. Secondary tensile group:

Trabeculae which arise from the lateral cortex below the principal tensile trabeculea. The trabeculae of this group arch upwards and medially across the upper end of the femur an end more or less irregularly after crossing the midline.

In the neck of femur, the principal compressive, the secondary compressive, and the tensile trabeculae enclose an area containing some thin and loosely arranged trabeculae, this is called Ward's triangle, other two triangle are underneath the superior and inferior head-neck junctions respectively. These two triangles are part of the circular subcapital tunnel that houses a vascular anastomosis. [32]

Singh index:

It may be used as a general indication of the degree of osteoporosis present in the proximal femoral fragments as noted on the initial x-rays. [33]

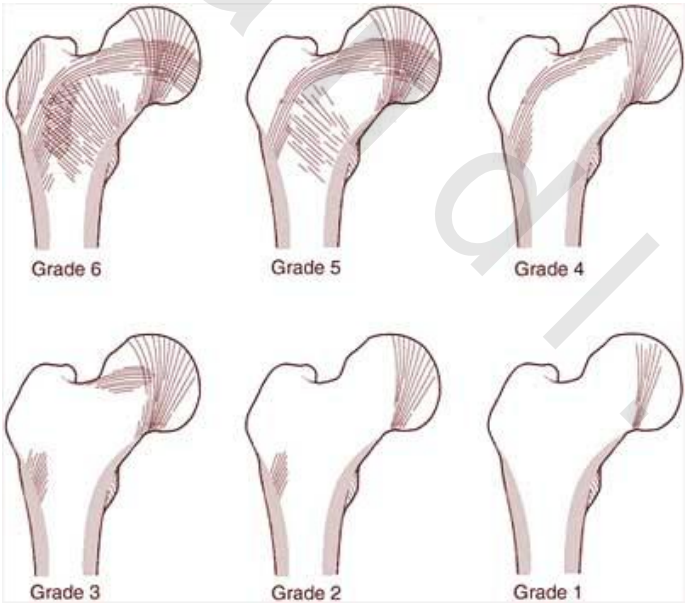

Fig. (4): Singh index. [33]

Grade VI:

- All normal trabecular groups are visible.
- Upper end of femur seems to be completely occupied by cancellous bone.

Grade V:

- Principal tensile & principal compressive trabeculae is accentuated.
- Ward's triangle appears prominent.

Grade IV:

- Principal tensile trabeculae are markedly reduced but can still be traced from lateral cortex to upper part of the femoral neck.

Grade III:

- There is a break in the continuity of the principal tensile trabeculae opposite the greater trochanter.
- This grade indicates definite osteoporosis.

Grade II:

- Only principal compressive trabeculae stand out prominently.
- Remaining trabeculae have been essentially absorbed.

Grade I:

- Principal compressive trabeculae are markedly reduced in number and are no longer prominent.

Calcar femorale:

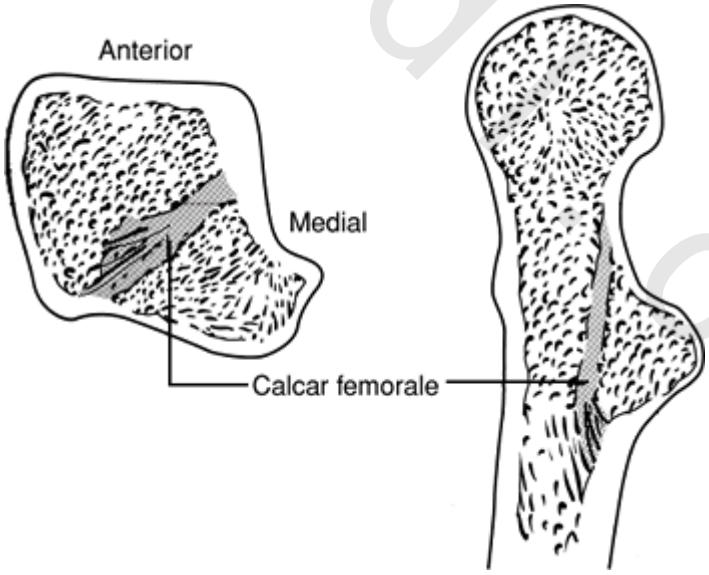

Fig. (5): Calcar femorale. [34]

It is a vertical laminated plate of condensed bone fanning laterally from the medial cortex toward the gluteal tubercle. Proximally it blends with the posterior cortex of the neck, and distally beyond the lesser trochanter it fuses with the postero-medial shaft. The thick walled tubular shaft pattern is interrupted by the posterior projection of the thin walled lesser trochanter and the trochanter crest. The calcar femorale represents the original cylindrical shaft, strives to maintain the tubular outline and counteract the postero-inferior forces of the external rotators, x-ray films taken at right angle to the neutral axis of the femoral neck best portray the calcar femorale, which stands out like a slid bone spur. It appears that the calcar femorale is best developed during early adulthood and then gradually atrophies, however, it always remains present. [34]

Dorr classification:

Dorr had developed indexes to characterize proximal femoral configuration. The Dorr index is a ratio of the canal diameter at the level of the lesser trochanter to the canal diameter at a point 10 cm distal. [35]

The Dorr classification of proximal femoral morphology:

Type A (champagne fluted)

Type B (funnel shaped)

Type C (cylindrical shape)

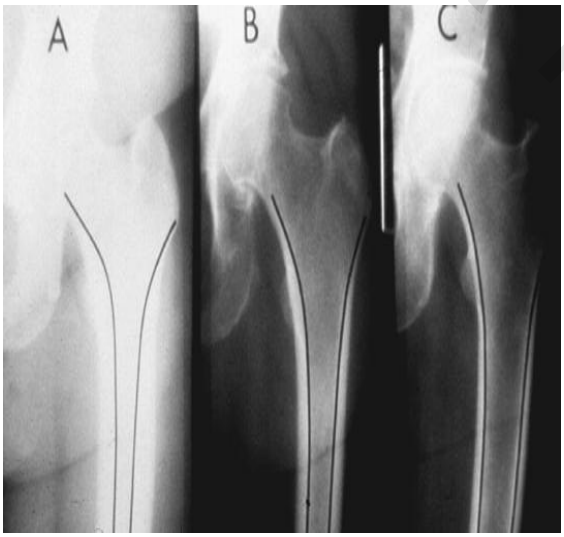

Fig. (6): Dorr classification. [35]

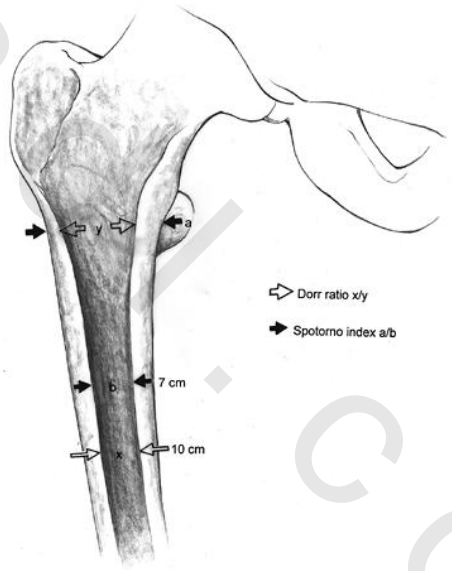

Fig. (7): Dorr index. [35]

Femoral anteversion :

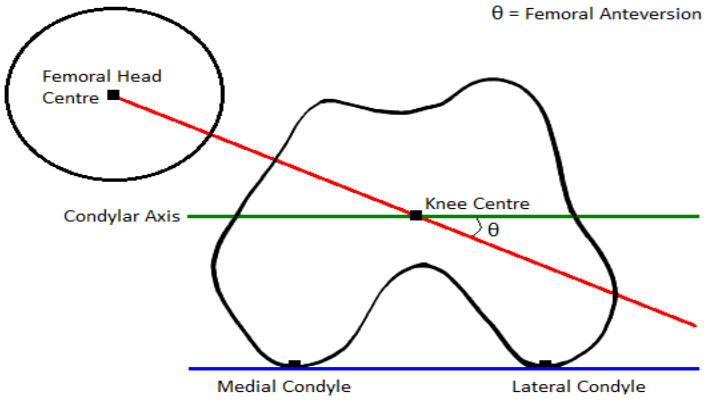

Fig. (8): Femoral anteversion. (36)

Femoral neck anteversion (FNA) describes the normal torsion or twist present in the femur. Femoral neck anteversion is defined as the angle between an imaginary transverse line that runs medially to laterally through the knee joint and an imaginary transverse line passing through the center of the femoral head and neck. In adults without pathology, the femur is twisted so the head and neck of the femur are angled forward between 15 and 20 degrees from the frontal plane of the body. (36)

Capsule of the hip :

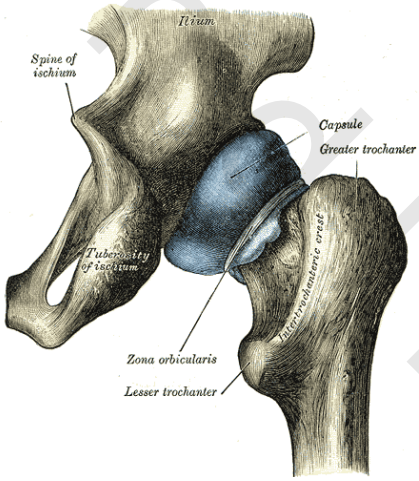

Fig. (9): Capsule of the hip joint. (37)

The articular capsule of the hip is strong and dense, contributing substantially to joint stability. The capsule is attached along the anterior and posterior periphery of the acetabulum just outside the acetabular labrum. Making anterior and posterior incisions between the capsule and labrum allow retractors to be placed safely over the anterior and posterior columns. Inferiorly, the capsule is attached to the transverse acetabular ligament. The capsule is attached to the femur anteriorly along the intertrochanteric line, but posteriorly it has an arched free border that results in only partial covering of the femoral neck. The femoral neck is intracapsular anteriorly, but posteriorly the basicervical portion and intertrochanteric crest are extracapsular. Most of the fibers of the capsule are

longitudinally orientated as they traverse from the pelvis to the femur, except for the circular fibers of the zona orbicularis located posteriorly and inferiorly. Two strong accessory ligaments, the iliofemoral and the pubofemoral ligaments, reinforce the anterior portion of the capsule. The ischiofemoral ligament reinforces the posterior capsule. (37)

Acetabular labrum:

It is a fibroacartilagenous rim attached to the acetabular margin, deepening the cup. It is triangular in cross section and its base is attached to the acetabular rim with the apex as the free margin. It bridges the acetabular notch as the transverse acetabular ligament, under which vessels and nerves enter the joint. (38)

Ligaments of the hip:

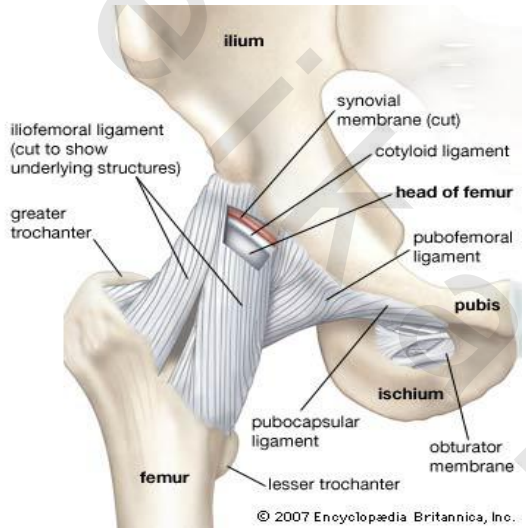

Fig. (10): Anterior view of hip ligament.(39)

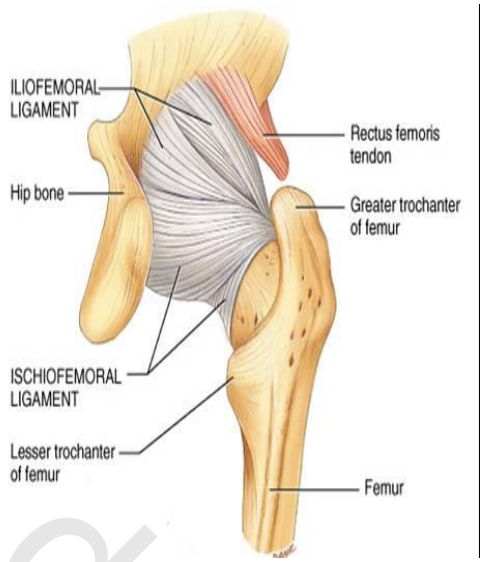

Fig. (11): Posterior view of hip ligament.(39)

1- **The iliofemoral ligament** often referred to as the Y ligament of Bigelow is a fan-shaped ligament that resembles an inverted letter Y. The apex of the ligament is attached to the lower portion of the anterior inferior iliac spine, and the diverging fibers of the Y fan out to attach along the intertrochanteric line. The fibers of the iliofemoral ligament become taut in full extension, providing a check to hip extension beyond neutral. The superior portion may resist excessive external rotation. When this ligament is contracted, a flexion/internal rotation contracture may result, requiring release at total hip arthroplasty. It is particularly important to correct this internal rotation contracture if a posterior approach to the hip is done (otherwise a tendency toward hip internal rotation will result). An anterolateral approach may be preferred as it will perforce release this contracture. (39)

2- **The pubofemoral ligament** is applied to the inferior and medial part of the anterior capsule. It arises from the pubic portion of the acetabular rim and the obturator aspect of the superior pubic ramus, passing below to the neck of the femur to blend with the inferior-most fibers of the iliofemoral ligament. The fibers of the pubofemoral ligament become taut in hip extension and abduction. In trying to correct a hip

adduction contracture at arthroplasty, these fibers may need to be released to provide for adequate hip abduction. (39)

3- **The ischiofemoral ligament** reinforces the posterior surface of the capsule. It arises from the ischial portion of the acetabular rim. Its fibers spiral laterally and upward, arching across the femoral neck to blend with the fibers of the zona orbicularis. The spiral fibers tighten during extension but loosen or unwind during hip flexion. Other fibers traverse horizontally and attach to the inner surface of the greater trochanter, providing a check to internal hip rotation. (39)

The twisted orientation of the capsular ligaments surrounding the hip joint provides for a screw home effect in full extension. Hip extension coils and tightens these ligaments, making extension the close-packed position of the joint and the position of maximum stability. Interestingly, in full extension the articular surfaces of the joint are not in optimal contact. The position of optimal articular contact (flexion, abduction, and external rotation) is the loose-packed position because flexion and lateral rotation tend to uncoil the ligaments. Because the joint surfaces are neither maximally congruent nor close packed, the hip joint is at greatest risk for traumatic dislocation when flexed and adducted. (40)

4- Ligaentum teres:

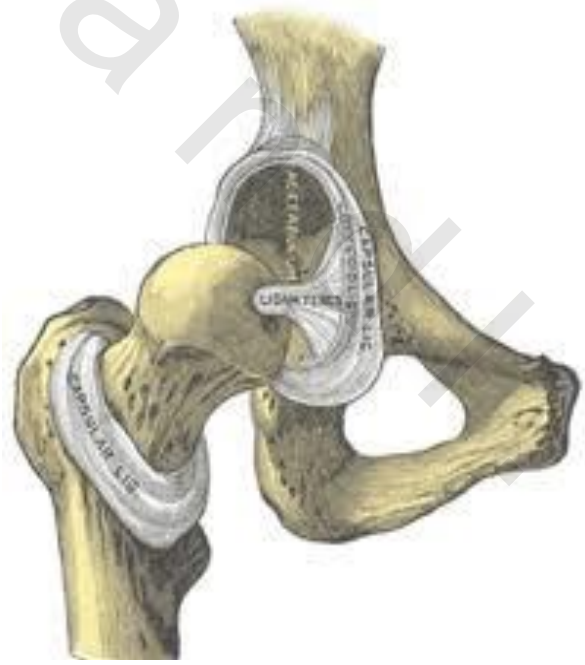

Fig. (12): Ligamentum teres. (41)

It is a triangular flat hand with apex attached to the pit on the femoral head and base on either side of the acetabular notch. It varies in length and sometimes being represented only by a synovial sheath. (41)

Nerve root innervation and function muscles of the hip joint.[42]

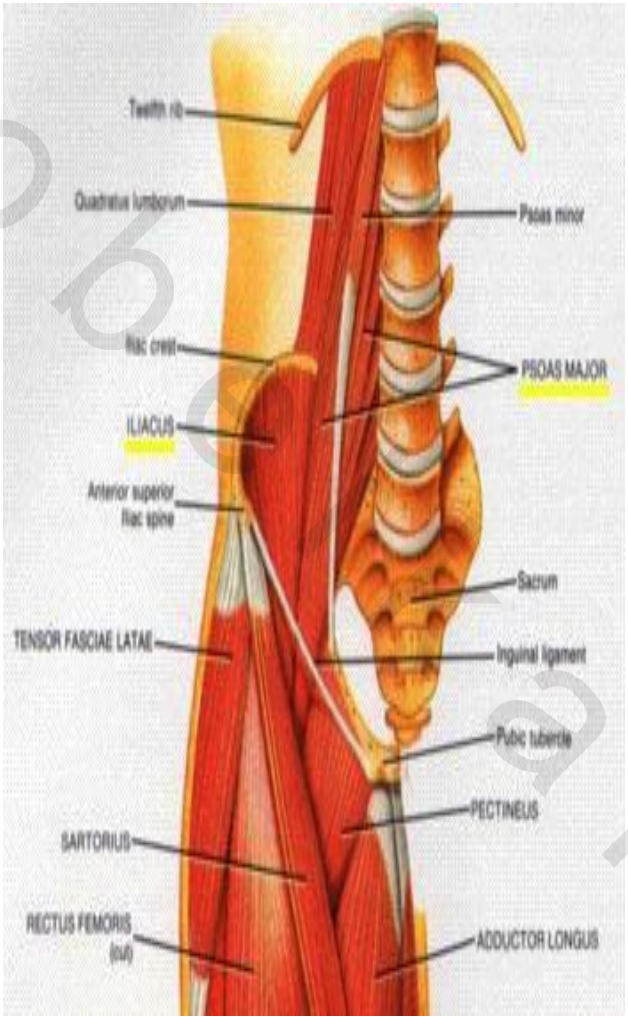

Fig. (13): Flexors of the hip joint. [42]

