INTRODUCTION AND AIM OF THE ESSAY

The last three decades have seen the development of minimally invasive surgery (MIS) techniques in a range of specialties, including abdominal surgery, thoracic surgery, and neurosurgery. Orthopedics has been no exception, with MIS techniques used to perform operations on several joints, such as the knee, shoulder, wrist, ankle, and hip. [49]

The definition of what constitutes Mini-Invasive Total Hip Arthroplasty (MITHA) has yet to be finalized, but at present, the term MITHA may be applied to any hip replacement procedure in which the length of the wound and the surgical access are deliberately modified in an attempt to reduce the tissue trauma associated with hip replacement, with most investigators reporting wounds of 10 cm length or less. The minimum length of the incision that can be used without skin stretch is determined by the diameter of the acetabular component that is to be used. [40]

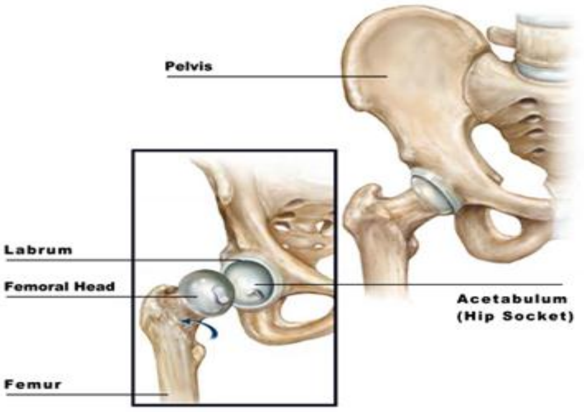
Several techniques of MIS hip arthroplasty have been described, and the authors have found it useful to divide the various MIS approaches into two main categories: the minimal incision approaches and the two-incisions approach. The minimal incision approaches are modifications of the standard posteriolateral **(Kocher Langenbeck)** anterior **(Smith-Peterson)**, lateral **(Hardinge)** and superior capsulotomy approaches that are performed through wounds 7-10 cm in length. The two-incisions approach includes anterior incision for acetabulum and posterior incision for the femur. [26]

Whichever technique is used, the reduced length of incision and the reduced dissection mean that exposure may be difficult using standard instruments. The development of MIS hip arthroplasty therefore has been accompanied by the development of specialized instruments designed to facilitate exposure and bony preparation. [62]

This Essay aims to study mini invasive T.H.A. considering techniques, surgical instrumentation, advantages& disadvantages, in comparison with conventional T.H.A. with stressing on intraoperative blood loss, operative time and postoperative pain, rehabilitation and recovery time. [49]

Surgical Anatomy Of Hip Joint

The hip joint is multi-axial, synovial and of ball and socket variety **(Fig.1)**. [55] Although the hip joint has high degree of stability it has wide range of movement. [53]



(Fig.1): Hip joint is of ball and socket variety. [38]

The acetabulum is formed by fusion of the three components of the hip bone; Ilium, Ischium, and pubis, which meet at a Y-shaped cartilage forming their epiphyseal junction. This epiphysis closes after puberty. The head of the femur is spherical and is adapted to the concavity of the articular surface of the acetabulum. The neck of the femur is narrower than the equatorial diameter of the head and considerable movement in all directions is possible before the femoral neck impinges upon the acetabular labrum. [20]

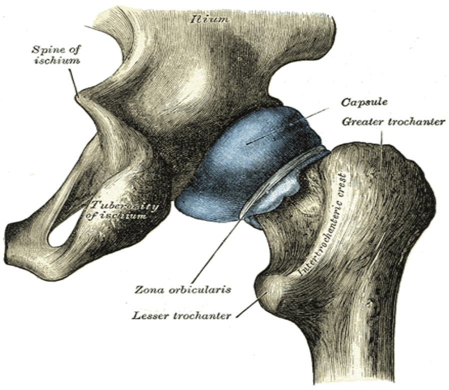
The ligaments of the hip joint are [25]:

The Articular Capsule.

The Iliofemoral.	The Ligamentum Teres Femoris.
The Pubocapsular.	The Acetabular Labrum.
The Ischiocapsular.	The Transverse Acetabular.

The Articular Capsule

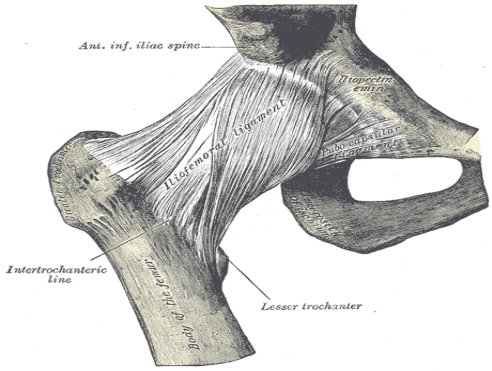
The articular capsule is strong and dense **(Fig.2),** above, it is attached to the margin of the acetabulum 5 to 6 mm. beyond the acetabular labrum behind; but in front, it is attached to the outer margin of the labrum. It surrounds the neck of the femur, and is attached distally, in front, to the intertrochanteric line, behind, to the neck, about 1.25 cm above the intertrochanteric crest. It consists of two sets of fibers, circular and longitudinal. [55]



(Fig.2) Capsule of hip-joint (distended). Posterior aspect. [38]

The Iliofemoral Ligament

The iliofemoral ligament is a band of great strength which lies in front of the joint **(Fig.3);** "most important ligament", it is intimately connected with the capsule, and serves to strengthen it in this situation. It is attached, above, to the lower part of the anterior inferior iliac spine; below, it divides into two bands, one of which passes downward and is fixed to the lower part of the intertrochanteric line; the other is directed downward and lateralward and is attached to the upper part of the same line. This ligament is frequently called the Y-shaped ligament of Bigelow; and its upper band is sometimes named the iliotrochanteric ligament. [20]



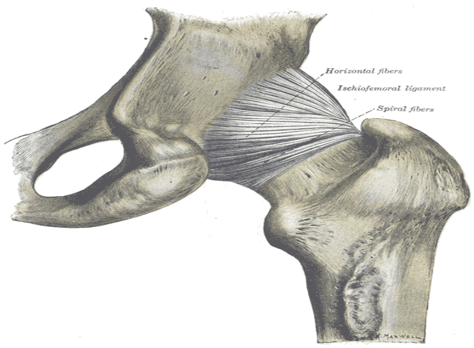
(Fig.3) Right hip-joint from the front [55]

The Pubocapsular Ligament

This ligament is attached, above, to the obturator crest and the superior ramus of the pubis; below, it blends with the capsule and with the deep surface of the vertical band of the iliofemoral ligament. [22]

The Ischiocapsular Ligament

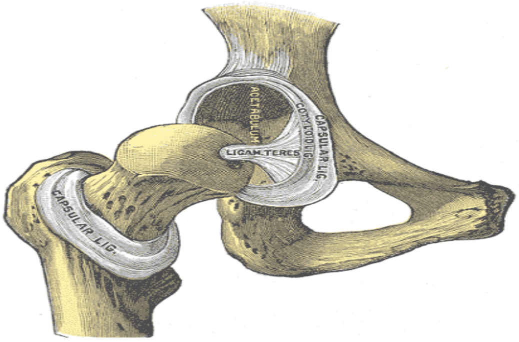
The ischiocapsular ligament consists of a triangular band of strong fibers **(Fig.4)**, which spring from the ischium below and behind the acetabulum, and blend with the circular fibers of the capsule. [55]



(Fig.4) The hip-joint from behind**.** [55]

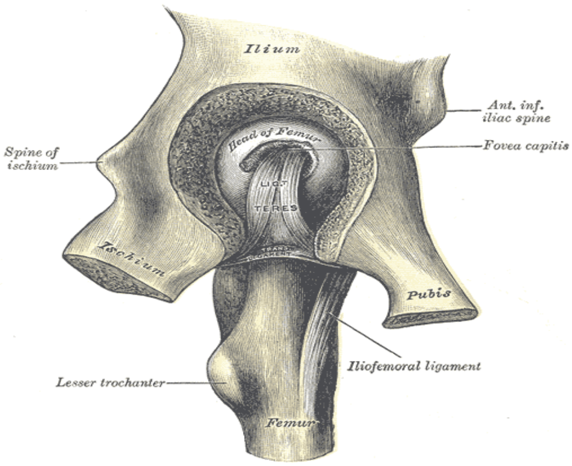
The Ligamentum Teres Femoris

The ligamentum teres femoris is a triangular, somewhat flattened band implanted by its apex into the antero-superior part of the fovea capitis femoris **(Fig.5)**



(Fig.5) Hip-joint, front view. The capsular ligament has been largely removed. [38]

its base is attached by two bands **,**one into either side of the acetabular notch, and between these bony attachments it blends with the transverse ligament. **(Fig.6)**. [25]



(Fig.6) Left hip-joint, opened by removing the floor of the acetabulum from within the pelvis. [55]

The Acetabular Labrum

The acetabular labrum is a fibrocartilaginous rim attached to the margin of the acetabular cavity of which it deepens. [55]

The Transverse Acetabular Ligament

This ligament is in reality a portion of the acetabular labrum. It consists of strong, flattened fibers, which cross the acetabular notch, and convert it into a foramen through which the nutrient vessels enter the joint. [53]

The Synovial Membrane

It is very extensive commencing at the margin of the cartilaginous surface of the head of the femur, it covers the portion of the neck which is contained within the joint; from the neck it is reflected on the internal surface of the capsule, covers both surfaces of the acetabular labrum and the mass of fat contained in the depression at the bottom of the acetabulum, and ensheathes the ligamentum teres as far as the head of the femur.[22]

The Muscles

In relation with the joint are, in front, the Psoas major and Iliacus, separated from the capsule by a bursa; above, the reflected head of the Rectus femoris and Gluteus minimus, the latter being closely adherent to the capsule; medially, the Obturator externus and Pectineus; behind, the Piriformis, Gemellus superior, Obturator internus, Gemellus inferior, Obturator externus, Quadratus femoris and above them Gluteus maximus and laterally Gluteus medius. [25]

The Arterial Supply

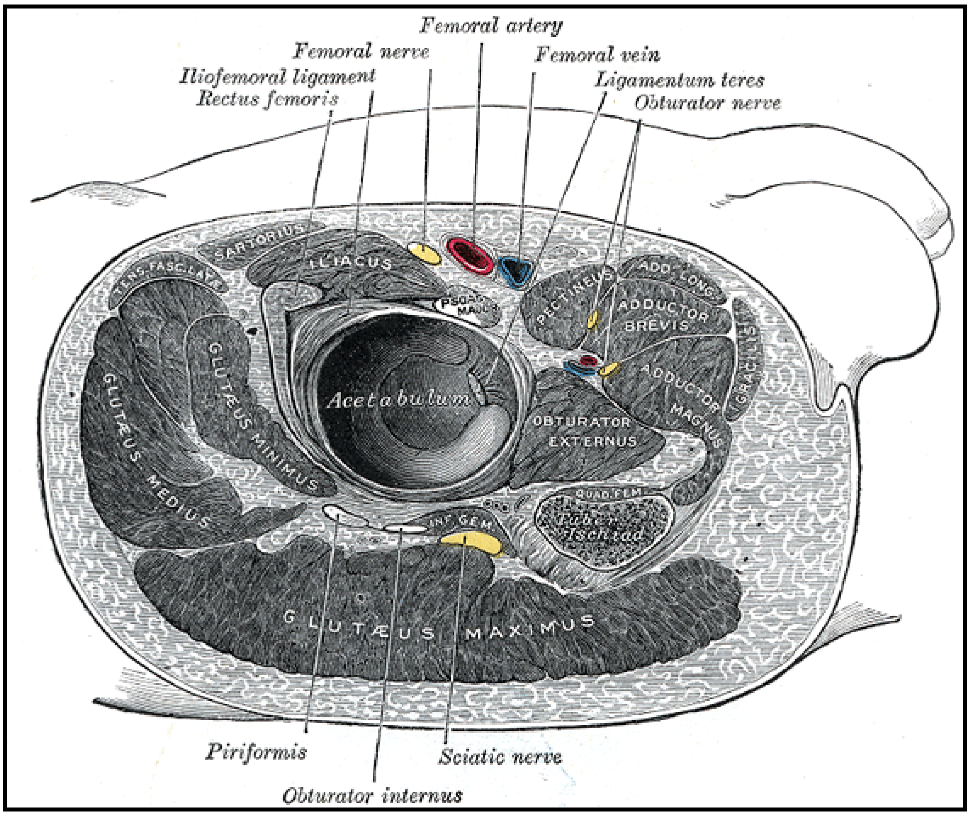
Arteries supplying the joint are derived from the obturator, medial femoral circumflex, and superior and inferior gluteals.[53] The arterial supply of the proximal end of the femur is described in three groups: an extracapsular ring located at the base of the neck; the subsynovial intraarticular ring for the superior part of the neck and arteries of the round ligament. [55]

The Nerves

They are articular branches from the sacral plexus, sciatic, obturator, accessory obturator, and a filament from the branch of the femoral supplying the Rectus femoris. All innervate the capsule and retinacular fibers. [55]