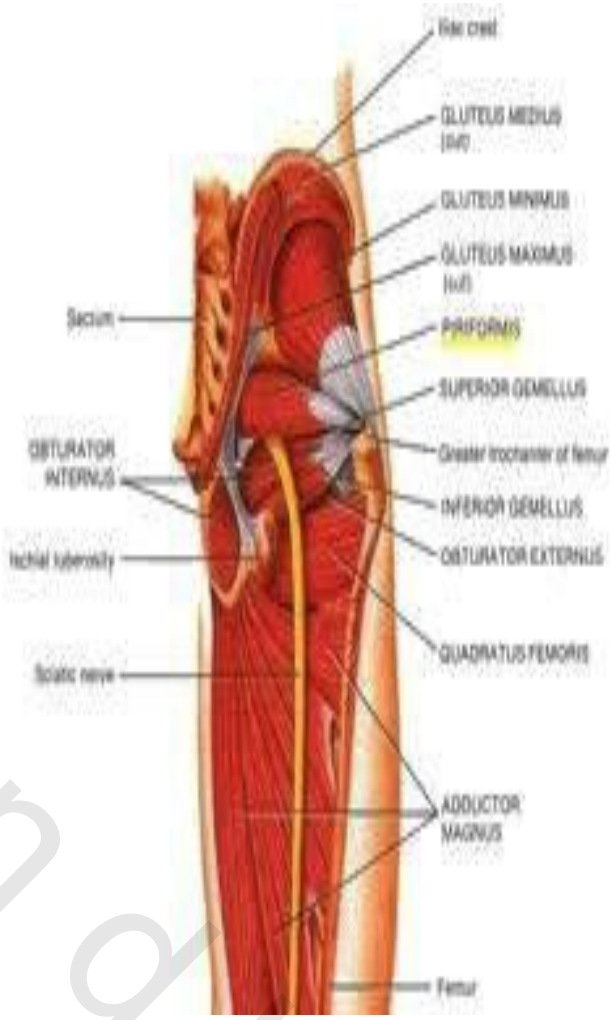

Fig. (14): Rotators of the hip joint. [42]

Table (I): Group muscle nerve supply

Flexors	Iliopsoas	N. to iliopsoas (L2, L3, L4)[a]
	Pectineus	Femoral (L2, L3, L4)[b]
	Rectus femoris	Femoral (L2, L3, L4)[b]
	Sartorius	Femoral (L2, L3, L4)[b]
	Adductors	
	Ant. portion gluteus maximus and minimus	
	Tensor fascia lata	
Extensors	Gluteus maximus	Inferior gluteal (L5, S1, S2)[b]
	Semimembranosus	Tibial (L4, L5, S1)[a]
	Semitendinosus	Tibial (L4, L5, S1)[a]
	Biceps femoris (long head)	Tibial (S1, S2, S3)[a]
	Adductor magnus (ischiocondyle part)	Tibial (L4, L5, S1)[a]
Abductors	Gluteus medius	Superior gluteal (L4, L5, S1)[b]
	Gluteus minimus	Superior gluteal (L4, L5, S1)[b]
	Tensor fascia lata	Superior gluteal (L4, L5)[b]
	Sartorius	
Adductors	Adductor brevis	Obturator (L2, L3)[a]
	Adductor longus	Obturator (L2, L3)[a]
	Adductor magnus (ant. part)	Obturator (L3, L4)[a]
	Gracilis	Obturator (L2, L3)[a]
	Obturator externus	Obturator (L2, L3, L4)[a]
	Pectineus	
	Hamstrings	
External rotators	Piriformis	N. to piriformis (S1, S2)[b]
	Quadratus femoris	N. to quad. femoris and inf. gemellus (L4, L5, S1)[a]
	Inferior gemellus	,,
	Superior gemellus	N. to sup. gemellus and obtur. internus (L4, L5, S1)[a]
	Obturator internus	,,
	Adductor muscles	
	Iliopsoas	
Internal rotators	Gluteus medius	Superior gluteal (L4, L5, S1)[b]
	Gluteus minimus	Superior gluteal (L4, L5, S1)[b]
	Tensor fascia lata	Superior gluteal (L4, L5)[b]
	Semimembranosus	Tibial (L4, L5, S1)[a]
	Semitendinosus	Tibial (L4, L5, S1)[a]
	Pectineus	
	Adductor magnus (post. part)	

N., nerve; ant., anterior; inf., inferior; sup., superior; post., posterior;
quad., quadratus; obtur., obturator. Bold type signifies major contribution to muscle action.
[a]Anterior nerve root division.
[b]Posterior nerve root division.

Vascular anatomy:

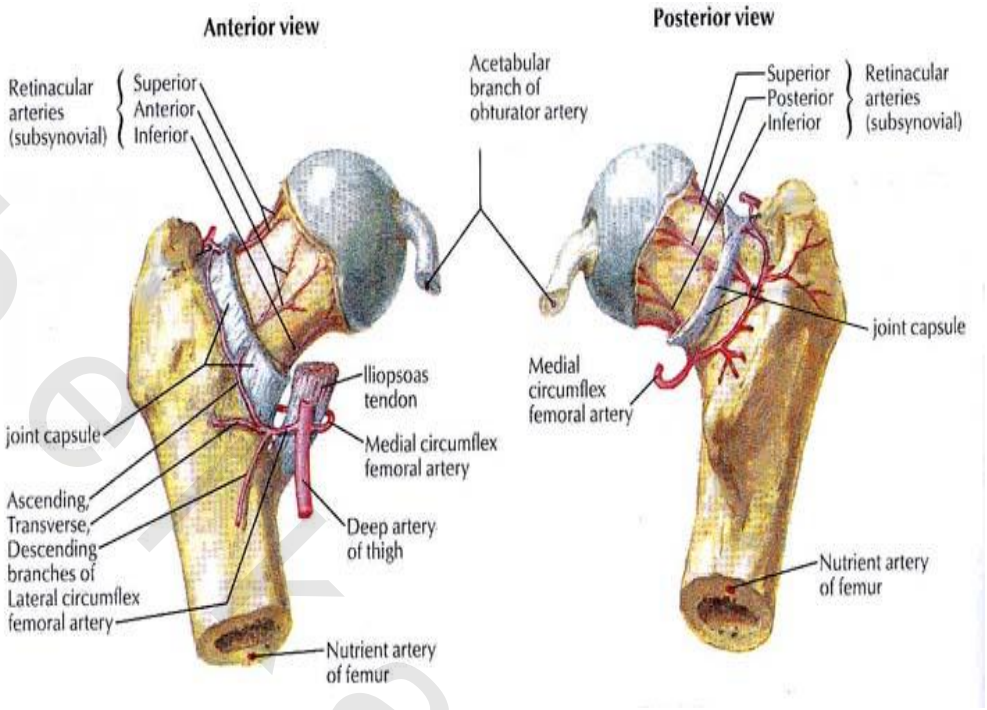

Fig. (15): Vascular anatomy of head and neck femur.[43]

The hip joint capsule is a strong fibrous structure that encloses the femoral head and most of its neck. The capsule is attached anteriorly at the intertrochanteric line; posteriorly, however, the lateral half of the femoral neck is outside the capsule, That portion of the neck that is within the capsule has essentially no cambium layer in its fibrous covering to participate in peripheral callus formation during the healing process, therefore, healing in the femoral neck area is dependent on endosteal union alone. Unless the fracture fragments are impacted, synovial fluid can lyse blood clot formation and thereby destroy another mode of secondary healing by preventing the formation of cells and scaffolding that would allow for vascular invasion of the femoral head. For all practical purposes, the femoral head is rendered largely avascular by a displaced femoral neck fracture. Fracture union can occur despite an avascular fragment, although the incidence of nonunion is increased, however, even with optimum treatment, signs of aseptic necrosis and later segmental collapse can still occur. [37,44,45]

Arteries of the proximal end of the femur are divided in three groups:[43]

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

(b) Ascending cervical branches of the extracapsular arterial ring on the surface of the femoral neck.

(c) The arteries of the round ligament.

The extracapsular arterial ring is formed posteriorly by a large branch of the medial femoral circumflex artery and anteriorly by branches of the lateral femoral circumflex artery. The superior and inferior gluteal arteries also have minor contributions to this ring. The ascending cervical branches arise from the extracapsular arterial ring. Anteriorly, they penetrate the capsule of the hip joint at the intertrochanteric line, and, posteriorly, they pass beneath the orbicular fibers of the capsule. The ascending cervical branches pass upward under the synovial reflections and fibrous prolongations of the femoral head from its neck. These arteries are known as retinacular arteries, described initially by Weitbrecht, the proximity of the retinacular arteries to bone puts them at risk for injury in any fracture of the femoral neck. As the ascending cervical arteries traverse the superficial surface of the femoral neck, they send many small branches into the metaphysis of the femoral neck. (46)

Additional blood supply to the metaphysis arises from the extracapsular arterial ring and may include anastomoses with intramedullary branches of the superior nutrient artery system, branches of the ascending cervical arteries, and the subsynovial intra-articular ring. In the adult, there is communication through the epiphyseal scar between the metaphyseal and epiphyseal vessels when the femoral neck is intact.(46)

This excellent vascular supply to the metaphysis explains the absence of avascular changes in the femoral neck as opposed to the head. The ascending cervical arteries can be divided into four groups (anterior, medial, posterior, and lateral) based on their relationship to the femoral neck. Of these four, the lateral group provides most of the blood supply to the femoral head and neck. At the margin of the articular cartilage on the surface of the neck of the femur, these vessels form a second ring, termed the subsynovial intra-articular arterial ring. At the subsynovial intra-articular ring, epiphyseal arterial branches arise that enter the femoral head. Disruption of this arterial ring has significance in high intracapsular fractures. Indeed, it was demonstrated that in all femoral neck fractures that communicated with the point of entry of the lateral epiphyseal vessels, aseptic necrosis occurred.(47,48)

Once the arteries from the subsynovial intra-articular ring penetrate the femoral head, they are termed the epiphyseal arteries. The artery of the ligamentum teres is a branch of the obturator or the medial femoral circumflex artery, the functional presence of this artery has been variably reported in the literature.(43)

Clinical significance of vascular anatomy:

In fracture neck of femur, the intraosseous cervical vessels are disrupted. Femoral head nutrition then is dependent on remaining retinacular vessels and those functioning vessels in the ligamentum teres. The amount of the femoral head supplied by the medial epiphyseal vessels varies from a very small area just beneath the fovea to the entire head. If the fracture occurs distal to the superior retinacular vessels and the displacement is not too great, both sources of blood supply may remain intact and prognosis is good (less chance of avascular necrosis). Abnormal degree of rotatory movement of the femoral head may destroy its own blood supply as any other form of displacement, with complete displacement of the head, only medial epiphyseal vessels supply the head. In approximately 30% of cases the loss of blood supply is total, the foveolar vessels are insufficient and entire head becomes necrotic.(49)

In 70% of cases, the nutrition of the femoral head is partially or wholly preserved by foveolar vessels. When avascular necrosis is partial, it usually involves a large area of the head at the upper outer portion, the region about the fovea remaining viable.(50)

Biomechanics of the hip joint

The hip joint is the pivot upon which the human body is balanced in gait. True bipedalism is limited to birds and man, and in both the stability of this joint is dependent upon the bony configuration of the joint. Lack of adequate bony configuration of the hip joint socket will lead to dislocation. The center of gravity in human beings is above the hip joints; thus, mechanisms must exist to balance the body's mass on the hip. (51)

Forces Acting on the Hip

To describe the forces 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 the greater trochanter to the center 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. Because the ratio of the length of the lever arm of the body weight to that of the abductor musculature is about 2.5 : 1, the force of the abductor muscles must approximate 2.5 times the body weight to maintain the pelvis level when standing on one leg. The estimated load on the femoral head in the stance phase of gait is equal to the sum of the forces created by the abductors and the body weight and is at least three times the body weight; the load on the head during straight leg raising is estimated to be about the same. (52)

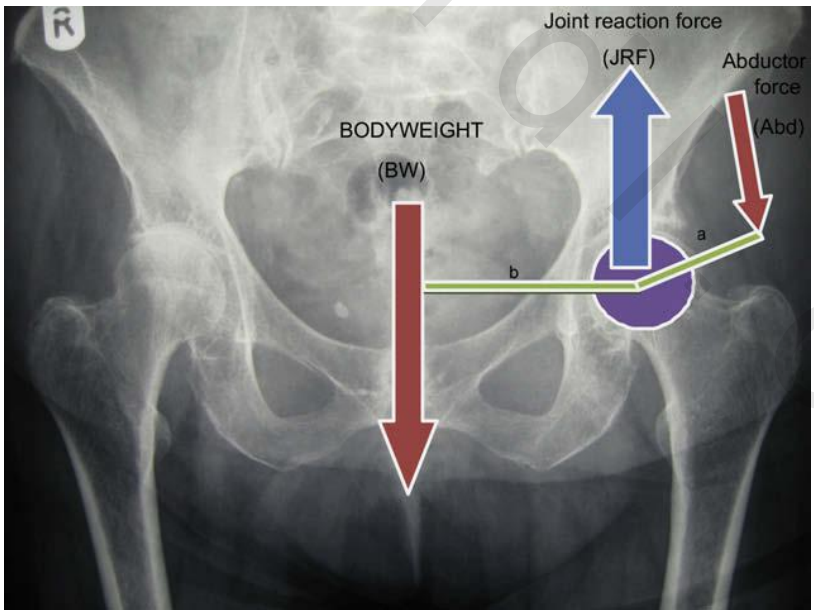

Fig. (16): Forces around the hip joint.(52)

The effect of alteration of hip joint geometry on the forces at the hip joint:

Alterations in joint anatomy, whether due to surgical intervention or a disease process, can dramatically affect the force acting across the joint and the stresses developed within the articular surfaces. These changes occur through alterations to the moment arms of the hip muscles and the area of contact between the femur and the acetabulum.

A decreased head neck angle (varus hip) increases the mechanical advantage of the abductors by increasing the moment arm of the joint reaction force. After hip replacement, these bending moments will generate stresses within both the femoral stem and its interfaces, which, if excessive, can lead to loosening. It also improves joint stability through increased coverage of the femoral head by the acetabulum. Conversely, a shorter or more vertically inclined (valgus) femoral neck reduces the bending moment in the stem. However, the reduction in head offset means that larger abductor forces are needed to balance the weight of the body, leading to an increase in the joint reaction force. In practice, this leads to a significant increase in the wear rate of the artificial joint and a greater incidence of implant failure secondary to wear and osteolysis. [53]

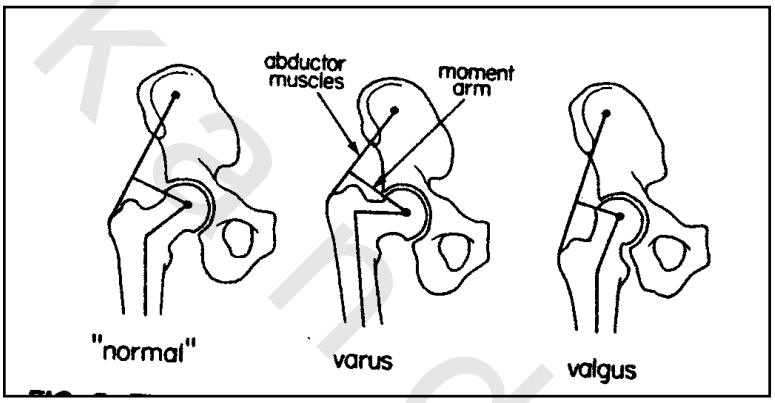

Fig. (17): Effect of femoral neck shaft angle on forces around.[53]

Principles of load transfer in hip replacement:

It is the function of the stem of the femoral component to transmit the force that is developed at the hip center during activity of the lower extremity through the surrounding cement to the proximal part of the femur in such a way that the stress patterns accompanying this load transfer mechanism will not cause failure for the longest possible period of time The stress pattern depends on: the magnitude and orientation of the applied load, the geometric configuration of the femoral stem, the mechanical properties of the material, and the interface conditions.[54]

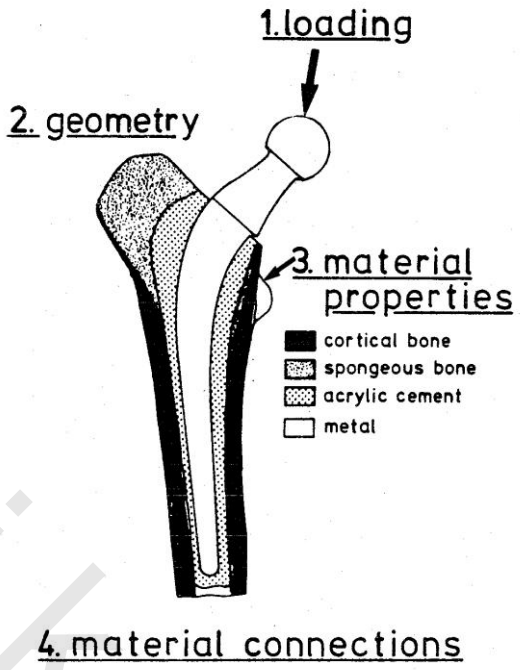

Fig. (18): Factors affecting load transfer of the femoral stem.[54]

Stress distribution in the femur after hip replacement:

In the femur, the hip contact force is distributed to the cancellous bone of the femoral head through a layer of compliant cartilage. The trabecular architecture in the proximal femur coincides with the trajectories of the principal stresses. Hip forces are transferred in a smooth and gradual manner from the cancellous bone of the femoral head to the cortex of the femoral shaft.[55]

Once the femoral head and neck are replaced by a femoral prosthesis, the stress patterns in the proximal femur are dramatically altered and they have certain characteristic features:

1- The load transfer is concentrated at the proximal and distal sides generating stress peaks in the cement and at the interfaces.