Relations Of The Hip Joint

The hip joint capsule is surrounded by muscles, **anteriorly**, lateral fibers of pectineus separate its most medial part from the femoral vein; lateral to this the tendon of psoas major, with iliacus lateral to it. The femoral artery is anterior to the tendon, the femoral nerve deep in a groove between the tendon and iliacus ,more laterally the straight head of rectus femoris crosses the joint with a deep layer of the fascial iliotibial tract, **superiorly**, the reflected head of rectus femoris and gluteus minimus, **inferiorly**, lateral fibers of pectineus adjoin the capsule and more posteriorly, obturator externus spiralizes obliquely to its aspect, **posteriorly**, the lower capsule is covered by the tendon of obturaor externus, separating it from quadratus femoris and accompanied by an ascending branch of the medial circumflex femoral artery, above this the tendon of obturator internus and the gemelli contact the joint,separating it from the sciatic nerve, **(Fig.7)**. [55]



(Fig.7) Structures surrounding left hip-joint**.** [38]

Movements of the Hip Joint

The movements of the hip are very extensive, and consist of flexion, extension, adduction, abduction, circumduction, and medial and lateral rotation of the femur. [53]

Surface Anatomy

The top of the greater trochanter normally corresponds to the level of the hip joint, and trochaneric elevation is one of the commoner manifestations of joint abnormality. [53]

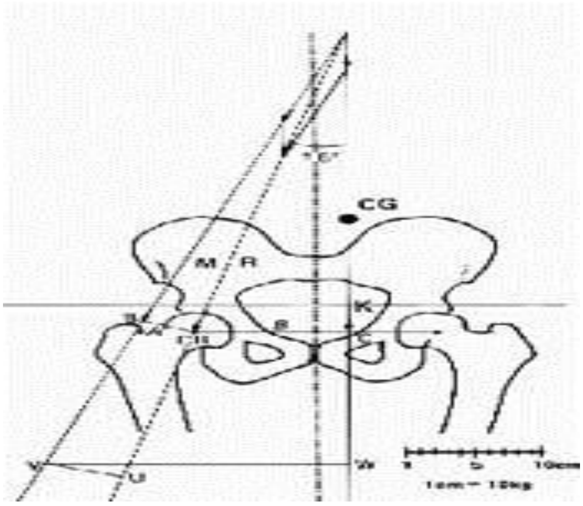
BIOMECHANICHS OF TOTAL HIP ARTHROPLASTY

A basic knowledge of the biomechanics of the hip of total hip arthroplasty is necessary to properly perform the hip replacement surgery. To successfully handle the problems that may arise during and after surgery, to intelligently select the components and to counsel patients concerning their physical activities. [29]

Mechanical problems associated with total joint replacements include issues related to wear of the bearing surface, mechanical failure of the implant, loosening of the implant from the bone, and dislocation of the implant at the articulating surfaces. [5]

Forces About the Hip

To describe the forces acting on the hip joint, the body weight may 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 in a one-legged stance, and greater moment to tilt the pelvis to the same side when walking or running. Since the ratio of the length of the lever arm of the body weight to that of the abductor muscles 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. when lifting, running, or jumping, the load may be equivalent to 10 times the body weight. Therefore excess body weight and increased physical activity add significantly to forces that act to loosen, bend or break the stem of the femoral component **(Fig.8)**. [29]



(Fig.8) Forces of the hip in single leg stance G, Center of gravity; M, muscle forces; K, effect of partial body weight; R, resultant vector. [36]

Centralization of the Femoral Head and Lengthening of Abductor Lever Arm

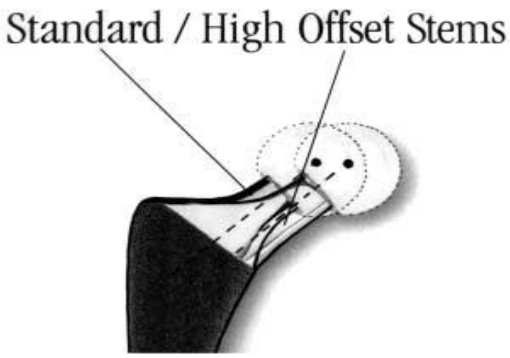
An integral part of the concept of total hip arthroplasty is to shorten the lever arm of the body weight by deepening the acetabulum; centralization of the femoral head, and to lengthen the lever arm of the abductor mechanism by reattaching the osteotomized greater trochanter laterally. Thus the movement produced by the body weight is decreased, and the counter-balancing force that the abductor mechanism must exert also is decrease. [13]

Neck Length and Offsets

The ideal femoral reconstruction reproduces the normal center of rotation of the femoral head. This location is determined by three factors:

- Vertical height (vertical offset)
- Medial offset (horizontal offset or simply offset)
- Version of the femoral neck (anterior offset)

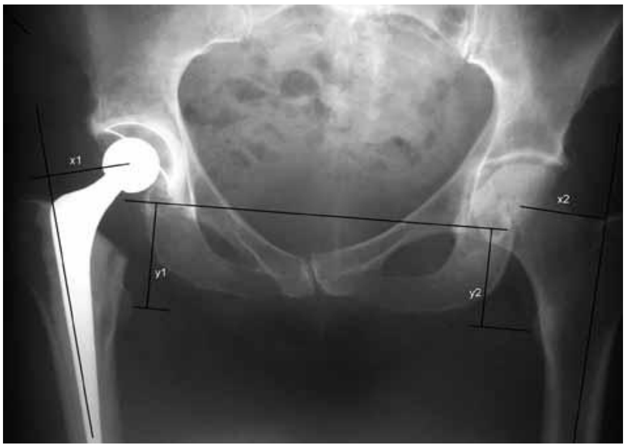
Vertical height and offset both increase as the neck is lengthened and proper reconstruction of both features is the goal when selection the length of the femoral neck. Neck length is adjusted by using modular heads with variable internal recesses that fit onto a Morse taper on the neck of the stem. Neck length typically ranges from 25 to 50 mm, and adjustment of 8 to 12 mm for a given stem size routinely is available **(Fig.9)**. [13]



(Fig.9) higher offset is achieved by medialization of the femoral neck. [13]

The vertical height of the femoral head usually is measured as the distance to the center of the head from a fixed point, such as the lesser trochanter,but the medial offset is the distance from the center of the femoral head to a line through the axis of the distal part of the stem, **(Fig10-Fig11)**. [13]

(Fig.10) Measurement of medial offset and limb length inequality in preoperative radiograph. [2]

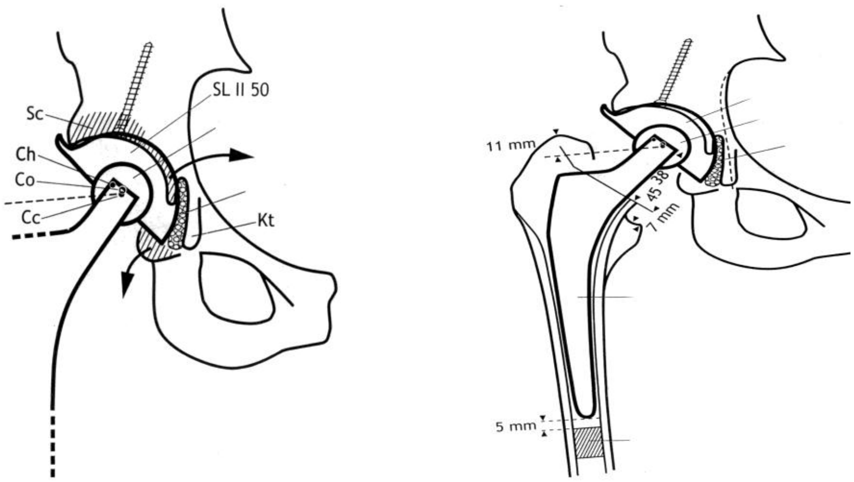


(Fig.11) Postoperative radiograph showing the measurements (medial offset). [2]

Coefficient of Friction and Frictional Torque

The coefficient of friction is the measure of the resistance encountered in moving one object over another. It varies according to the material used, the finish of the surfaces of the materials, the temperature and whether the device is tested in the dry state with a specific fluid as a lubricant. Load may be another factor. The coefficient of friction of normal joint has been estimated as 0.008 to 0.02. The aim is always to try to get as low coefficient of friction of the prosthesis as much as possible and to try to approach the normal value. [5]

A Frictional torque force is produced when the loaded hip moves through an arc of motion, frictional force depends on the coefficient of friction, the applied load and the surface area of contact between the head and the socket. If two hip joints with different size heads are put through the same arc of motion and are subjected to the same load, the frictional torque force of the smaller head will be less. This frictional torque force is transmitted to the cup, the stem of the femoral component **(Fig.12)**. [29]



(Fig.12) Transmission of frictional torque force to the prosthesis parts. [29]

PATIENT SELECTION

Who is a candidate for the new procedure? Virtually all patients undergoing first-time hip replacements. Of course it depends on the anatomy and nature of arthritic deficiency. Some surgeons have ruled out using the procedure on obese patients or those with dense musculature. According to the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS); the THR surgery used to be an option primarily for people over 60 years of age, but in recent years, doctors have found that hip replacement surgery can be very successful in younger people as well. [42]

Patient selection for less invasive surgery is evolving. Some surgeons define the ideal patient as young, thin, healthy, and motivated. Other surgeons, however, have offered this type of surgery to most or all of their patients. Some of these selection criteria are difficult to quantify, which further confounds evaluation of this type of surgery. [52]

Minimally invasive total hip arthroplasty is better not to be attempted on patients with a history of significant hip operations (including those with existing orthopedic implants), those with significant deformity, morbidly obese patients, or patients with significant or uncontrolled co-morbidities, so the rise in obesity world-wide may prohibit more and more patients with disabling hip arthritis from being optimal candidates for a so-called minimally invasive procedure. Proponents of the procedure recommend a Body Mass Index of less than thirty for performing minimally invasive techniques. [12]

Because of faster recovery times, postoperative care is a critical component of managing patients after minimally invasive THA. Special consideration must be given to the type of anesthesia, physical therapy, blood management, thromboembolic prophylaxis, and wound care applied postoperatively. [58]

SURGICAL APPROACHES OF T.H.A.

The most frequently used approaches to the hip are the anterior, anterolateral, posterior, lateral and posterolateral approaches, with or without trochanteric osteotomy. [17]

Anterior Approach (*Smith-Petersen*)

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 the outer surface of the iliac crest to the anterosuperior iliac spine. The incision is then continued distally for approximately 10 cm along the lateral aspect of the femoral shaft **(Fig.13)**. Then dissection is done between the sartorius (innervated by the femoral nerve) and the tensor fascia lata (innervated by the superior gluteal nerve). The leg is rotated externally to stretch the sartorius. 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 **(Fig. 14)**. 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 **(Fig.15)**. [49]

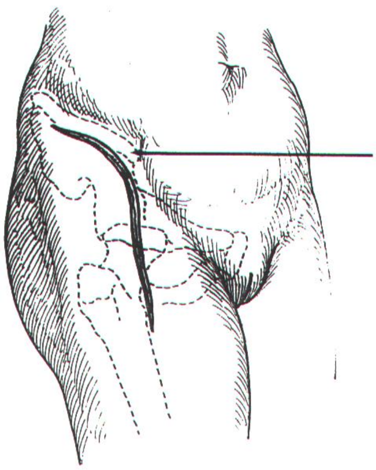


Fig.13. Incision for the anterior approach begins along the iliac crest and curves distally at the anterosuperior iliac spine**.** [17]

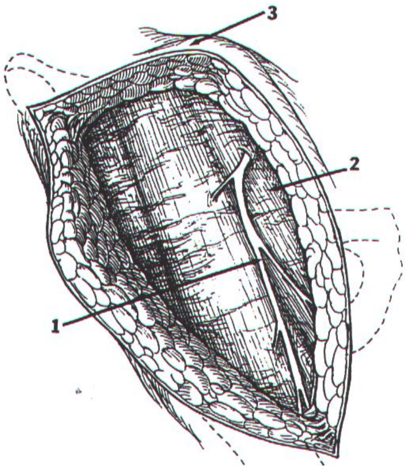


Fig.14. Lateral femoral cutaneous nerve (1) usually crosses the sartorius (2) approximately 4 to 5 cm distal to the anterosuperior iliac spine (3). [17]

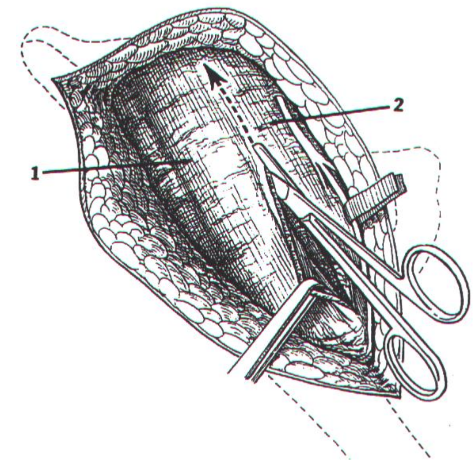


Fig.15. The nerve is retracted medially and the fascia split between the tensor fascia lata (1) and the sartorius (2). [17]

The iliac origin of the tensor fascia lata is elevated from the outer table of the ilium with a periosteal elevator, allowing visuaIization in the interval of the rectus femoris muscle where the ascending branch of the lateral femoral circumflex artery is ligated or coagulated **(Fig. 16)**. The exposure may be improved by releasing the sartorius from its attachment to the anterosuperior iliac spine. Next, the rectus femoris muscle is detached from its origins on the anteroinferior iliac spine, the superior aspect of the acetabulum, and the hip capsule **(Fig.17)**, **(Fig.18)**. 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.19)**. [17]