2- The stress shielding effect in the bone caused by load sharing between the stem and bone, so removal of the normal stresses from the proximal femur can result in decrease of bone density due to the removal of normal stresses according to Wolff's Law.

The amount of stress shielding depends mainly on the stiffness(thickness and elastic modulus) of the stem.[55]

Contact forces are transferred from the prosthetic head down the prosthetic neck and stem. From there, the forces are transferred either directly or indirectly through cancellous bone to the femoral cortex.[55]

The predominant effect of the load is bending, generating compressive stresses on the medial surfaces, and tensile stresses on the lateral periosteal surfaces of the bone in the longitudinal direction (bending stresses). The stem is also loaded predominantly in bending, with longitudinal compression along its medial faces and tension along its lateral faces Interface stress transfer can be characterized by shear and normal (perpendicular) stress components, the latter of which is either tensile or compressive.[56]

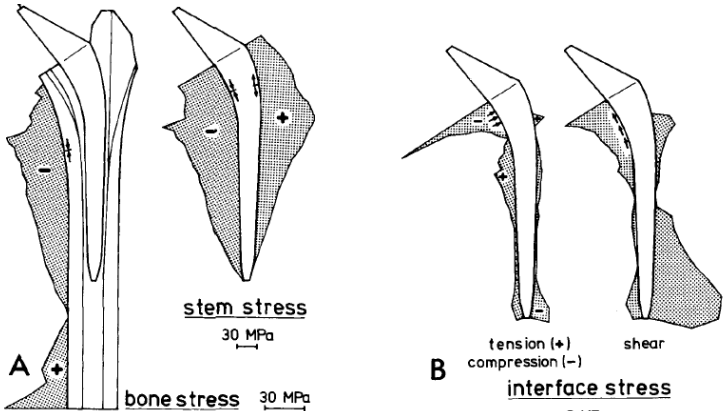

Fig. (19): Stresses of the cemented femoral stem.[56]

In an uncemented stem, shear stresses develop between the prosthetic stem and the host bone. These stresses tend to loosen the interface between the stem and bone. In a cemented stem, shear stresses develop at the interfaces between the prosthetic stem and the cement mantle, and also between the cement mantle and the host bone. These shear stresses tend to disrupt the bond between the prosthetic stem and the cement, or between the cement and the bone.[53]

A bone-prosthesis structure is known as a composite structure. This implies that it consists of separate substructures with different elastic and geometric properties that are bonded to each other in some specified manner. The stress patterns in these composite structures depend on the bonding characteristics at the interfaces between the substructures, and on the relative magnitudes of their elastic moduli. So in a cemented component, this composite consists of host bone, cement, and femoral stem.[57,58]

This composite structure has the following characteristics:[57,58]

- The stresses are essentially non-uniform, concentrated predominantly in the part of the structure, directly under the applied load.
- If load applied simultaneously to the substructures of the composite beam, the material with higher modulus of elasticity experience the higher load(load sharing)
- If load is applied to the prosthesis only it produces load transfer via interface shear stresses.
- Stress transfer in composite structures is very much affected by the bonding characteristics at the interface. A femoral stem functions either as a composite beam (shape closed fixation) or a taper slip model (force closed fixation) with both having different mechanisms of load transfer. In the composite beam model, the stem is considered a rod within two tubes, cement and bone, and depends on strong bonding between both interfaces to form a stable construct from three materials with different mechanical properties (metal, cement and bone). Load is transmitted *via* the femoral head and stem to its tip, bypassing the proximal femur and thereon to the bone cement and subsequently to host bone. The taper slip model on the other hand, must be able to move within its cement mantle to function as a loaded taper. The load is transmitted from the prosthetic head and forces the taper to subside within the cement mantle, creating radial compressive forces within cement and hoop stresses within bone to prevent expansion, thus minimizing proximal stress shielding. Thus these two biomechanical systems require different prosthesis-cement interfaces, a perfect stem-cement bond for the composite beam system but no bond between the stem and cement in the taper slip design.[57,58]

Biomechanics of bipolar hip endoprosthesis

Several theoretical biomechanical features of the bipolar hip endoprosthesis are important in the discussion of the functional features of the bipolar hip and includes: frictional factors, centricity, motion, and modularity.[59]

1) Frictional factors:

Bateman pointed out that shear stress at a joint interface is proportional to the coefficient of friction. The coefficient of friction for a metal surface against cartilage is three times that of a purely cartilaginous articulation. Therefore shear stress occurring across a metal cartilage interface is 300% higher than that occurring in a natural joint. In the bipolar system the coefficient of friction among stainless steel, high density polyethylene and joint fluid is less than the coefficient of friction among stainless steel, acetabular cartilage and joint fluid so most hip motion during normal gait occurs in the inner bearing and the outer cup movement occurs only at the extremes of motion so less friction and motion means less shear stress at the acetabular cartilage and hence less acetabular erosion.[59]

2) Centricity:

The concept of centricity has become essential in understanding the bipolar designs. When the geometric centers of the outer and inner bearing coincide it is called centric. The first generation bipolar designs were designed with negative eccentricity because the external center of articulation was positioned above the internal center of articulation. This negative eccentricity resulted in persistent varus tilt of the external cup which produce destabilizing torque which produces undesirable load bearing conditions, impingement and disassembly of the prosthesis. A result of this early experience that the centres of the inner and outer bearing were separated, with the outer head centre moving slightly more distal. This is the eccentric offset (positive eccentricity) which result in self centering mechanism. This self centering mechanism decreases the chance of impingement, provides symmetrical load bearing surfaces, increases range of motion, and decreases acetabular wear.[60]

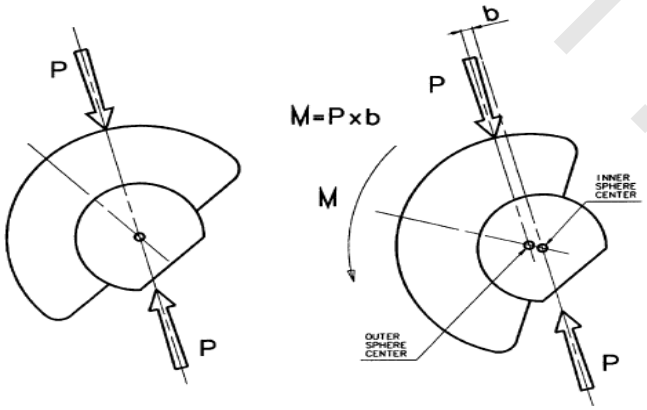

Fig. (20): First generation bipolar heads. LEFT. Concentric heads. Resultant force (P) does not bear any moment. RIGHT. Negative eccentricity (the inner head center is below the outer head center). An overturning moment (M) causes the varus of the outer sphere.[60]

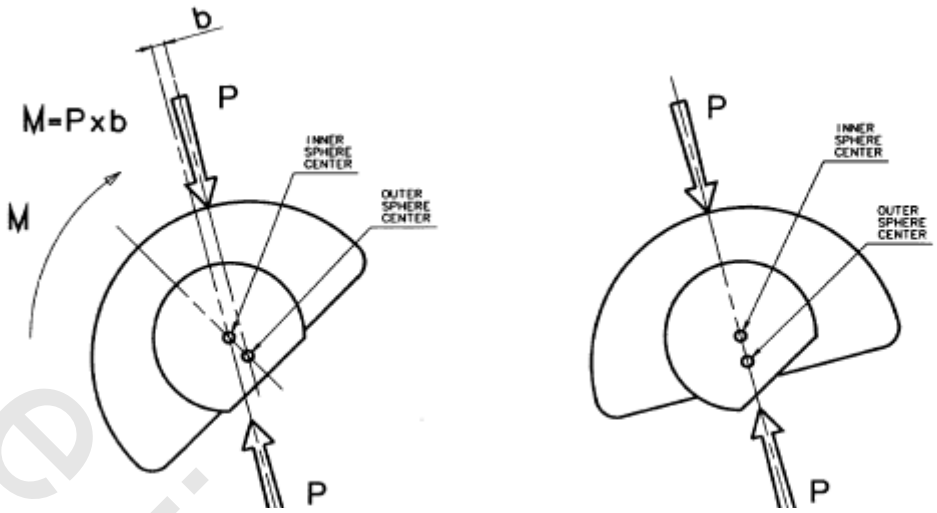

Fig. (21): Positive eccentricity (the inner head center is above the outerhead center). A self-centering moment (M) (Left) arranges both the centers on the loading axis (Right).[60]

When there is a low friction outer bearing, the forces applied during physical activity will act through the outer head center. If this force does not also act through the inner head centre, the outer head will rotate so that both centers become aligned with the force. So, perhaps the most compelling evidence for the effectiveness of the eccentric offset is the reduction in the incidence of the clinical problem of the early varus bipolar. [5, 59-61]

3) Differential motion:

Bipolar prosthesis was thought to allow differential motion at two bearing surfaces with majority of movement occurring at inner bearing and the outer bearing motion occurring only at extremes of motion. Some workers believe that in normal acetabulum the cartilage prosthesis junction has low coefficient of friction and therefore even bipolar prosthesis may work as unipolar hemiarthroplasty with movement occurring mainly between acetabulum and outer cup of the bipolar prosthesis. Following replacement with Monk duo-pleet prosthesis in femoral neck fractures Chen et al (1980) have reported on radiological study that movement occurs between inner metallic head and polyethylene and between acetabulum and outer metallic cup of the prosthesis. They also found that movement increases with passage of time and the two sites of movement contribute to greater range of motion and possibly less migration of the prosthesis. [5, 62, 63]

There are different patterns of inner bearing motion which depend on the static friction at the metal acetabular articulation during gait. During stance phase of gait there is increased static friction at the outer metal acetabular articulation that tends to prevent its movement; hence, during this phase, articulation mainly occurs at the interprosthetic low-friction articulation. However, during the swing phase of gait the weight of the leg causes the inner head to engage the outer rim of the prosthetic socket and both components move as one unit, and this accounts for the `unipolar' movement during swing phase.[64]

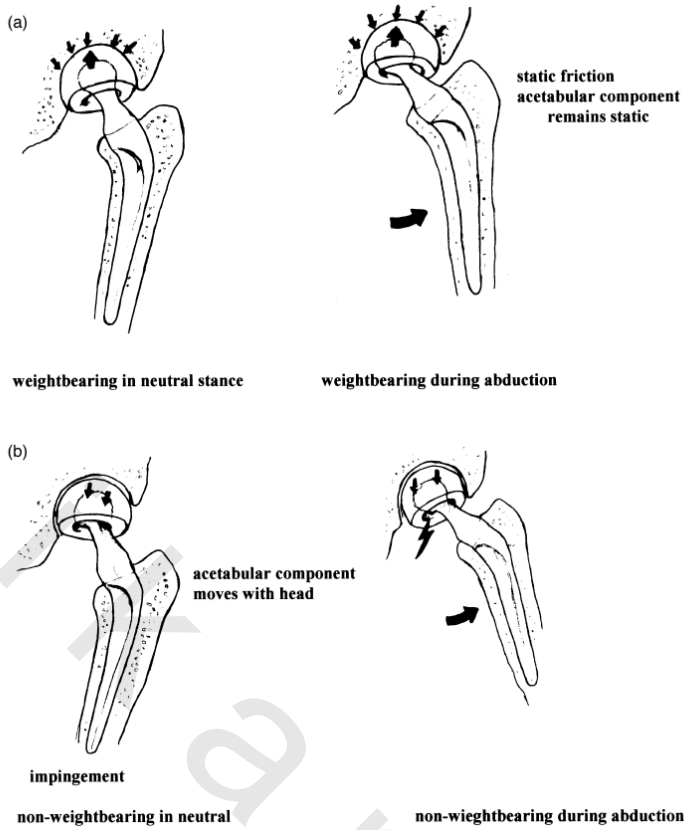

Fig. (22): Mechanism of bipolar motion in stance phase of gait. (B) Mechanism of unipolar motion in swing phase of gait.[64]

4) Modularity:

The neck length and offset can be changed intra-operatively and the leg length can be adjusted; also theoretically the revision of the bipolar prosthesis into total hip is easy as it entails only removal of the outer bearing and its replacement with acetabular cup. [65]

5) Umbrella effect:

A bipolar head with variable polyethylene thickness (centrally thinned polyethylene) should move about to a point where the resultant force is perpendicular on the thinnest point of the polyethylene similar to holding the umbrella in a way to be perpendicular to the line of rain drops. This principle should ensure the dissipation of the arc of motion between two poles of bearing hence reducing the acetabular friction. [59]

Techniques and surgical Approaches for hip arthroplasty

Hip arthroplasty is carried out through one of different surgical approaches. There are advantages and disadvantages for each, and there is a great controversy among hip surgeons as to which is the best. (66-68)

There are several incisions and approaches, defined by their relation to the gluteus medius such as: posterior (Moore), Posterolateral, lateral (Hardinge or Liverpool), anterolateral (Watson-Jones) anterior (Smith-Petersen) and greater trochanter osteotomy (Fig. 23, 24).(66-68)

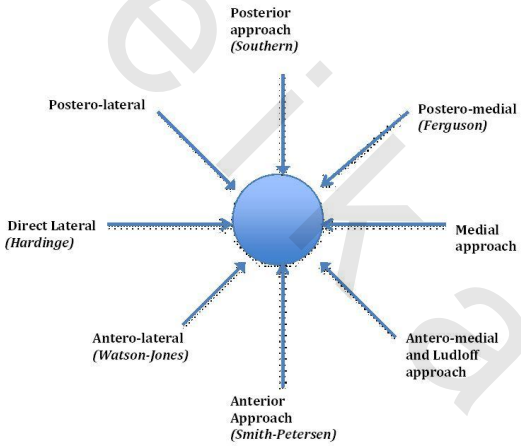

Fig. (23): All directions the hip can be approached. (69)

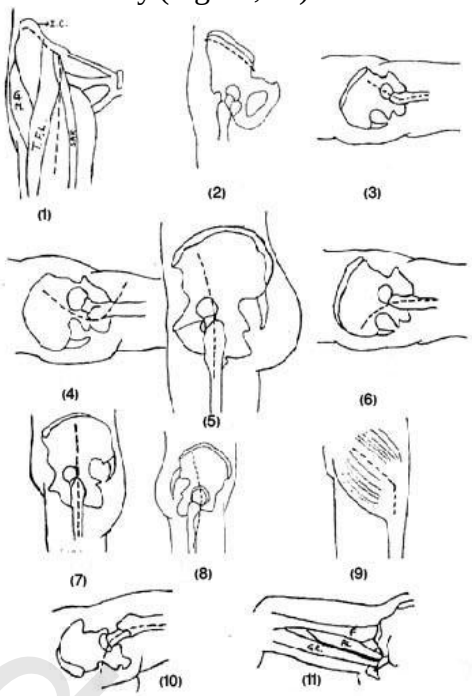

Fig. (24): Approaches to Hip Joint

(1) Smith Peterson approach.
(2) Somerville Bikni Incision.
(3) Watson Jones lateral approach.
(4) Harris technique
(5) Mc Farland Osborne technique.
(6) Hardinge Modification
(7) Mc Lauchlan Incision
(8) Gibson's Postero Lateral approach.
(9) Osborne's posterior approach
(10) Moore's Southern approach
(11) Ludloff's Medial approach.(70)

1. Anterior Approach (Smith – Petersen)

It is also known as Anterior iliofemoral approach, it is a true internervous approach as it dissects the interval between two internervous planes; the superficial plane lies between the sartorius (femoral nerve innervated) and the tensor fasciae lata (superior gluteal nerve innervated), and the deep plane lies between the rectus femoris (femoral nerve innervated) and the gluteus medius (superior gluteal nerve innervated). [67,69-74]

The patient is placed supine on the operating table with a bump (rolled up sheet) underneath the involved hip, and an incision made from midpoint of outer surface of the iliac crest, 2 cm below the crest of the ilium to avoid a painful postoperative scar adherent to bone. The incision is extended anteriorly below the anterior superior iliac spine. The incision is curved distally for approximately 10 cm along the lateral aspect of the femoral shaft (Fig.25). The dissection is done between the sartorius (innervated by the femoral nerve) and the tensor fascia lata (innervated by the superior gluteal nerve). The sartorius muscle can be noted to be muscular at its origin, and the tensor fasciae lata to be tendinous at its origin. The leg is rotated externally to stretch the sartorius. The interval between the tensor fascia lata and sartorius is identified distally as the muscles begin to separate (Fig. 26). At this point it is important to identify the lateral femoral cutaneous nerve, which usually crosses the sartorius approximately 4 to 5 cm distal to the anterosuperior iliac spine. The nerve should be retracted medially and the fascia between the tensor fascia lata and the sartorius is splitted proximally to the anterosuperior iliac spine. [67,69-74]