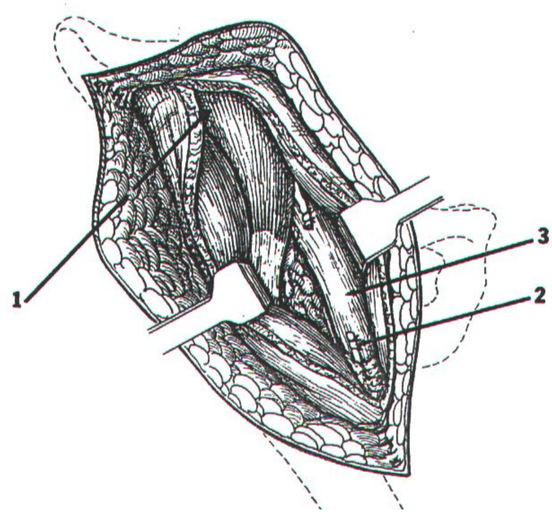


Fig.16. Iliac origin of the tensor fascia lata (1). The ascending branch of the lateral femoral circumflex artery is then ligated (2) over the rectus femoris (3). [17]

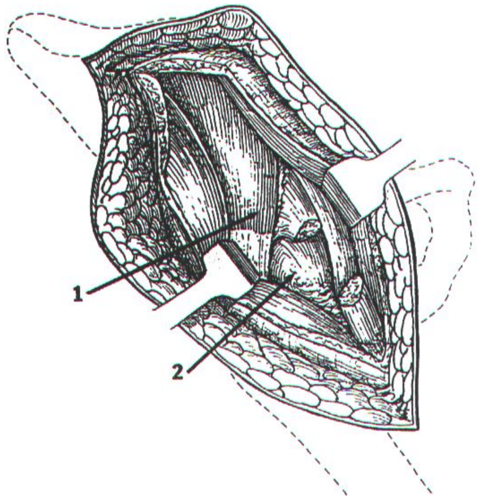


Fig. 17. Gluteus medius in retracted (1) The joint capsule (2) is cleaned of soft tissue. The iliopsoas is retracted. [17]

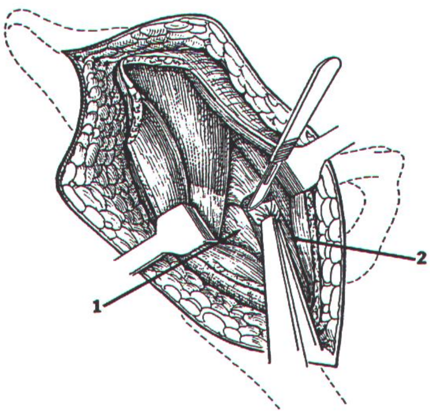


Fig.18. Rectus femoris muscle (1) is detached from its origins on the anteroinferior iliac spine, superior acetabulum, and anterior hip capsule (2). [17]

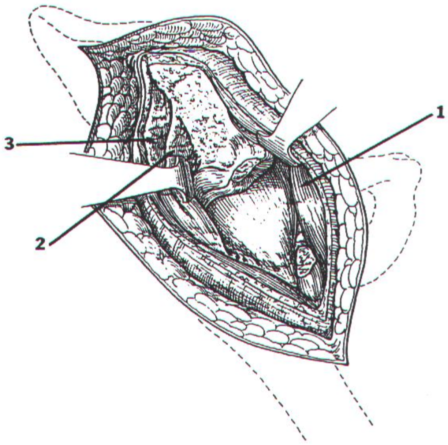


Fig.19. Hohmann retractors are helpful for retracting the sartorius, iliopsoas (1), gluteus minimus (2), and medius (3), thereby exposing the joint capsule and, if need be, the ilium**.** [17]

The leg is adducted and externally rotated so that the hip joint capsule can be incised (T-shaped based at the acetabular rim) **(Fig.20)**. [7]

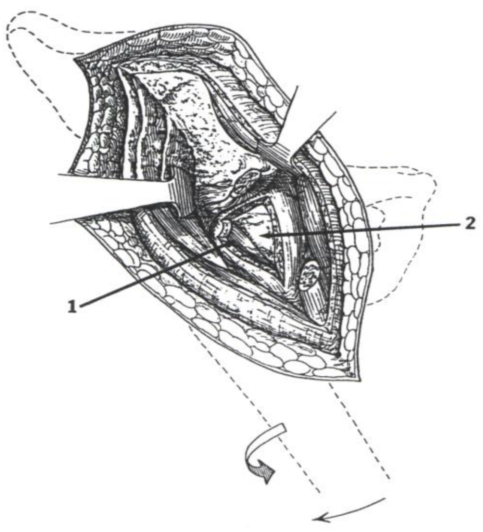
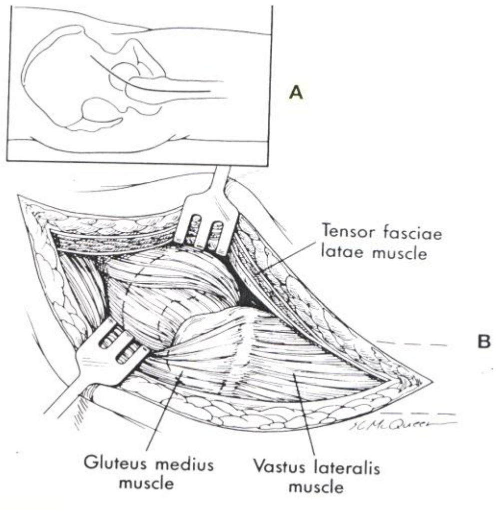


Fig.20. Anterior joint capsulotomy (1) from the acetabular rim to preserve blood supply to the head and neck (2). [17]

Anterolateral Approach *(Watson-Jones)*

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 2.5cm distal and lateral to ASIS and curve it distally and posteriorly over lateral surface of greater trochanter and femoral shaft to about 5cm distal to the base of the trochanter **(Fig.21)**.[26]



(Fig.21) Watson-Jones anterolateral approach to hip joint. A, Skin incision. B, Approach has been completed except for incision of joint capsule. [40]

Fascia lata incised posterior to tensor fascia lata **(Fig.22)**, then the interval between the tensor fascia lata (anteriorly) and the gluteus medius (posteriorly) is identified and dissection is through this plane till we reach the anterior joint capsule **(Fig.23)**. [62]

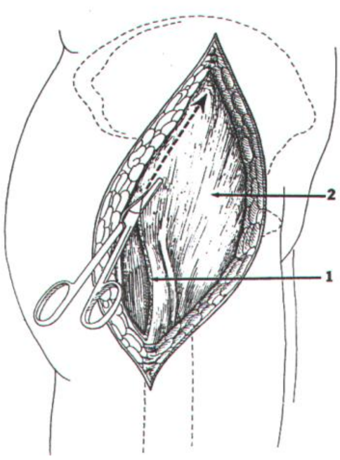


Fig.22. Fascia lata (1) is incised posterior to the tensor fascia lata (2). [17]

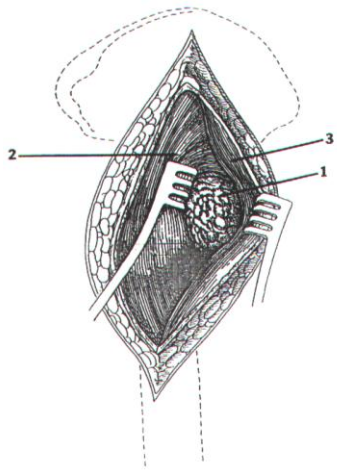
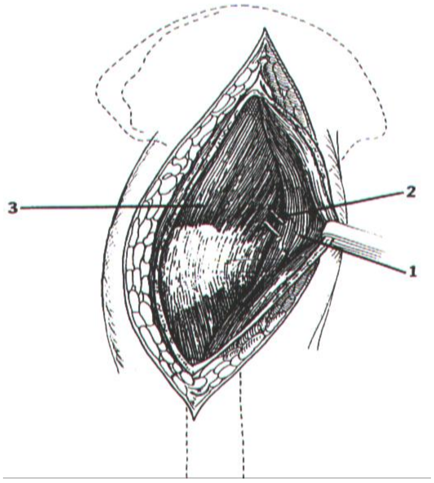


Fig.23. Fat over the anterior joint capsule (1) is between the gluteus medius (2) and the tensor fascia lata (3). [17]

Superior gluteal vessels in between these 2 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 **(Fig.24)**. 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.25)**. [26]



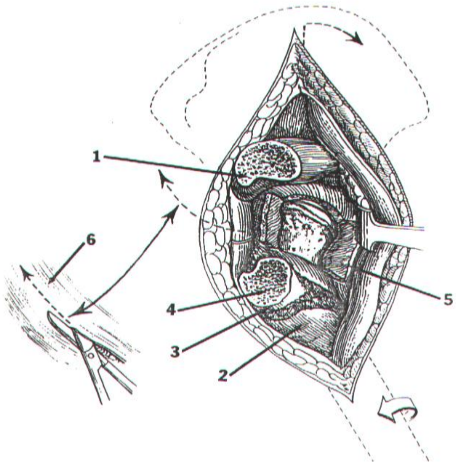


Fig.24. Tensor fascia lata (1) is retracted anteriorly. Note the superior gluteal artery (2). Gluteus medius (3) is posterior. [17]

Fig.25. Anterior greater trochanter is osteotomized (1), and the vastus lateralis is released (2) at the vastus ridge (3) from the proximal femur (4). The joint capsule is opened (5), as are the gluteus maximus fibers (6). [17]

Then retractors are inserted anterior, posterior and superior to acetabulum to expose the capsule and a T-shaped capsulotomy based at the acetabular rim is done, **(Fig.26)**. [62]

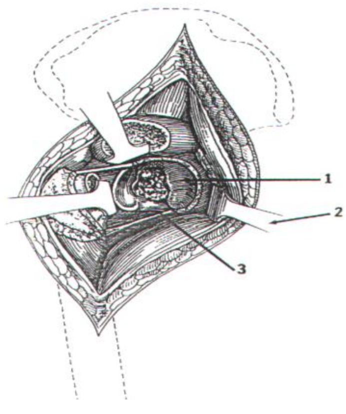


Fig.26. Acetabulum is exposed (1) using Hohmann retractors (2) posteriorly, superiorly, and anteriorly. Infenor joint capsule (3) is also exposed.). [17]

Lateral Approach *(Hardinge)*

Place the patient supine with the greater trochanter at the edge of the table and the muscles of the buttocks freed from the edge. Make either a straight or posteriorly directed lazy-J incision centered over the greater trochanter **(Fig.27, A)**. Divide the fascia lata in line with the skin incision and centered over the greater trochanter. Retract the tensor fascia lata anteriorly and the gluteus maximus posteriorly exposing the origin of the vastus lateralis and the insertion of the gluteus medius **(Fig.27, B)**. Incise the tendon of the 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. [37]

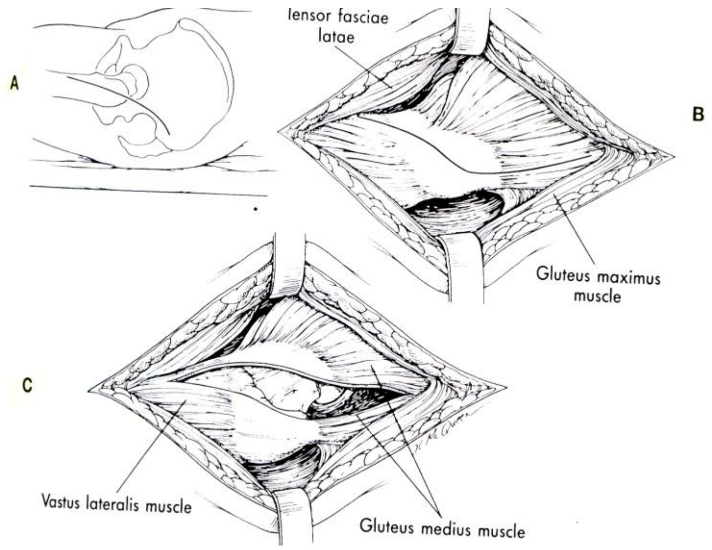


Fig.27.

Hardinge direct lateral approach. A, Lazy-J lateral skin incision. B, Tensor fasciae lata 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**.** [43]

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.27, B)**. Elevate the tendinous insertions of the anterior portions of the gluteus minimus and vastus lateralis muscles by cautery leaving a stump of tendon attached to bone as well as a portion attached to the muscle preserving the functional continuity of gluteus minimus and vastus lateralis muscles. Abduction of the thigh then exposes the anterior capsule of the hip joint **(Fig.27, C)**. Capsulotomy is done followed by flexion, adduction, and external rotation of limb allowing femoral head dislocation. [56]

Posterior Approach *(Osborne and Moore)*

The patient is positioned in the lateral decubitus position and firmly held with padded kidney rests and back support. The incision begins 4.5 cm distal and lateral to posterosuperior iliac spine and continue it laterally distally, remaining parallel with the fibers of the gluteus maximus muscle, to the posterosuperior angle of greater trochanter, and then along the posterior border of the trochanter for 5 cm. The fascia lata is split in line with the incision, and the gluteus maximus fibers are spread by blunt dissection at the proximal aspect of the wound **(Fig.28)**. The leg is maximally internally rotated and posterior border of the gluteus medius is retracted anteriorly exposing the piriformis tendon as it inserts on the posterosuperior aspect of the greater trochanter **(Fig.29)**. [32]