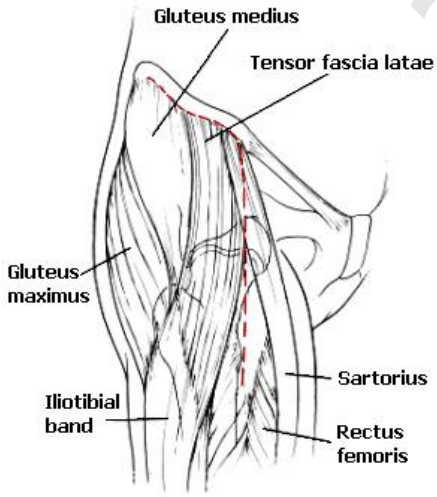

Fig. (25): The skin incision (dotted line) for the anterior iliofemoral approach. Parallels the iliac crest, turns downwards below the anterior iliac spine and extends along the shaft of the femur in the direction of the lateral border of the patella. [66]

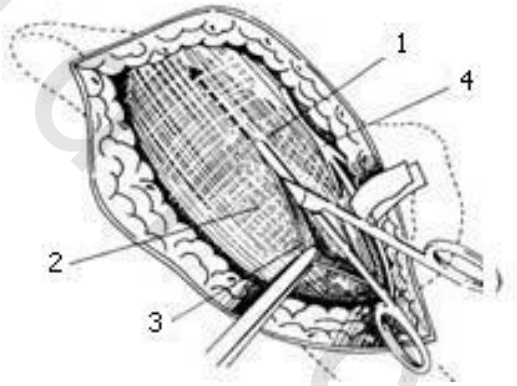

Fig. (26): The dissection between the tensor fascia lata and sartorius is started distally rather than at the anterior superior iliac spine. The lateral femoral cutaneous nerve is identified and retracted medially.**1.** Fascia lata; **2.** Fascia over tensor fascia lata; **3.** Fascia over sartorius; **4.** Lateral femoral cutaneous nerve. [66]

The iliac origin of the tensor fascia lata is elevated from the outer table of the ilium with a periosteal elevator, allowing visualization in the interval of the rectus femoris muscle where the ascending branch of the lateral femoral circumflex artery lies 5 cm distal to the hip joint crossing the gap between the gluteus medius muscle and rectus femoris tendon, it should be ligated or coagulated. The exposure may be improved by releasing the sartorius from its attachment to the anterosuperior iliac spine. Next, the periosteum with the attachments of the gluteus medius and minimus is stripped from the lateral surface of the ilium, and bleeding from the nutrient vessels is controlled by packing the interval between the ilium and the reflected muscles. The rectus femoris muscle is then detached from its origins on the anteroinferior iliac spine, the superior aspect of the acetabulum, and the hip capsule (Fig. 27).[67,69-74]

An interneural plane exists between the rectus femoris (femoral nerve) and the gluteus medius (superior gluteal nerve). The femoral artery should remain medial to the plane of dissection. After exposure of the hip joint capsule, a blunt Hohmann retractor can be placed over the superior capsule to retract the glutei. As well as around the inferior capsule retracting the detached rectus, sartorius and iliopsoas muscles (Fig. 28). The leg is adducted and externally rotated so that the hip joint capsule can be incised (T-shaped based at the acetabular rim), you should preserve the Y ligament of Bigelow. The incision is therefore made in the superior portion of the capsule, just above the border of this structure. (Fig. 29). The femoral head is removed. Then femoral preparations are done.[67,69-74]

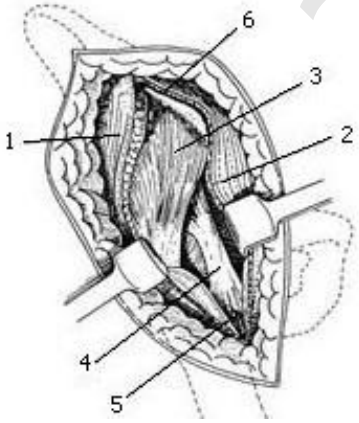

Fig. (27) Deep dissection
- **1.** Retraction of the tensor fascia lata
- **2.** The sartorius
- **3.** Exposes the gluteus medius
- **4.** Rectus femoris
- **5.** The ascending branch of the lateral femoral circumflex artery has been ligated.
- **6.** The anterior part of the tensor fascia lata muscle origin has been stripped from the ilium. [66]

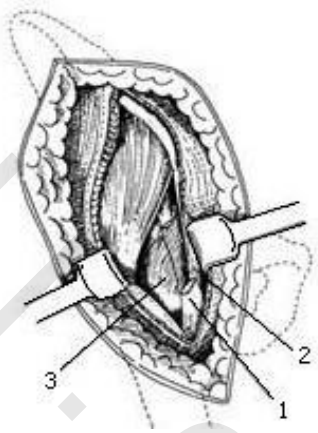

Fig. (28) Reaching the capsule
- **1.** After detaching the rectus femoris from its origin
- **2.** retracting the iliopsoas medially
- **3.** Much of the anterior aspect of the capsule is exposed. [66]

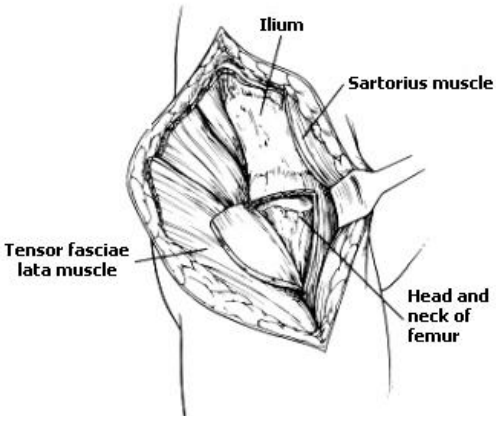

Fig. (29): Exposure of joint after reflection of tensor fasciae lata and gluteal muscles from lateral surface of ilium and division of capsule. (66)

Disadvantages and pitfalls

1- The starting point between tensor fasciae lata and sartorius muscles is poorly defined. If the dissection is carried medial to the sartorius, damage to the femoral nerve and the lateral femoral cutaneous sensory branch (lateral cutaneous nerve of the thigh) may occur and formation of a painful neuroma or may produce an area of diminished sensation on the lateral aspect of the thigh.
2- The ascending branch of lateral femoral circumflex artery crosses the operative field, running proximally in the internervous plane between tensor fasciae lata and sartorius muscles. It should be identified and ligated or coagulated.
3- The extensive exposure of the ilium and acetabulum afforded by extensive stripping of the abductors off the ilium results in a high incidence of residual weakness of the abductors and formation of heterotopic bone.(67,69-74)

2. Anterolateral Approach (Watson Jones)

The anterolateral approach was first popularized by Watson Jones in his description of fracture fixation to provide better exposure of the hip without the extensive dissection that is characteristic of the anterior approach.(67,69,70,72,73,75)

The approach exploits the intermuscular plane between tensor fasciae lata and gluteus medius muscles, both are supplied by superior gluteal nerve (so it is not a true internervous plane). It also involves partial or complete detachment of some or all of the abductor mechanism so that the hip can be adducted during reaming of the femoral shaft and so that the acetabulum can be more fully exposed. (67,69,70,72,73,75)

The patient is placed supine on the operating table, and a bump (rolled sheet) is placed underneath the ischial tuberosity to bring the hemipelvis forward and to allow the buttock to hang freely down from the area of dissection. Skin incision begins 2.5 cm distal and lateral to the anterior superior ischial spine and curve it distally and posteriorly over the lateral surface of greater trochanter and femoral shaft to about 5 cm distal to the base of the trochanter (incision better be performed more posterior over lateral aspect of trochanter and femoral shaft to avoid impingement of soft tissue during adduction and external rotation of femur) (Fig. 30). (67,69,70,72,73,75)

Fascia lata incised posterior to tensor fascia lata (Fig. 31), then the interval between the tensor fascia lata (anteriorly) and the gluteus medius (posteriorly) is identified, the delineation of this interval often is difficult but it can be done more easily by beginning the separation midway between the anterosuperior spine and the greater trochanter, before the tensor fasciae lata blends with its fascial insertion. The coarse grain and the direction of the fibers of the gluteus medius help to distinguish them from the finer structure of the tensor fasciae lata muscle. Dissection is done through this plane till we reach the anterior joint capsule. Superior gluteal vessels in between these two muscles are cauterized, and we should avoid dissection between gluteus medius and tensor fascia lata more than few centimeters proximal to greater trochanter to avoid injury of superior gluteal nerve present in this plane. [67,69,70,72,73,75]

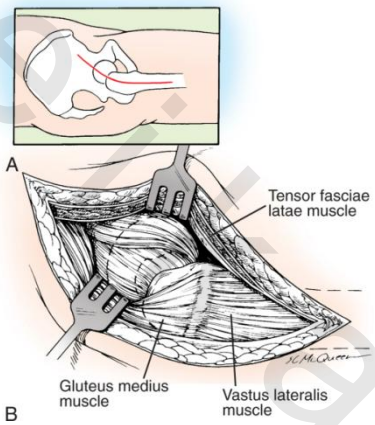

Fig. (30): Watson Jones approach to hip joint. **A.** Skin incision **B.** Approach has been completed except for incision of joint capsule. **(66)**

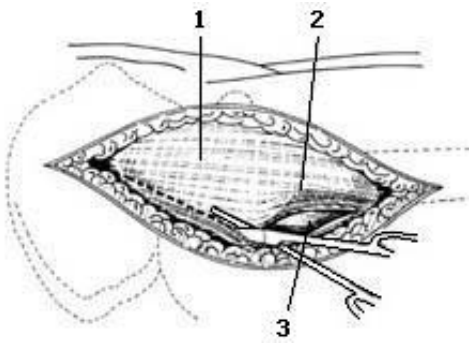

Fig. (31): The tensor fascia is incised in line with the skin incision and behind the tensor fascia lata muscle. **1.** Fascia over tensor fascia lata; **2.** Iliotibial band. **3.**Vastus lateralis **(66)**

Anterior portion of gluteus medius inserted into greater trochanter is released by cautery and tendon is tagged with nonabsorbable suture or a small trochanteric osteotomy is done reflecting part of greater trochanter with gluteus medius (Fig. 32). [67,69,70,72,73,75]

Dissection in a medial direction on the hip capsule to the border of gluteus minimus exposes the anterior capsule of the hip as far as the acetabular rim. The direct head of the rectus tendon can be easily palpated along the anteromedial border of the hip capsule. To gain exposure of the anterior column, a blunt cobra retractor can be placed beneath the rectus tendon by blunt dissection of anterior soft tissue slightly inferior to the axis of the femoral head, over the brim of the anterior column. An index finger can be passed safely over the anterior column in a posterior direction into the pelvis. Rotation of the digit anteriorly identifies the tight tendon of the direct head of rectus femoris which extends from its origin on AIIS into the thigh. The blunt rectus retractor can then be safely substituted for the digit over the anterior column and beneath the direct head of the rectus tendon for exposure of the anteromedial hip capsule. [67,69,70,72,73,75]

The reflected head of the rectus tendon can be released and detached from the joint capsule to expose the anterior rim of the acetabulum. This is easier if the leg is partial flexed to relax the rectus femoris. [67,69,70,72,73,75]

In the distal part of the incision the origin of the vastus lateralis may either be reflected distally or split longitudinally to expose the base of the trochanter and proximal part of the femoral shaft. (67,69,70,72,73,75)

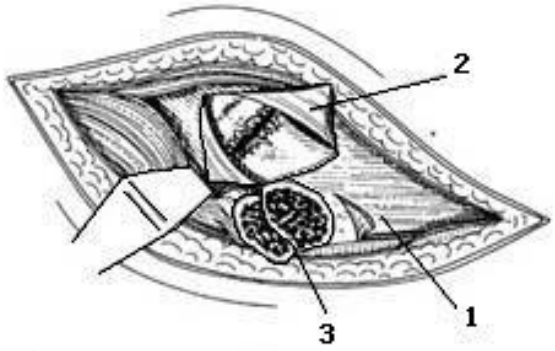

Fig. (32): The anterior superior part of the greater trochanter may be osteotomized with the attached insertion of the gluteus medius muscle: **1.** Vastus lateralis; **2.** Capsule; **3.** Trochanter (66)

Then retractors are inserted anteriorly, posteriorly and superiorly to acetabulum to expose the capsule and a T-shaped capsulotomy based at the acetabular rim is done. Then the head is removed and femoral preparations are done.(67,69,70,72,73,75)

Dangers and pitfalls

1- The femoral nerve is the most laterally placed structure in the neurovascular bundle in the femoral triangle and the closest to the operative field and the most at risk. Compression neuropraxia may occur, caused by excessive medial retraction of the anterior covering structures of the hip joint. Less frequently, the nerve is directly injured by retractors placed more anterior and not directly on bones but biting into the substance of the iliopsoas. (67,69,70,72,73,75)

2- The femoral vessels may be damaged by incorrectly placed acetabular retractors that penetrate the iliopsoas, piercing the vessels as they lie on the surface of the muscle. This can be avoided by ensuring that the tip of the retractor is placed firmly on bone and remain beneath the rectus femoris and iliopsoas. The anterior retractor should be placed in the 1 o'clock position for the right hip and in 11 o'clock position for the left hip. Flexing the limb 30° facilitates finding the correct plane between the rectus femoris and the anterior part of the hip joint capsule. (68,70,71,73,74,76)

3- Femoral shafts have been known to fracture while hips are being dislocated. For that reason, it is critical to do an adequate capsular release before attempting dislocation. To dislocate the joint, lever the femoral head out of the acetabulum with a skid while the assistant gently externally rotates the limb. The assistant has a considerable lever arm during this procedure; if he rotates the leg too forcible, he can cause a spiral fracture of the femur. (67,69,70,72,73,75)

The two incision anterior approach typically uses one or two smaller incisions over the front of the thigh with the patient supine. Dissection is in the plane between sartorius and tensor fascia lata in the superficial layer and in the deep layer between rectus femoris and gluteus medius muscle. This also facilitates bilateral surgeries. The lower incision is used to remove the femoral head and The upper incision, if needed for a large or muscular patient, is used to insert stem in the femur.(23, 76-79)

3. Lateral Approach (Hardinge)

The direct lateral approach or (transgluteal approach) provides excellent exposure of the hip joint replacement through the anterior hip capsule directly through the anterior portion of the abductors. It can provide excellent access to both the anterior hip and upper femur with a similar exposure to the anterolateral approach. [69,70,72,73,75,80]

In 1954, McFarland and Osborne described a lateral approach to the hip that preserves the integrity of gluteus medius muscle depending on the functional continuity of the gluteus medius and vastus lateralis muscles through the thick periosteum covering the greater trochanter. They separated the gluteus medius from the piriformis and gluteus minimus and retracted it forward in continuity with a portion of vastus lateralis. Gluteus minimus was divided and retracted proximally to allow exposure of the hip. A number of modifications have been applied to the direct lateral approach in the manner and extend of the dissection of soft tissue. [69,70,72,73,75,80]

In 1982, Hardinge described a useful modification of the McFarland and Osborne direct lateral approach and popularized it. His modification was based on the fact that the insertion of the gluteus medius to the greater trochanter is by a strong mobile tendon which is wide in its anterior half and follows a crescent shaped insertion that curve around the apex of the trochanter. The major change described by Hardinge was to leave the posterior portion of the gluteus medius, with its thickest insertion point undisturbed from the greater trochanter.[69,70,72,73,75,80]

Place the patient supine with the greater trochanter at the edge of the table and the muscles of the buttocks freed from the edge of the table to allow muscles of the buttock and gluteal fat to fall posteriorly away from the operative plane. Begin the incision 5 cm above the tip of the greater trochanter. Make either a straight or posteriorly directed lazy-j incision centered over the tip of the greater trochanter and extends down the line of the shaft of the femur for approximately 8 cm (Fig. 33A). Divide the fascia lata in line with the skin incision and centered over the trochanter. Retract the tensor fascia lata anteriorly and the gluteus maximus posteriorly exposing the origin of the vastus lateralis and insertion of the gluteus medius (Fig. 33B). Incise the tendon of gluteus medius obliquely across the greater trochanter leaving the posterior half still attached to the trochanter. Carry the incision proximally in line with the fibers of the gluteus medius at the junction of the middle and posterior thirds of the muscle. [69,70,72,73,75,80]

The danger of a gluteus medius splitting approach is that if the dissection is carried too far proximally the superior gluteal nerve may be injured as it traverses the medius muscle, denervating its anterior portion. Distally, carry the incision anteriorly in line with the fibers of the vastus lateralis down to bone along the anterolateral surface of the femur (Fig. 33 B) Elevate the tendinous insertions of the anterior portions of the gluteus minimus and vastus lateralis muscles by cautery as one flap off the trochanter sharply. Leaving a stump of tendon attached to bone as well as a portion attached to the muscle preserving the functional continuity of gluteus medius and vastus lateralis muscles. Abduction of the thigh then exposes the anterior capsule of the hip joint (Fig. 33C). Capsulotomy is done followed by femoral head is removed. [69,70,72,73,75,80]