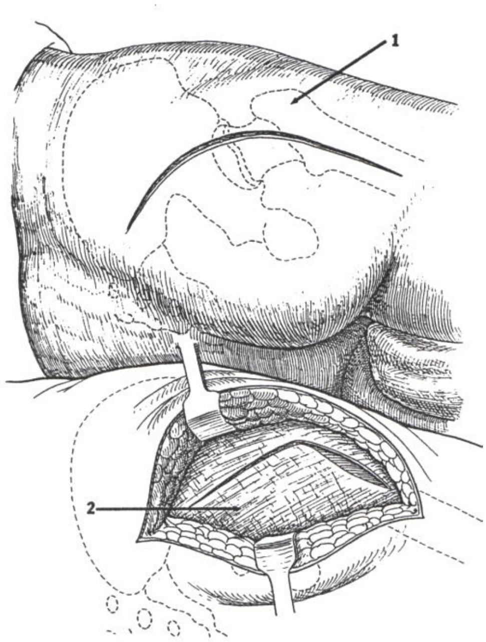


Fig.28. Incision for the posterior approach centers over the greater trochanter (1) and curves posteriorly over the gluteus maximus (2). [17]

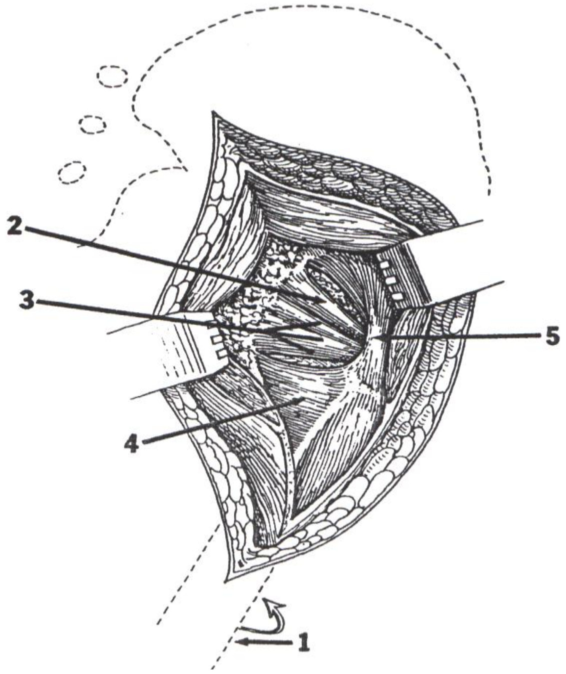


Fig.29. With internal rotation (1) one can see the short external rotators, piriformis (2), obturator internus, gemelli, obturator externus (3), quadratus femoris (4), and gluteus medius (5). [17]

The insertions of the piriformis, gemelii, and obturator internus are then released as close to their insertion as possible using electrocautery and tagged with nonabsorbable sutures for reattachment at the end of the case, and are reflected posteriorly protecting the sciatic nerve **(Fig.30)**. 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. [56]

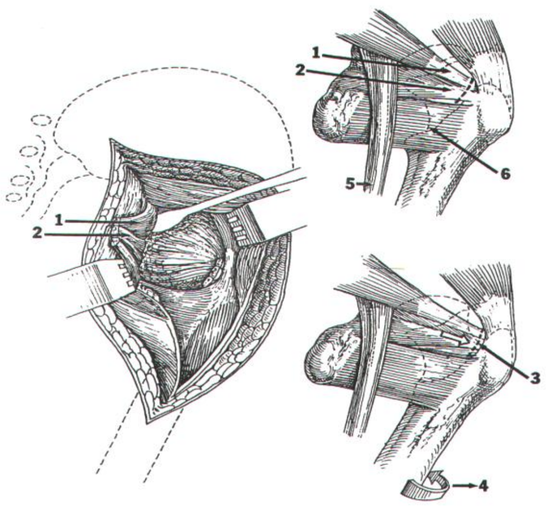
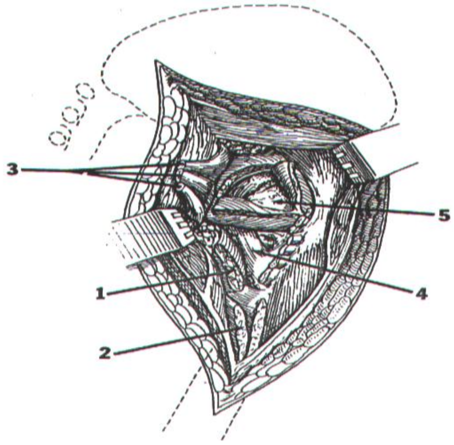


Fig.30. Insertions of the piriformis (1), obturator internus (2), and gemelli are released close (3) to the insertion on the trochanter with maximal internal rotation of the femur (4). Note the sciatic nerve (5) and quadratus femoris (6). [17]

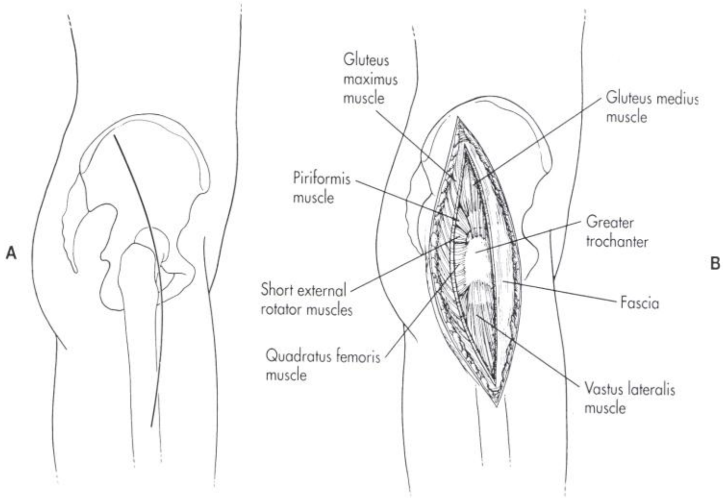
Then capsular incision is begun superiorly and carried parallel to the acetabular rim as far distally as possible. The incision is converted to a T incision cutting from the posterior acetabular rim anteriorly to meet the longitudinal incision **(Fig.31)**. [37]



(Fig.31) Quadratus femoris (1) and gluteus maximus tendon (2) are released. Note the short rotators (3), iliopsoas tendon (4), and femoral head and neck (5). [17]

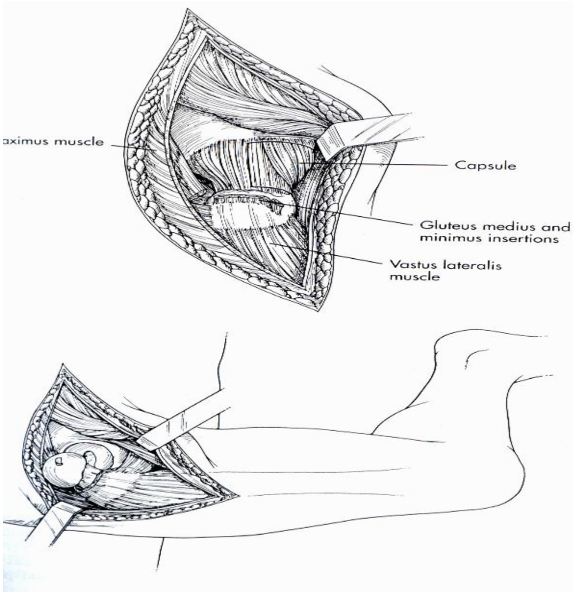
Posterolaterl Approach *(Gibson), (Kocher Langenbeck)*