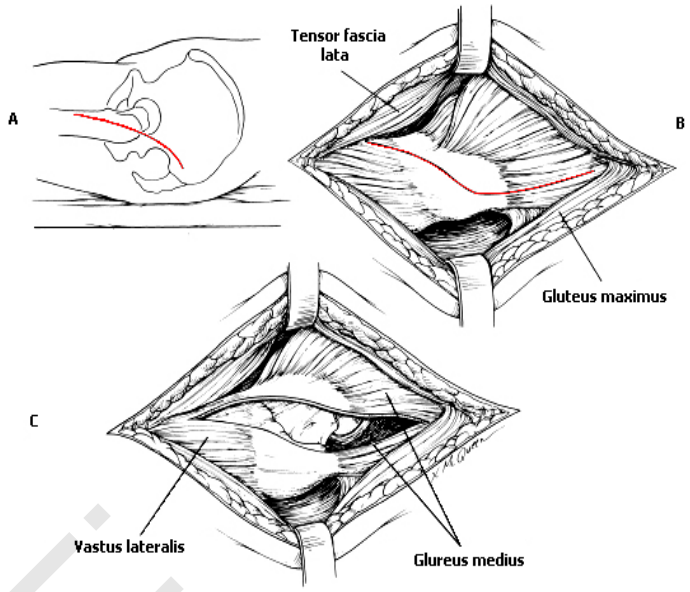

Fig. (33): Hardinge direct lateral approach. **A.** Lazy-J lateral skin incision. **B.** Tensor fasciae latae is retracted anteriorly and gluteus maximus posteriorly. Incision through gluteus medius tendon is outlined. Posterior half is left attached to greater trochanter. **C.** Anterior joint capsule is exposed. **(66)**

Frndak and Mallory modified the Hardinge direct lateral approach by placing the abductor "split" more anterior, directly over the femoral head and neck (Fig. 34). The incision preserves more of the superior gluteus medius than the Hardinge description but release more of the vastus lateralis. The "split" must not extend more than 2 cm above the lateral lip of the acetabulum to avoid damage to the gluteal neurovascular bundle. Because the abductor "split" is more anterior, exposure of the femoral head and neck requires less retraction. (69,70,72,73,75,80)

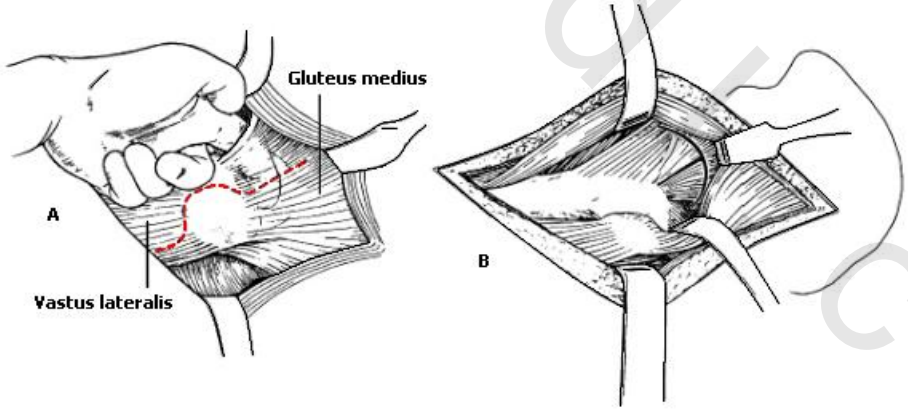

Fig. (34): Mallory direct lateral approach. A. Abductor "split" is determined by location of the femoral neck. B. Capsular incision parallels the superior border of the acetabulum. (81)

4. McLauchlan, Hay technique

In 1984, McLauchlan described a direct lateral approach to the hip through the gluteus medius based on the anatomical facts that the gluteus medius and vastus lateralis are in functional continuity through the thick periosteum covering the greater trochanter. [69,70,72,73,75,80]

Place the patient in the Sims position with the affected hip uppermost. Make a lateral longitudinal skin incision (Fig. 35 A) centered midway between the anterior and posterior borders of the greater trochanter and extending an equal distance proximal and distal to the tip of the trochanter. In lateral rotational deformities of the hip, place the incision more posteriorly. Next, incise the deep fascia and the tensor fasciae lata in line with the skin incision; retract these structures anteriorly and posteriorly to expose the greater trochanter with the gluteus medius attached to it proximally and the vastus lateralis attached distally (Fig. 35 B). Split the gluteus medius in the line of its fibers and with an osteotome elevate two rectangular slices of greater trochanter, one anteriorly and one posteriorly. [69,70,72,73,75,80]

These slices of trochanter have gluteus medius attached to them proximally and vastus lateralis attached distally (Fig. 35 C). Retract anteriorly and posteriorly to reveal the gluteus minimus, rotate the hip externally, and split the gluteus minimus in the line of its fibers or detach it from the greater trochanter. Next, incise the capsule of the hip joint, insert spike retractors anteriorly and posteriorly over the edges of the acetabulum, and dislocate the hip anteriorly by flexion and external rotation (Fig. 35 D). The femoral head is removed and femur is prepeard [69,70,72,73,75,80]

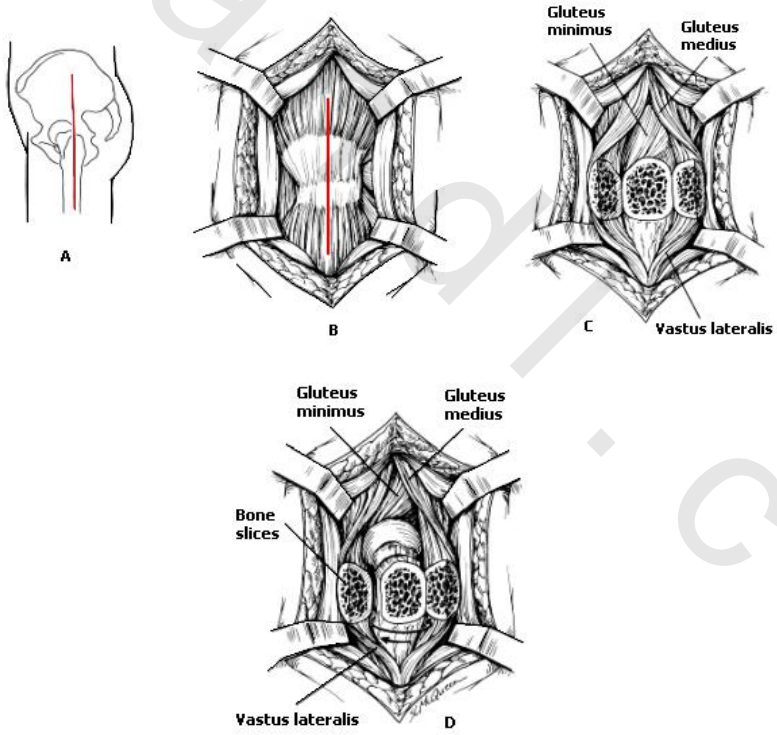

Fig. (35): McLauchlan; Hay lateral approach to hip. **A.** Skin incision. **B.** Greater trochanter is exposed with gluteus medius attached to it proximally and vastus lateralis distally. Solid line indicates incision to be made in soft tissues. **C.** Rectangular slices of greater trochanter have been elevated anteriorly and posteriorly. **D.** Hip joint has been opened and can be dislocated as described. [14]

When closing, suture the capsule if enough of it is left. Internally rotate the hip and suture the trochanteric slices to the periosteum and the other soft tissue covering the trochanter. Carefully close the deep fascia with interrupted sutures. The trochanteric slices unite without any problem, and abductor function returns rapidly. [69,70,72,73,75,80]

The lateral approach to the hip seems to have two main advantages:

1- It avoids the complication of trochanteric non-union associated with the transtrochanteric approach.
2- Postoperative dislocation is less likely than with the posterior approach.[69,70,72,73,75,80]

Yet, the lateral approach still has some disadvantages. Most of the problems reported with the direct lateral approach are those associated with the postoperative weakness of abductor function with subsequent postoperative limb due to injury to the superior gluteal nerve, specially its inferior branch which lies 3–5 cm away from the tip of the greater trochanter anteriorly and 6-8 cm posteriorly. For this reason, insert a stay suture at the apex of the gluteus medius split, this will ensure that the split does not inadvertently extend itself during the operation. [69,70,72,73,75,80]

An understanding of distribution of the superior gluteal nerve and strictly remaining within the limits of the safe area should decrease the risk of its injury (Fig. 36). During exploration of the acetabulum, the retractors should exert moderate muscular pressure to avoid crushing of the superior gluteal nerve. The gluteus minimus muscle also has to be respected and kept uninjured, because it ensures adequate protection for the nerve situated between the muscle bulk of gluteus medius and gluteus minimus. [69,70,72,73,75,80]

Also the femoral artery and vein are vulnerable to inappropriately placed anterior retractors, so anterior retractors should be placed strictly on the bone of the anterior aspect of the acetabulum and should not infringe on the substance of the psoas muscle. The transverse branch of the lateral circumflex artery of the thigh is cut as the vastus lateralis is mobilized. It must be cauterized during the approach. [69,70,72,73,75,80]

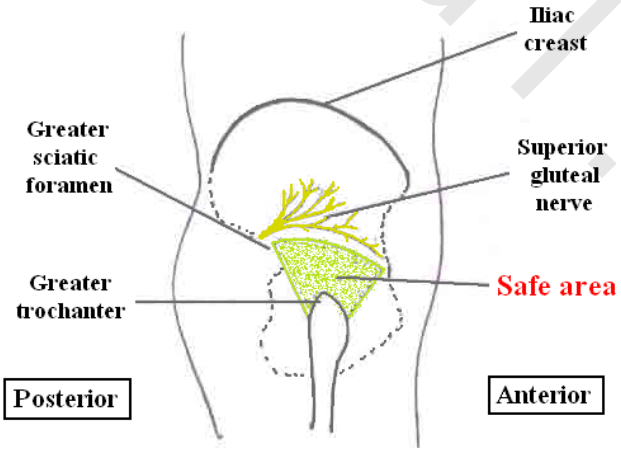

Fig. (36): The safe area above the greater trochanter without any neural branches up to a mean value of 2.7 cm in front and above, 4.8 cm superior and 8.1 cm above and behind the mid-trochanteric point. (The tip of greater trochanter) [81]

5. Posterior Approach (Osborne and Moore)

The posterior approach described by Moore (1957), and popularized as the southern approach is considered to be the classic posterior approach to the hip and is probably the most, or one of the most, commonly used approaches for total hip arthroplasty, primarily because it avoids displacement of the abductor mechanism and so maintains the abductor power in the immediate postoperative period. [67,69,70,72,73]

5.1. Osborne technique

The patient is securely fixed in the lateral position with the involved side uppermost and firmly held with padded kidney rests and back support. The leg is draped so that it can be manipulated during the procedure. Begin the incision 4.5 cm distal and lateral to the posterosuperior iliac spine and continue it laterally and distally, remaining parallel with the fibers of the gluteus maximus muscle, to the posterosuperior angle of the greater trochanter, and then distally along the posterior border of the trochanter for 5 cm. Separate the fibers of the gluteus maximus parallel with the line of incision. Relatively little bleeding occurs because the branches of the superior gluteal artery are contained in the proximal half of the muscle and those of the inferior gluteal in the distal half. Divide the insertion of the gluteus maximus into the fascia lata for 5 cm, corresponding to the longitudinal limb of the incision. Rotate the thigh internally, detach the tendons of the piriformis and gemelli muscles near their insertions into the trochanter using electrocautery, and tagged with nonabsorbable sutures for reattachment at the end of the case, and reflect these muscles posteriorly protecting the sciatic nerve (Fig.37). [67,69,70,72,73]

The proximal portion of the quadratus femoris is also released with electrocautery and branches of the medial femoral circumflex vessels are cauterized. The obturator externus is identified deep to the quadratus femoris and is divided as well. The capsular incision is begun superiorly and carried parallel to the acetabular rim as far as possible. The incision is converted to a T incision cutting from the posterior acetabular rim anteriorly to meet the longitudinal incision. [67,69,70,72,73]

Dislocation of the femoral head is achieved by adduction, flexion and internal rotation of the leg (Fig. 38). The neck is exposed with a bent Hohmann retractor placed superiorly and another retractor inferiorly. The neck osteotomy is then done after marking its site by electrocautery. [67,69,70,72,73]

A retractor is placed underneath the proximal femur and the tip passed up over the anterior margin of the acetabulum allowing anterior retraction of the femur to expose the acetabulum. Retraction is completed by placement of a retractor inferiorly, a Hohmann retractor posteriorly, and a stout Steinmann pin superiorly into the ilium. The inferior retractor is placed first outside the inferior acetabular ligament while soft tissue debridement is carried out and then just superior to the ligament, levered over the inferior bony lip of the acetabulum. All soft tissue is removed from the rim and the base of the acetabulum so the acetabular fossa is well visualized. If exposure is insufficient or if abductor muscles advancement is desired, trochanteric osteotomy can be done. [67,69,70,72,73]

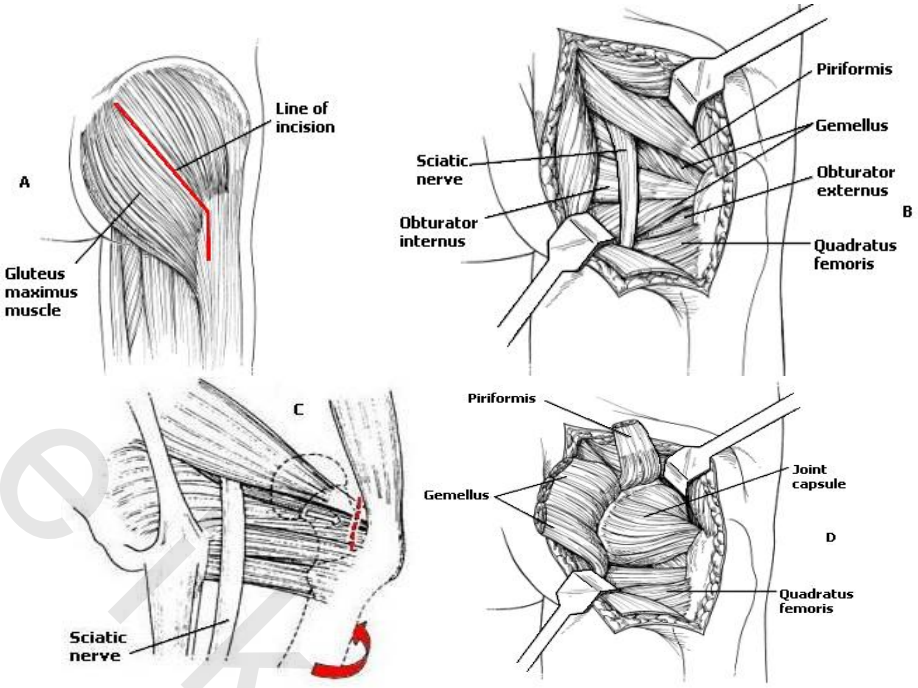

Fig. (37): Osborne posterior approach to hip joint. A. Skin incision. B. Gluteus maximus has been opened in line with its fibers and retracted. C. Internal rotation and detachment of the short external rotator muscles along the back of the trochanter (dotted line). D. Piriformis, gemelli, and obturator internus have been divided at their insertions and reflected medially to expose posterior aspect of joint capsule. (67)

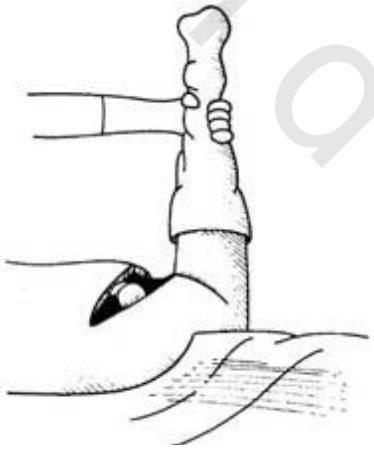

Fig. (38): The head is dislocated by adduction, internal rotation and flexion of the hip with the foot above. The transverse axis of the knee joint is parallel to the floor which provides a point of reference for anteversion of the neck of the femur.(67)

5.2. Moore technique

Moore's approach has been facetiously labeled “the southern exposure.” Place the patient on the unaffected side. Start the incision approximately 10 cm distal to the posterosuperior iliac spine and extend it distally and laterally parallel with the fibers of the gluteus maximus to the posterior margin of the greater trochanter. Then direct the incision distally 10 to 13 cm parallel with the femoral shaft (Fig. 39A). Expose and divide the deep fascia in line with the skin incision. By blunt dissection separate the fibers of the gluteus maximus; take care not to disturb the superior gluteal vessels in the proximal part of the exposure (Fig. 39B). Retract the proximal fibers of the gluteus maximus proximally and expose the greater trochanter. Retract the distal fibers distally and partially divide their insertion into the linea aspera in line with the distal part of the incision. Expose the sciatic nerve and retract it carefully. (After the surgeon becomes familiar with this approach, he rarely exposes the sciatic nerve.) Divide a small branch of the sacral plexus to the quadratus femoris and inferior gemellus, which contains sensory fibers to the joint capsule. Next, expose and divide the gemelli and obturator internus and, if desired, the tendon of the piriformis at their insertion on the femur and retract the muscles medially. The posterior part of the joint capsule is now well exposed (Fig. 39C); incise it from distal to proximal along the line of the femoral neck to the rim of the acetabulum. Detach the distal part of the capsule from the femur. Flex the thigh and knee 90 degrees, internally rotate the thigh, and dislocate the hip posteriorly (Fig. 39D). [67,69,70,72,73]

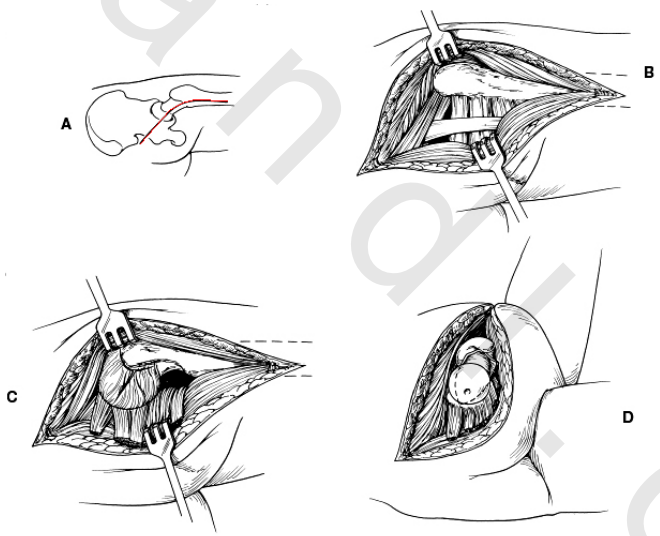

Fig. (39): Moore posterior approach to hip joint. A. Skin incision. B. Gluteus maximus has been split in line with its fibers and retracted to expose sciatic nerve, greater trochanter, and short external rotator muscles. C. Short external rotator muscles have been freed from femur and retracted medially to expose joint capsule. D. Joint capsule has been opened, and hip joint has been dislocated by flexing, adducting, and internally rotating thigh. [67]

Dangers and pitfalls

1. Superficial surgical dissection consists of cutting through the outer muscle layer by splitting the fibers of the gluteus maximus. The fibers of the gluteus maximus are extremely coarse; they run obliquely downward and laterally across the buttock. The muscle's innervation, the inferior gluteal nerve, emerges from the pelvis beneath the inferior border of the piriformis and almost immediately enters the muscle's deep surface close to its medial border, its origin. From there, the nerve's branches spread throughout the muscle. Splitting the gluteus maximus close to its lateral insertion does not denervate significant portions of the muscle, because its main nerve supply passes well medial to the most medial point of splitting. (67,69,70,72,73)
2. The sciatic nerve is rarely exposed or transected during this approach. However, it is sometimes involved in major complications. It can be damaged if it is compressed by the posterior blade of a self retaining retractor used to split the gluteus maximus. The sciatic nerve sometimes divides into its tibial and common peroneal branches within the pelvis; on occasion, we may expose these two "sciatic nerves" during this approach. If we have identified the sciatic nerve but think that it looks too small, search for the nerve's other branch; it is in danger if it is overlooked.
3. The inferior gluteal artery leaves the pelvis beneath the piriformis. It spreads to supply the deep surface of the gluteus maximus. Its branches are inevitably cut when the gluteus maximus is split. It can be identified and coagulated before they are avulsed, if dissection is done carefully.(67,69,70,72,73)

The main trunk of this artery is vulnerable as it emerges from beneath the lower border of the piriformis when pelvic fractures involved the greater sciatic notch. If it retracts into the pelvis and bleeding is brisk, turn the patient over into the supine position, open the abdomen, and tie off the artery's feeding vessel, the internal iliac artery.(67,69,70,72,73)

6. Posterolateral Approach

(Gibson), (Kocher Langenback)

Gibson (1950) is responsible for the rediscovery of the posterolateral approach to the hip first described and recommended by Kocher and Langenbeck. Gibson modified the approach to improve the exposure of the hip by adding the release of the two main abductors of the hip, the gluteus medius and minimus muscles at their insertion but leaving enough of their tendons attached to the greater trochanter to reattach the muscles at the end of the procedure. Reflecting these muscles anteriorly exposes the anterior and the superior part of the joint capsule. Because detaching the gluteal muscles from the ilium and interfering with the function of the iliotibial band are unnecessary, rehabilitation after surgery is rapid. (67,69,70,72,73)

With the patient in the lateral position, begin the proximal limb of the incision at a point 6 to 8 cm anterior to the posterosuperior iliac spine and just distal to the iliac crest, overlying the anterior border of the gluteus maximus muscle. Extend it distally to the anterior edge of the greater trochanter and then farther distally along the line of the femur for 15 to 18 cm (Fig. 40 A). By blunt dissection reflect the flaps of skin and subcutaneous fat from the underlying deep fascia a short distance anteriorly and posteriorly. Then incise

the iliotibial band in line with its fibers. To avoid splitting of the gluteus maximus fibers, the incision in the fascia is initiated at the distal end of the wound and extending proximally to the greater trochanter. Next, abduct the thigh, insert the gloved finger through the proximal end of the incision in the band, locate by palpation the sulcus at the anterior border of the gluteus maximus muscle, and extend the incision proximally along this sulcus, preserving the upper border of the muscle. Then adduct the thigh, reflect the anterior and posterior masses, and expose the greater trochanter and the muscles that insert into it (Fig. 40B). [67,69,70,72,73]

Next, separate the posterior border of the gluteus medius muscle from the adjacent piriformis tendon by blunt dissection. Divide the gluteus medius and minimus muscles at their insertion but leave enough of their tendons attached to the greater trochanter to permit easy closure of the wound. Reflect these muscles (innervated by the superior gluteal nerve) anteriorly (Fig. 40C). The anterior and superior parts of the joint capsule can now be seen. Incise the capsule superiorly in the axis of the femoral neck from the acetabulum to the intertrochanteric line; incise as much of the capsule as desired along the joint line anteriorly and along the anterior intertrochanteric line laterally. The hip can now be dislocated by flexing the hip and knee and abducting and externally rotating the thigh (Fig. 40D). [67,69,70,72,73]

Sufficient exposure of the hip can often be obtained with less extensive division of the muscles inserting on the trochanter; the extent of division depends on the type of operation proposed, the amount of exposure required, the tightness of the soft tissues, and the presence or absence of contractures around the joint. Conversely, when wide exposure of the joint, especially of the acetabulum, is needed, more extensive division of the muscles may be necessary. Gibson thinks that reattaching the muscles to the greater trochanter by interrupted sutures is adequate, but many surgeons usually prefer to preserve the insertion of the muscles by osteotomizing the trochanter and later reattaching the trochanteric fragment with two wire loops or 6.5 mm lag screws. [67,69,70,72,73]

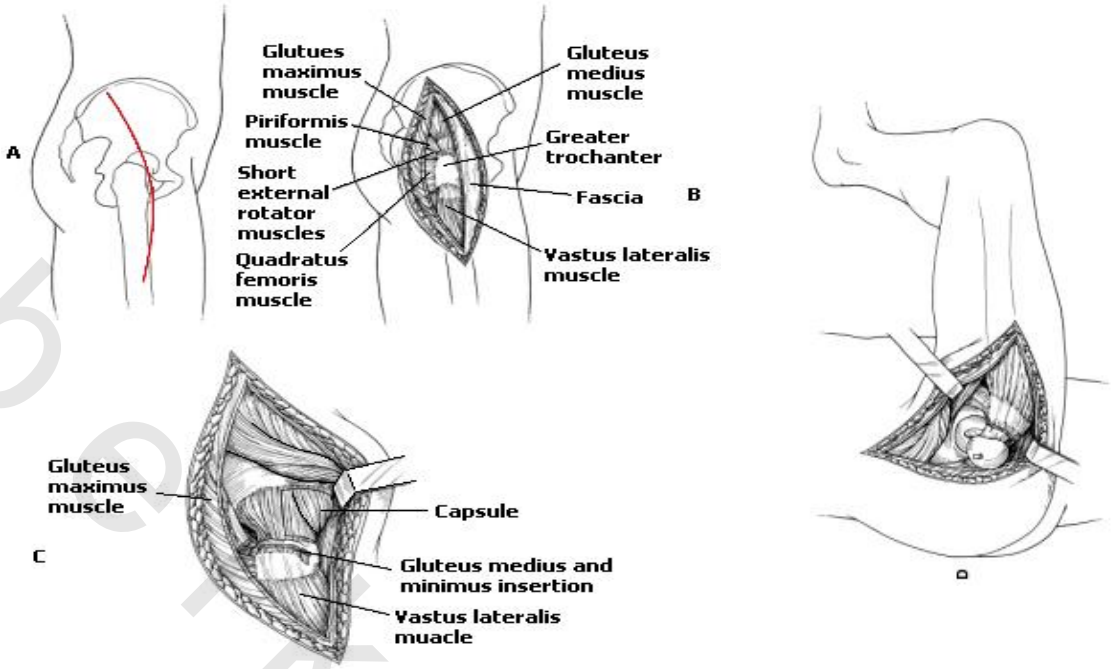

Fig. (40): Gibson posterolateral approach to hip joint. A. Skin incision. B. Anterior and posterior muscle masses have been retracted to expose greater trochanter and muscles that insert into it. C. Gluteus medius and minimus have been divided near their insertions into greater trochanter and retracted. Incision in capsule is shown. D. Hip joint has been dislocated by flexing, abducting, and externally rotating thigh. (67)

A modification of the Gibson approach by Marcy and Fletcher in which the hip is dislocated by internal rotation and the anterior part of the joint capsule is preserved to keep the hip from dislocating after surgery (Fig. 41).(67)

Fig. (41): Modification of Gibson posterolateral approach to hip. Anterior part of joint capsule is preserved to keep hip from dislocating after surgery. Acetabulum is not well exposed, but approach is sufficient for removing femoral head and inserting prosthesis. (67)

Minimally invasive approaches

Definition:

Minimally invasive surgical (MIS) hip replacement includes any hip replacement procedure in which the wound length and surgical dissection are modified in an attempt to reduce the tissue trauma associated with hip replacement. [76]

This new modification allows entering the hip between tissue planes rather than cutting through muscle. [76]

Approaches:

A number of different minimally invasive approaches are being used more and more for total hip arthroplasty. In principle, they can be divided into two groups:

1. The muscle-sparing approaches.
2. The mini-incision approaches (Fig. 42). [76, 82-89]

The former group, where muscles are not cut, includes the two incision technique, the anterolateral mini-approach and the direct anterior mini approach. [76, 82-89]

There is another single incision approach which is Tissue preserving minimally invasive hip arthroplasty using a superior capsulotomy. It is a modification of the two-incision approach.[90]

The mini-incision group approaches involve a shorter incision in the skin and less muscle are detached than in the corresponding standard approach. This group includes the mini-incision lateral approach and the mini-posterior approach. [76, 82-89]

In general, the minimally invasive approach is described as having a lower degree of trauma for the soft tissues and, in particular, for the muscles.[76, 82-89]

This opinion is based on the fact that the loss of blood is lower, rate of recovery is faster, the postoperative level of pain is lower and patients are released sooner from hospital. [76, 82-89]

Minimally invasive surgery of the hip has gained specific interest within the arthroplsty surgeons' community, mainly in the United States as documented on the American Academy of Orthopedic Surgeons (AAOS). In Europe the discussion about the length of skin incision was regarded with some curiosity. [76]

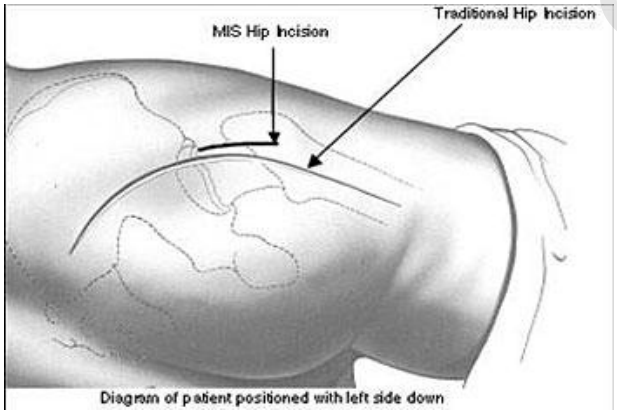

Fig. (42): MIS hip incision in comparison to traditional hip incision.[91]

II- Posterior mini-incision THR:

The less invasive posterior approach was originally developed by Khan et al[92] between January and March 2002 (Fig. 43). [92]

Surgical technique:

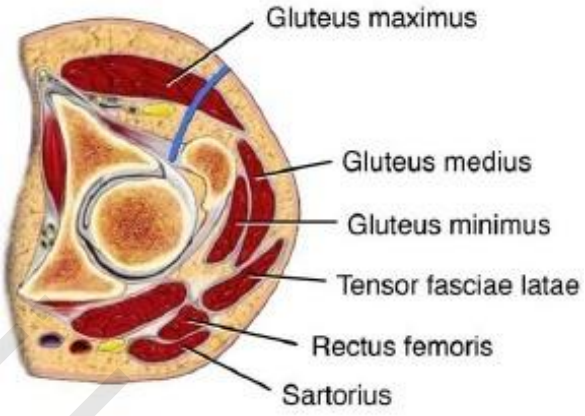

Fig. (43): Posterior minimal invasive approach.[93]

No specialized instruments are required. The patient is placed in the lateral decubitus position, the leg positioned in 45° of flexion at the hip and 90° of flexion at the knee. Landmarks for the skin incision are identified: the tip, anterior, and posterior borders of the greater trochanter forming an equilateral triangle (Fig. 44). [92]

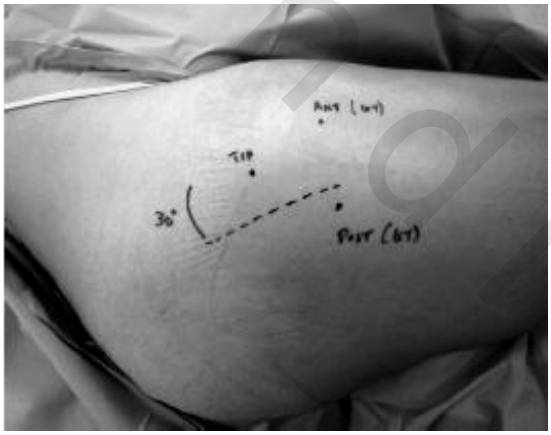

Fig. (44): Landmarks for skin incision.[92]

A 6 cm incision is made, starting one finger's breadth anterior to the posterior corner of the triangle, extending cranially and posteriorly at an angle of 30° to the long axis of the femur, such that two thirds of the incision is distal to the tip of the greater trochanter and one third proximal. In all but the very slimmest of patients, the incision is extended distally if there is inadequate access of the acetabulum or proximally for better access to the femur. In the non-obese patients, an incision of 7 to 10 cm is the normal. Longer incisions are needed in the obese or highly muscular patient. Sharp dissection is continued to gluteus maximus, which is split in the line of the incision, and fascia lata is split distally. The fascial layer overlying the short external rotators (SERs) is incised and fat is reflected posteriorly to reveal piriformis. Capsule is incised using cutting diathermy along the inferior border of piriformis from the edge of the acetabulum to the posterior border of the femur, the incision is continued distally in an "L" shape. Thus the posterior capsule and

tendons of the gemelli and obturator internus are detached as one from their insertion, and quadratus femoris may be partially detached to visualize the inferior part of the neck (Fig. 45 A & B). [92]

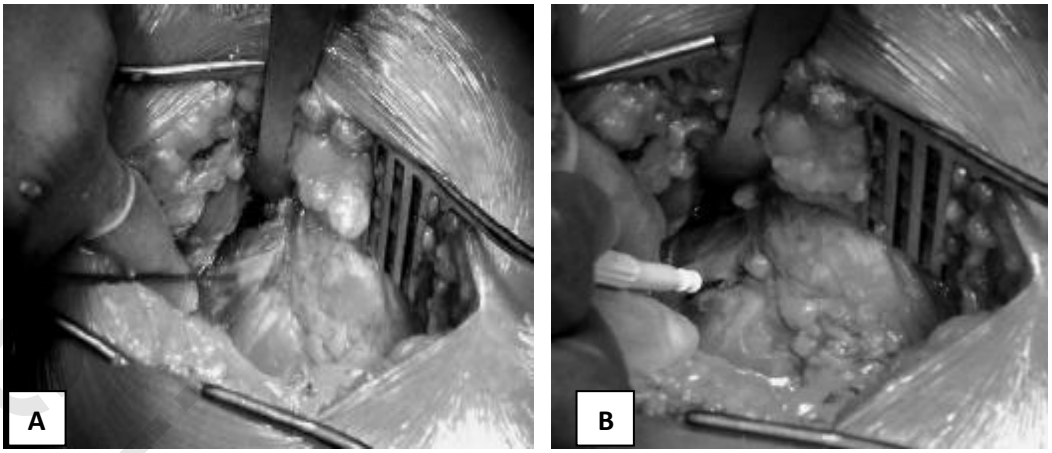

Fig. (45): **Left:** Hohmann retractor under posterior border of gluteus medius exposing piriformis. **Right:** capsular incision with cutting diathermy along inferior border of piriformis.[92]

The femoral head is removed then the neck is osteomized. Then femur is then prepared and the definitive components are inserted (Fig. 47 A & B), closure commences with repair of the posterior capsule, which is sutured to the back of the greater trochanter. At this stage, the entire posterior envelope has been reconstructed, the remaining tissues are closed in layers. Neither hip abduction wedge nor pillow is used. Patients are mobilized without restrictions (Fig. 46). [92]

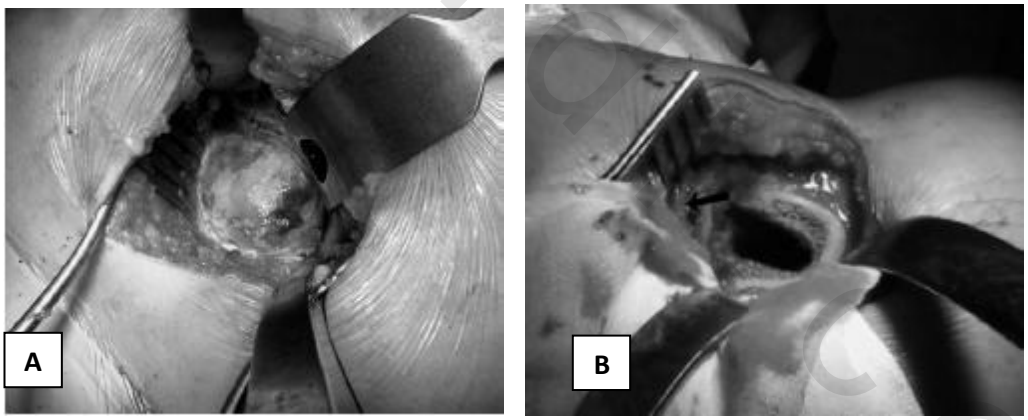

Fig. (46): **Left:** view of acetabulum (360°). Three Hohmann retractors are used: anterior, inferior, and posterior. **Right:** proximal femur delivered through incision, black arrow demonstrates intact piriformis tendon.[92]

Risks:

One of the main potential risks associated with this approach in particular is the risk of sciatic neuropraxia as a result of vigorous retraction to gain a better posterior view. If the view is in adequate then it is safer to extend the incision and have a longer scar than to risk sciatic injury. [95]

Advantages of minimally invasive hip arthroplasty:

The advantages of the MIS arise from the reduction in trauma to the soft tissue with dissection.

These advantages include:

- Shorter incision with better cosmesis (Fig. 47).
- Shorter hospital stay. [96]
- Decrease blood loss during surgery.
- Decrease postoperative pain.
- More rapid recovery of hip function and return to normal activity. [97]
- Less muscle dissection: piriformis and most of the quadratus femoris remain intact.[92]
- Postoperative rehabilitation is changed, instead of protected weight bearing with crutches or a walker for six weeks. Patients begin immediate weight bearing as tolerated, advancing to a cane as rapidly as possible, sometimes as early as 4 hours postoperatively. [93]

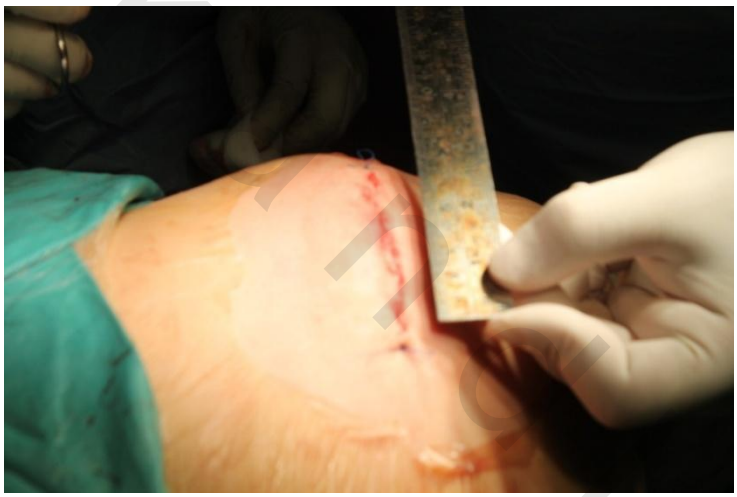

Fig. (47): Minimally invasive approach - Length of incision with a mean of 10.0 ± 1.75 cm

Disadvantages of minimally invasive hip arthroplasty:

- Longer operating room time.
- Needs for more assistants.
- Potential nerve injury.
- Unrecognized fractures.
- Recognized fractures.
- Malposition of the component. [96]

Contraindications of minimally invasive hip arthroplasty:

- Patient size may also be a limiting factor. In an obese or well muscled patient, it can be very difficulty to reach the deeper structures through a small incision. [95]

Complications of minimally invasive hip arthroplasty:

These complications are due to the reduced exposure.

- Neurovascular injury.
- Component malposition.
- Dislocation.
- Leg length discrepancy. [92]

However, it is unclear whether muscle trauma is really reduced as a result of the smaller sized access incisions and the lack of, or lower amount of, muscle detachment because, normally, the surgical hooks and retractors used during the operation exert a much greater pressure on, and cause extensive contusions in, the muscle tissue. [76, 82-89]

Indeed, measurable muscle damage has been identified in all the currently used minimally invasive approaches tested in cadaver studies. [26, 98-100]

The lower level of soft tissue trauma is particularly questionable for the mini-incision techniques. [26, 98-100] Woolson et al.[87,88] Goldstein et al. [101], Wright et al.[17,102], and Ogonda et al.[103] did not observe any objective clinical advantages of the mini-posterior approach when compared to the standard posterolateral approach. It must be said, however, that the minimal invasion in these studies was only at the level of a shorter skin incision.

In contrast, Sculco et al.[104-106]and DiGioia et al.[107] observed a smaller loss of blood and a faster postoperative recovery following a mini-posterior approach while Inaba et al.[89] and Dorr et al.[108] reported a lower level of postoperative pain and a more rapid recovery of muscle function using the same technique. However, the mini-incision technique used in these reports did not involve detachment of the quadratus femoris muscle.

Fink et al.[109] in 2011 investigate whether a minimally invasive posterior approach for total hip arthroplasty results in lower levels of muscle-derived enzymes and better postoperative clinical results than those obtained with the standard posterolateral approach fifty patients in both groups were compared in a prospective and comparative study. The minimally invasive operated patients exhibited a significantly lower loss of blood, significantly less pain at rest and a faster rate of recovery but the clinical chemistry values and the other clinical parameters were comparable. [109]

The double incision surgery and minimally invasive surgery seeks to reduce soft tissue damage through reducing the size of the incision. However, component positioning accuracy and visualization of the bone structures is significantly impaired. This can result in unintended fractures and soft tissue injury. Surgeons using these approaches are advised to use intraoperative x-ray fluoroscopy or computer guidance systems.[109]

Computer Assisted Surgery techniques are also available to guide the surgeon to provide enhanced accuracy. Several commercial CAS systems are available for use worldwide. HipNav was the first system developed specifically for total hip replacement, and included navigation and preoperative planning based on a preoperative CT scan of the patient. Improved patient outcomes and reduced complications have not been demonstrated when these systems are used when compared to standard techniques. [107,110]

❖ Longevity

The longevity of hip prosthesis means the lifespan of this prosthesis. The longevity depends upon a variety of factors including, Patient weight, Patient activity and the mechanical properties of the prosthesis. Current studies indicated that about 80% of prostheses will function well for 20 years. Charnley hips had about a 92% survival rate after 10 years while Muller curved hips had 82% survival rate after 10 years. [111-114]

❖ Postoperative course

After hip arthroplasty surgery, patients will be in the recovery room. Most patients are able to go to a regular room after a few hours, when the sensation returns in legs. On the day of surgery, patients may do some of the exercises as instructed by physical therapist, including buttock clenches and moving the feet up and down. Once patient regains the movement in the foot, they may be allowed to sit up, stand, and take a few steps with the assistance of a walker and a therapist. Generally, patients are able to walk as much as they want by six weeks postoperatively.[115]

Contraindications of hip hemiarthroplasty: [116]

1. Presence of systemic and/or hip infection.
2. Young age.
3. Charcot joint.
4. Inadequate bone stock, such as in severe hip dysplasia or when the femoral shaft is quite narrow.
5. Rheumatoid arthritis affecting the acetabulum.
6. Osteoarthritis.

Complications of hip hemiarthroplasty

Many authors reported that complications following the hemiarthroplasty of the hip joint affect the final results of the procedure. [117]

These complications are classified into early complications which are discovered or occur during operation or in the period of hospital stay (around 1 week); and late complications which occur later on. [117]

Early complications:

(1) Mortality:

Hip arthroplasty remains one of the safest, most reliable, and cost-effective surgical procedures. Although hip arthroplasty is generally regarded as safe, it has been associated with the risk of mortality. A large variation has been reported in the perioperative mortality rate, which has ranged from less than 1% to as high as 30 %. [118]

The potential risk factors which are associated with a significant increase in mortality rates include old age, female gender, and history of cardiorespiratory disease, cement fixation, and waiting period for surgery. [119]

The reason for the increased mortality among patients who have a hip fracture is likely multifactorial. First, and perhaps foremost, is that patients with hip fractures are, in general, older than patients who undergo elective hip arthroplasty and have a greater number of comorbidities. Second, the urgent nature of fracture treatment may predispose these patients to a greater risk in association with anesthesia because of the lack of adequate time for optimization of medical status before hip surgery. In addition, some fractures may occur in patients who have preexisting medical conditions, such as arrhythmia or cerebrovascular insufficiency that have anaesthetic risk. [120]

Life span of patients after hemiarthroplasty was estimated, 83.9% to 92.9% of patients lived for 4 months, 71.3% to 83.3% lived for one year and 50% lived for 5 years.[120]

(2) Infection:

Surgical-site infection (SSI) after hip arthroplasty can have serious consequences for the patient, may lead to revision surgery and have long-term effects on health and mobility. These infections impose a considerable economic cost both to health care and to patients and their families. [121] The reported incidence of infection after primary hemiarthroplasty varied from 2.1% to 7.1 %. [122]

Infection is more likely in patients with hip fractures undergoing hip arthroplasty than in those undergoing elective arthroplasty. [123]

- **Etiology:**

Patient factors:

Patient risk factors for deep postoperative infection include previous surgery of the joint, rheumatoid arthritis, corticosteroid therapy, diabetes mellitus, poor nutritional state, obesity and advanced age. Perioperative risk factors include a break in sterility during the operation, postoperative wound infection, postoperative urinary tract infection and an unhealed wound at discharge. [124]

Microbiology:

Both aerobic and anaerobic bacteria have been implicated in hip arthroplasty infections. Staphylococcus epidermidis which is part of normal skin flora and Staphylococcus aureus are the most common infecting organisms. [125, 126]

- **Classification:**

Coventry (1975) [126], and later Fitzgerald et al (1977) [127], described the most common system for the classification of infection in hip arthroplasty. This classification is based on the mode or timing of infection:

- **Type I infection (*Acute postoperative infection*)** originates at the time of operation and become symptomatic in the immediate postoperative period. The patient is usually seen during the first month after the operation, and the diagnosis can be made on the basis of

medical history and physical examination. Systemic signs of infection may be present, and there is usually continuous pain. The wound may be erythematous, swollen, fluctuant and tender and there may be purulent wound drainage on examination. These infections are caused by infected hematomas. Wound infection will spread to the periprosthetic space if not treated.[127, 128]

- **Type II infection (*Deep delayed infection)*** is also believed to originate at the time of operation, but the onset of symptoms in these cases is delayed. The patient is usually seen between six months and two years after the operation. This type of infection is associated with deteriorating function and increasing pain. Pain is often present from the time of the procedure, and it may be activity related or occur during rest. Early loosening of the components is often the only clue to infection, and systemic symptoms are not part of the presentation. The findings on examination are non specific. [127, 128]
- **Type III infection *(Late hematogenous infection)*** are the least common and are caused by hematogenous spread to the hip, which usually occurs two years after arthroplasty or later. Dental manipulation, catheter associated urinary tract infections and remote infections may trigger hematogenous seeding. Streptococci are more frequently isolated in this type of infections than in others. There is generally a febrile episode accompanied by sudden deterioration of the hip. This infection is likely to occur in patients who are immunosuppressed. [127, 128]

- **Clinical manifestations:**

Pain is the presenting symptom of most patients who have a deep infection. If the pain occurs while the patient is at rest, the physician should be alerted to the possibility that it represents an inflammatory process. [127]

Discharge is the second most common symptom and is strongly suggestive of an infection. It can occur within the first few days after the operation or weeks later. If it occurs within the first few days, it is typically either sanguineous, originating from a hematoma, or serous, originating from inflamed subcutaneous tissue. Discharge that occurs several days to weeks later is typically serous and, if left untreated or allowed to progress, will result in formation of a sinus tract. A history of prolonged discharge after the operation in a patient who has persistent pain can be very helpful in establishing the correct diagnosis. [129]

- **Investigations: [129]**

Helpful laboratory investigations include the erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). The white blood cell count is usually unhelpful and is often normal even in patients with an actively infected hip. CRP level is a sensitive indicator of postoperative infection; it reaches maximum values within 48 hours from surgery, returning to normal levels within 2 to 3 weeks. However the ESR may remain elevated for months after an uncomplicated hip arthroplasy. Therefore, a persistently elevated CRP is more accurate in identifying patients with a deep infection. It is essential to recognise that both ESR and CRP are nonspecific markers of inflammation that may be elevated in other conditions such as rheumatoid arthritis, neoplasia, collagen vascular disease, other inflammatory conditions and after a recent operation. [129]

Plain radiographs should be taken in all failed arthroplasties and can occasionally provide clues to infection, but they are neither sensitive nor specific for detection of infection. Radiographic findings including loosening, osteolysis and endosteal scalloping. Periosteal new bone formation has been considered by some to be suggestive of infection.[129]

Hip joint aspiration is useful when ESR and CRP levels are elevated in chronic inflammatory conditions. However, the reported rates of sensitivity and specificity have varied widely in the literature, with the sensitivity ranging from 0.50 to 0.93 and the specificity ranging from 0.82 to 0.97. Therefore, a strict aseptic technique is imperative to reduce false positive results as well as preventing iatrogenic periprosthetic infection. It is also essential that all antibiotics are discontinued several weeks prior to joint aspiration to reduce the number of false negative test results. [129]

Nuclear medicine studies are second-line investigations of patients with infected hip arthroplasty when serologic tests may be falsely elevated and aspiration cultures from the hip joint are unreliable because of the administration of antibiotics. However, its use is limited by cost, the time to undertake the procedure and because scans can remain positive for as long as one year after a hip replacement due the surgery itself or complications such as heterotopic ossification. Various isotopes including Technetium-99 m, Gallium-67 citrate, and Indium-111-labeled white blood cells have been used, resulting in a wide range of sensitivities and specificities in detecting periprosthetic infection. [129]

Intra-operative evaluation at revision THA, including tissue appearance combined with intra-operative gram stains, are unreliable for detecting periprosthetic sepsis. Intra-operative frozen section has been shown to be a useful tool for identifying infection during the revision procedure. Intra-operative culture, although assumed to be the gold standard for identifying periprosthetic infection, is subject to false-negative and false-positive results. As with joint aspiration, careful technique and withholding antibiotics for a few weeks preoperatively are essential in reducing false results. A minimum of five tissue samples should be sent to the laboratory for processing to rule out infection. [129]

- **Treatment:[129]**

The goals of surgical treatment are the eradication of the infectious process and the restoration of function of the affected limb. Restoration of function by maintaining or reinserting a prosthesis is preferred when it is medically possible. Operative debridement and antibiotic therapy are the mainstays of treatment. The debridement includes the excision of all infected and necrotic tissue and the removal of cement, wires, non absorbable sutures, and the prosthesis if it is not well fixed. [129]

Acute infection:

Debridement with component retention:

For early or late infections with a short duration of symptoms, stable components, no significant immunosuppression and overlying soft tissue and skin of good condition, irrigation and debridement with exchange of mobile parts (femoral heads and acetabular inserts) but retention of the infected implant has been advocated. The aim is the prevention

of the production of a biofilm by the infecting organism. Success rates in the literature range between less than 10% and more than 50%.[129]

Chronic infection:

Reimplantation into a sterile bed is the goal of treatment and can either be performed at the same stage of debridement as part of a single-stage procedure, using cemented components with spacer or, alternatively, as part of a two or multi-stage procedure where debridement and reimplantation are separated by a period of antibiotic delivery, both locally and systemically. [129]

i. Single-stage revision:

The advantage of simultaneous debridement and exchange of the prosthesis is the avoidance of additional surgical procedures for patients who have major medical problems.[129]

ii. Two-stage revision:

Two-stage reimplantation is the gold standard for the treatment of infected total hip replacements. The successful eradication of a THA infection is over 90%. The principles of two-stage revision include removal of the implant along with all cement and necrotic tissue which contain the infecting organisms, administration of systemic antibiotics postoperatively for 6 to 12 weeks followed by implantation of a new prosthesis. A patient is considered free of infection and able to proceed to second-stage arthroplasty when repeat joint aspirates after 4 weeks of discontinuing antibiotics are negative, and the ESR and CRP return to normal value. [129]

iii. Multi-stage revision:

A three-stage reimplantation procedure is suitable for treatment of extensive bone defects, and also is indicated when clinical presentation, blood parameters and cultures are suggestive of persistent infection requiring further debridement and possible repeat of antibiotic loaded cement to eradicate infection after the first stage of revision. [129]

iv. Long term suppressive antibiotics:

Chronic suppressive therapy for periprosthetic infections is indicated when an operation is refused by the patient or is has an unacceptable risk in medically unfit patients.[129]

(3) Dislocation:

When the bipolar hip hemiarthroplasty was introduced one of its proposed advantages was that the double joint within the implant would reduce the risk of dislocation occurring. Yassin and colleagues speculated the high friction interface between the prosthesis and acetabulum prevents dislocation. They suggested that the bipolar prosthesis had a lower dislocation rate. Iorio et al. also concluded that bipolar hemiarthroplasty should be used in patients with instability risks.[130, 131]

The prevalence of dislocation in bipolar arthroplasties during a 17-year period is about 1.5%. [132]

Factors predisposing to dislocation of hip hemiarthroplasty include the posterior approach to the hip, the length of the residual femoral neck, the version of the implant and acetabular dysplasia, muscle imbalance, and neurological conditions such as Parkinsonism, stroke, and dementia.[132]

The most significant determinant of dislocation is the approach, with the posterior approach having a dislocation rate over twice that of the anterior approach. [131]

Open reduction following dislocation was more comment after bipolars. Inter-prosthetic dislocation of a bipolar in which the head separates from the stem, invariably leads to open reduction. This may be less common now with many of the bipolar heads being factory fitted to prevent inter-prosthetic dislocation. An open reduction is still more common for a bipolar hemiarthroplasty even if inter-prosthetic dislocation does not occur, due to the movement of the bipolar head preventing reduction.[131]

(4) Thromboembolic complications:

Patients who undergo hip fracture surgery are at a very high risk for venous thromboembolic disease. Prospective studies using routine contrast venography found an incidence of thrombosis in 27 to 50 percent of patients who had not received prophylaxis. Without prophylaxis, the rate of fatal pulmonary embolism has been reported to be in the range of 1.4 to 7.5 percent within 3 months after hip fracture surgery.[133, 134]

The perioperative state exacerbates the three risk factors for venous thrombosis: stasis, vascular damage, and hypercoagulable state. Venous stasis results from positioning of the limb during the procedure, localized postoperative swelling, and reduced mobility after the operation.Endothelial injury may occur both at the time of injury as well as during positioning and reduction of the fracture. The trauma causing a hip fracture can result in sustained activation of clotting factors, which subsequently localize at sites of vascular injury and areas of venous stasis. Furthermore, blood loss at the time of injury and during the surgery results in a reduction of antithrombin (AT) III levels and inhibition of the endogenous fibrinolytic system, which allows thrombus growth and propagation. Finally, Wilson and colleagues have demonstrated a significant increase in blood coagulability in both the immediate postoperative period and 6 weeks after a proximal femur fracture. Hypercoagulability was also correlated with an increased. [135, 136]

The risk factors that increase the incidence of deep venous thrombosis (DVT):[137]

- Age older than 40 years.
- Prolonged immobility or paralysis.
- Major surgery (abdomen, pelvis, lower extremity).
- Nephrotic syndrome
- Cancer.
- Prior DVT.
- Obesity.
- Heart failure and stroke

(5) Periprosthetic fractures:

Periprosthetic femoral fractures are a recognized complication of both total hip arthroplasty and hemiarthroplasty, and can occur intraoperatively or postoperatively. Usually, they occur at low energy levels, either after a fall or spontaneously during activities of daily living. A number of risk factors have been identified, including osteoporosis, female gender, cortical perforation, loosening and the use of uncemented implants.[138]

Patients who sustain a periprosthetic femoral fracture often require further surgery, and since many of these individuals are elderly with coexisting medical problems, revision surgery is associated with an overall increase in morbidity and mortality. Minimising the risk of this potential complication is therefore important since the treatment of periprosthetic fractures is often complex, expensive and associated with high complication rates.(138)

Bone cement may act to reinforce the proximal femur, improve load distribution and hence protect against shaft fracture. This may explain the low incidence of periprosthetic fracture with cemented prostheses.(138)

(6) Nerve injury:

Sciatic, femoral, obturator or peroneal nerve palsies can occur by direct surgical trauma, traction, pressure from retractor, extremity positioning, limb lengthening, thermal or pressure injury from cement, compression from hematoma and dislocation.(53)

Late complications:

(1) Heterotopic ossification:

Heterotopic ossification (HO) is the abnormal formation of mature lamellar bone in soft tissues. It was first described in 1883 by Reidel. (139) HO is most commonly classified using the Brooker system. This is based on the appearance of ossification on a plain anteroposterior radiograph of the hip.(140) (Fig 48)

HO following primary replacement of the hip is typically asymptomatic and is most commonly identified as an incidental radiological finding. When symptomatic, it presents with a reduced range of movement. Pain is uncommon, but can occur. Soft tissue signs include localised warmth, mild oedema and erythema which may be misdiagnosed as signs of infection. (141)

HO can be detected on a bone scan as early as three weeks after operation, with increased uptake in the soft tissues surrounding the hip. Plain radiographs will not reveal any abnormality for four to six weeks. (142)

The etiology of HO can be broadly divided into traumatic, neurological and genetic, that following arthroplasty falling into the traumatic group. The abductor compartment is most commonly involved. (142)

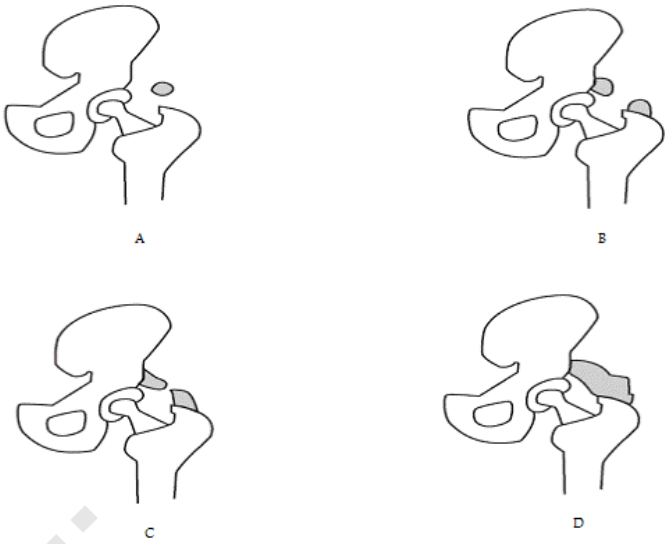

Fig. (48): **Brooker classification of HO** showing A) grade 1: islands of bone within the soft tissues about the hip, B) grade 2: bony spurs from either the femur or the pelvis, with a gap of more than 1 cm between opposing bony ends, C) grade 3: the gaps between the spurs are less than 1 cm and D) grade 4: apparent ankylosis of the hip due to the heterotopic ossification. (142)

Risk factors for HO around the hip include male gender, old age, and a history of HO in the ipsilateral or contralateral hip, a preexisting hip fusion, hypertrophic osteoarthritis, ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis, Paget's disease, posttraumatic arthritis, osteonecrosis, and rheumatoid arthritis. Patients with a previous history of HO in an ipsilateral joint are at greater risk of developing HO than those in whom previous HO was on the contralateral side. (142)

Risk factors that are related to surgical technique include the extent of soft tissue dissection, bone trauma, persistence of bone debris (reamings, marrow or dust within the surgical field) and the presence of a haematoma.(143)

Conservative management includes intensive physiotherapy during the maturation phase of the disease in an attempt to limit the final stiffness.(92) Surgical excision after maturation of the ossification, typically at 12 to 24 weeks, and can be expected to improve the functional outcome. (143)

HO following replacement of joints in the lower limb is common but rarely results in significant symptoms. There is no indication to give prophylactic treatment following routine replacement. (142) Primary prevention may be advocated for high risk patients, the two main lines of prophylaxis available are radiation therapy and NSAIDs. (142)

(2) Aseptic loosening:

Aseptic loosening is the bone loss that results from biological processes occurring at the metal-bone or cement-bone interface, and it is considered the most common cause of failure of total joint replacements, being responsible for 79% of failures of total hip replacements.(144) The phenomenon of aseptic loosening is a consequence of the host response to debris originating from the prosthetic devices. This debris may originate from several interfaces comprising the joint reconstruction including the articulating surfaces, modular component surfaces, fixation surfaces, and devices used for adjuvant fixation. (145)

The precise pathogenesis of the process remains controversial, but Central to all theories of aseptic loosening is the development of a 'synovial-like membrane' between the implant and bone. The membrane was found to consist of three distinct histological layers: a synovial-like layer, one or two layers cells at the cement surface; a middle zone of fibro-vascular tissue with sheets of granular histiocytes (tissue macrophages) and other mononuclear cells (lymphocytes and mast cells) interspersed among multinucleate foreign-body giant cells and a fibrous layer that blends into the marrow spaces between bone. Conditioned media from in vitro culture of this tissue has been shown to cause bone resorption and the cells within the membrane that are implicated in this resorption are found to be the macrophages and giant cells.(146)

Theories: (147)

1) Particle disease

Particles of prosthetic wear debris are found in enormous numbers in the synovial-like membrane surrounding aseptically loose joint replacements. The number of particles present has been found to correlate with the size of osteolytic defects. Particles of all components of joint replacements, i.e. polyethylene, bone cement and metal/alloy have been identified within the membrane, the vast majority being sub-micron in size.

The role of particulate debris in the pathogenesis of aseptic loosening has been linked to the presence of tissue macrophages in the synovial-like membrane around the implant. These cells are believed to phagocytose wear particles and release the inflammatory cytokine. Tumour necrosis factor alpha (TNFa), Interleukin-1-beta (IL-1b) and Interleukin-6 (IL-6) have been shown to be released by macrophages in response to particulate debris, to stimulate osteoclast activation and differentiation and reduce osteoblast proliferation. Thus the normal balance between bone deposition and resorption is lost, resulting in net bone loss and osteolysis. It has also been suggested that particle-stimulated macrophages may themselves resorb bone or actually differentiate into osteoclasts.

The role of the immune response in prosthetic loosening remains controversial Lymphocytes are present in the synovial-like membrane and some researchers have found cutaneous sensitivity to prosthetic metals in patients with loose implants.(145)

2) Other theories include: micromotion, stress shielding, endotoxins, and sealed interface theory.

Clinical picture:

Pain is an unreliable parameter for evaluation of the stage of loosening. Pain in the thigh is often reported by patients with firmly fixed large or cylindrical stem implants. Circumferential pain, pain while resting and pain in the proximal femur are often reported by patients with femoral shaft osteolysis without component loosening. But it is pain when beginning to walk and on weight-bearing or thigh pain (stem loosening) when standing and walking that indicates that loosening has begun. Typically the pain may radiate into the groin, the buttocks and the ipsilateral knee. Relatively soon the distance and duration of the patient's ability to walk become progressively shorter, and this is accompanied by a feeling of insecurity, the tendency to fall or the impression of no longer being able to control the leg properly. Anewly developed leg length discrepancy indicates an advanced stage of loosening with stem migration or subsidence.(147)

Radiological evaluation[147]

There are 10 diagnostic criteria:

1. Lytic lines. at the implant-bone, implant-cement or cement-bone interface. If the patient is pain-free, a line of lysis does not necessarily constitute evidence of loosening and needs only to be monitored regularly. Circumferential lines of lysis >1 mm or lines >2 mm that cover more than one-third of any of the 14 Gruen zones(stem) on the anteroposterior or lateral radiograph are suspect loosening.
2. Osteolysis. appears as circular or oval patches in the bone. The Formation within the first six months of osteolytic zone at the stem which does not progress any further is not pathological. The most important factor is therefore the increase in size. Isolated lysis of >2 mm has a certain predictive value for early loosening.
3. Vertical subsidence of the stem implant. The vertical distance between the tip of the greater trochanter and the centre of the prosthesis head or the distance between the lower edge of the collar and the upper edge of the lesser trochanter is used as a reference value. Subsidence of 1.5–2.0 mm in the first two years (threshold value) has a certain predictive value with regard to early loosening of the stem. The increase in the speed of migration is the most certain sign of the onset of loosening. Therefore regular radiographic controls at intervals of 3–6 months are necessary
4. Bone resorption at the calcar and implant shoulder.
5. Proximal osteopenia
6. Femoral bone remodelling.
7. Altered position of the stem. Increasing varus or valgus deviation of the prosthetic stem with are clear signs of loosening. Periprosthetic fractures of the femur are frequently the first indication of latent or undiagnosed loosening
8. Quality of the cement mantle. A cement mantle that is incomplete, inhomogeneous or less than 2-mm thick in any of the Gruen zones, early radiolucent lines at the bone-cement interface and the absence of a cement coating around the stem tip are certain indications that early loosening of cemented prostheses will occur. Fractures in the cement mantle are a sign that loosening of the stem or cup is already in progress.
9. Heterotopic ossifications.
10. Implant damage and fracture of other fixation material. Fracture of a stem is usually the result of proximal loosening of a prosthesis that is still firmly fixed at the distal end.

❖ **Harris'criteria for diagnosis of loosening: [147]**

Definite loosening:

1- Migration. (Migration is defined as change in position of the prosthesis, cement mantle, or both
2- Fracture of the cementmantle or prosthesis
3- Appearance of a radiolucent line at the stem cement junction that did not exist on the immediate post-operative radiographs

Probable loosening: Continuous radiolucent zone at the cement bone interface, surrounding the entire cement mantle (i.e.100%) on either APor lateral radiograph.

Possible loosening: Radiolucent zone between the cement and bone of 50-99% of the cement bone interface on either AP or lateral radiograph, that was not present on the immediate post-operative radiograph.

Management of loosening:

If evidence of stem loosening develops, even in the absence of symptoms, the patient is followed closely for further loosening, bone absorption or stem failure. The patient is urged to reduce his/her activities and use a walker support, and is warned that revision may be necessary. (125)

Revision is indicated if loosening is definite and symptoms are sufficient to justify a major operation. (125)

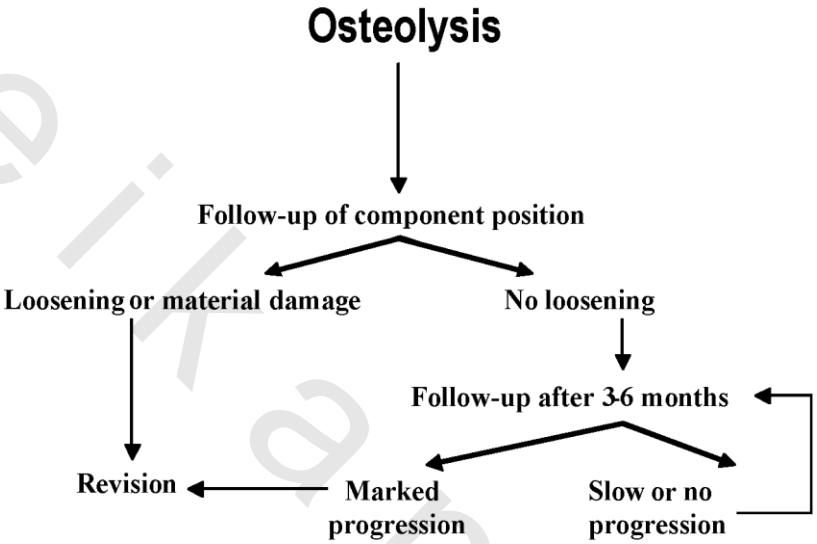

Fig. (49): Algorithm for treatment of aseptic loosening and osteolysis.(147)

(3) Acetabular erosion:

As a treatment for displaced fractures of the femoral neck, hemiarthroplasty has an excellent record with regard to its ability to restore the functional level of activity. However, there have been concerns about the fate of the acetabular cartilage that articulates with these prostheses and about the risk that protrusio acetabuli may develop. Indeed. it is a commonly held belief that articulation with metal may hasten the degeneration of the adjacent articular cartilage.(148,149)

The bipolar endoprosthesis was developed to provide motion at a second interface in order to address concerns that direct articulation with metal could cause erosion of cartilage and bone. (149)

Special factors predisposing to acetabular erosion: active patients, obesity (also was a factor in the development of erosion, but less than activity) and osteoporosis. (150)

The reported incidence of erosion of the acetabulum after hemiarthroplasty varies widely. With single component prostheses it varies from zero to 64%, and with biarticular prostheses, from zero to 9%. (150)
Pain is the symptom which is severe and even at rest associated with decreased range of movements. (150,151)

The acetabular response to the bipolar is a controversial issue in hip reconstruction. Devas and Hinves reported no acetabular erosion over a four year period of implantation of bipolar implant in 161 femoral neck fractures. By contrast Leyshon and Matthews using Monk hard top prosthesis for 162 femoral neck fractures had an alarming incidence of acetabular erosion necessitating revision in seven patients after 3 years. (150)

(4) Distal migration:

Distal migration of the prosthesis in the femur sometimes accompanies loosening of its stem but more often does not. Any measurement of the amount of settling, determined by comparing late radiographs with early ones, is of course a rough estimate. (152) Distal migration of prosthesis could possibly be caused by pressure stresses, lack of blood supply, but the actual cause is not clear. It is not always painful. (153)

(5) Stem failure:

Prosthetic component failure occurs in total hip arthroplasty infrequently. Fractures of hemiarthroplasty components are extremely uncommon. Cemented femoral prostheses have been known to fracture through the head neck junction or further down the stem with an incidence varying between 0.23% and 0.27 %.(154)

(6) Painful endoprosthesis:

Groin pain is one of the most common indications for revision after previous hemiarthroplasty. Pain is usually due to articular cartilage degeneration in the acetabulum, loosening of the prosthesis in the proximal femur, a combination of the two, or sepsis.(155)

These pathological processes are exacerbated by many factors including incongruencies between the femoral head and the acetabulum; the use of cement; excessive neck length; impaction at the time of injury; physiologically young, active patients; and shear forces between the prosthesis and the cartilage.(155)

Failure of bipolar hemiarthroplasty has been reported to occur at different rates, depending on type of prosthesis. Various studies have reported clinical failure rate from 19% to 37% and revision rate from 7% to 21%. More recently, 2 additional indications for conversion of bipolar prosthesis have been added: disassembly and wear which significantly increased in young active patients.(155)

There are other causes of painful prosthesis: (155)

- Improper prosthetic seating*:* If the prosthetic head is more than one half of an inch above the top of the greater trochanter, the neck is too long. Excessive anteversion, retroversion, or varus can also cause pain. They can be prevented by precise technique and should be corrected if they cause difficulties.
- Metallic corrosion and tissue reaction: stainless-steel prostheses can cause a marked synovial reaction, Replacement with Vitallium prostheses resulted in prompt relief of pain.
- Improper head size*:* A prosthetic head must be fit the acetabulum accurately. When a head is too small, it causes pain by pressure because of the limited area of contact; when it is too large, it compresses the joint surface at the ring of contact and causes pain.
- Redundant ligamentum teres: Failure to remove a large ligamentum teres from the acetabulum can produce pain.