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 further distally along the line of the femur for 15 to 18 cm **(Fig.32, 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, beginning 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. Then adduct the thigh, reflect the anterior and posterior masses, and expose the greater trochanter and the muscles that insert into it **(Fig.32, B)**. [24]



(Fig.32) Gibson posterolateral approach to hip joint. **A,** Skin incision. **B,** Anterior and posterior muscle masses have been retracted to expose greater trochanter and muscle that insert into it. [24]

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.33)**. 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. [46]



A

B

Fig.33. A,Gluteus medius and minimus have been divided near their insertions into greater trochanter and retracted. Incision in capsule is shown. **B,** Hip joint has been dislocated by flexing, abducting and externally rotating thigh. [24]

TECHNIQUE OF MINI-INVASIVE TOTAL HIP ARTHROPLASTY

Mini-invasive total hip replacement ***(MITHR)*** has several techniques which were described, and it is useful to divide the various MIS approaches into two main categories**:** the minimal incision approaches and the two-incisions approach. The minimal incision approaches are modifications of the standard posteriolateral **(Kocher Langenbeck),** anterior **(Smith-Peterson)**, lateral **(Hardinge)** and superior capsulotomy approaches that are performed through wounds 7-10 cm in length. The two-incision approach includes anterior incision for acetabulum and posterior incision for the femur. [59]

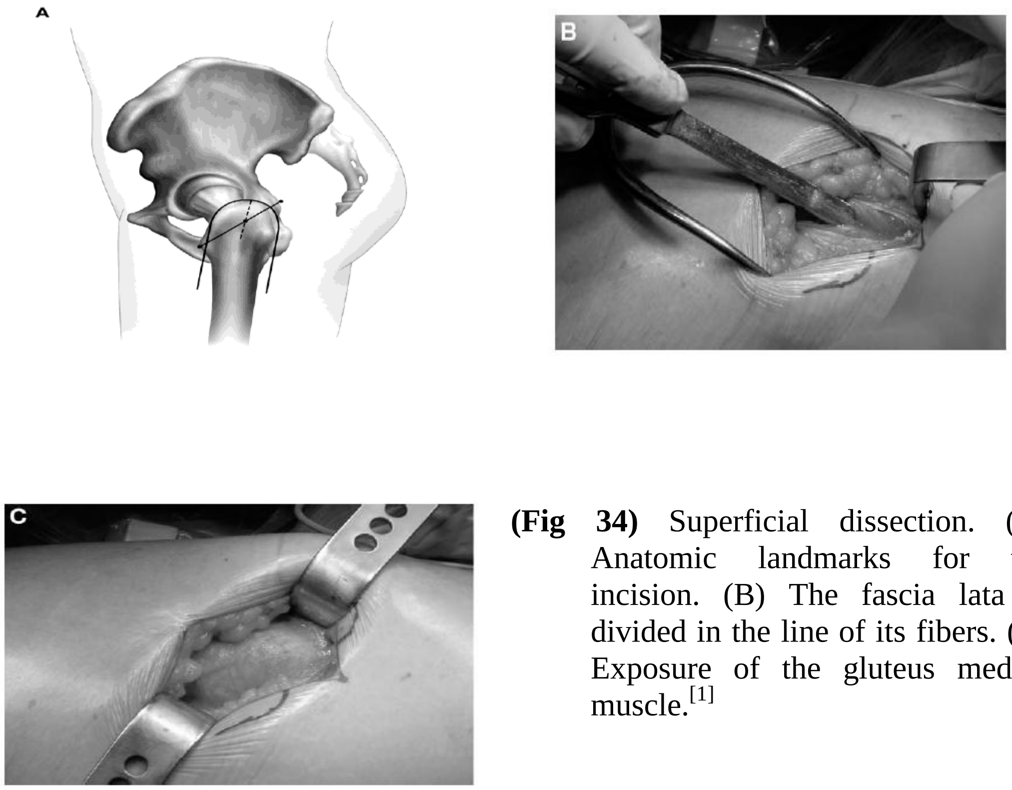
Minimal Anterior Approach *(Modification of Smith–Petersen)*

The mini-invasive anterior approach is a modification of the Smith-Peterson approach, patient is placed supine and a 5-8 cm curved incision, with its convexity placed laterally, from a point just distal to the anterior superior iliac spine extending to the anterior border of the greater trochanter. The deep dissection is through a plane between tensor fascia lata (superior gluteal nerve) and the sartorius (femoral nerve), and then deep to this, the dissection is extended between the rectus femoris (femoral nerve) medially and gluteus medius (superior gluteal nerve) laterally, which exposes the anterior aspect of the hip joint capsule. This approach provides good exposure of the acetabulum, and in most patients reaming may be performed through this incision using a straight reamer. On the contrary this approach provides inadequate exposure of the femoral canal which may be overcome by extreme external rotation of the femur and placement of a bone hook around the femur at the level of the lesser trochanter. [33]

Minimal lateral Approach *(Modification of Hardinge)*

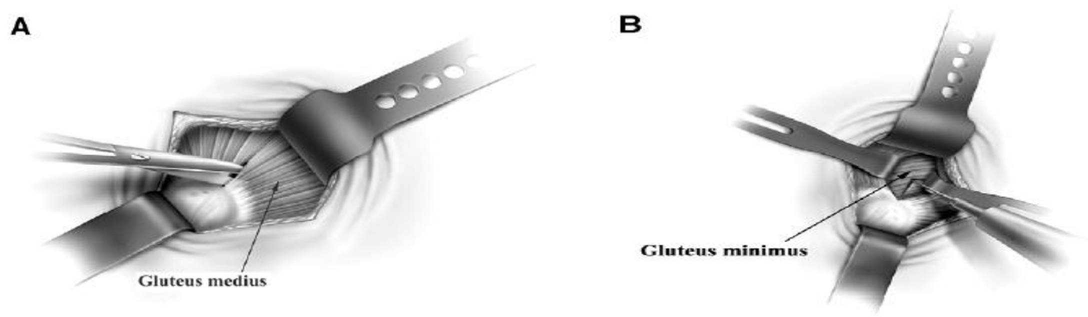
The patient is placed in the lateral position and the skin incision which is centered on a point 2 cm distal to the tip of the greater trochanter **(Fig. 34 A).** The incision is marked 1.5 inches on both side of this point, the proximal half angled 30° posterior to the long axis of the femur and the distal half 30° anterior. The skin and fat are incised along this line to expose the underlying fascia lata **(Fig. 34 B, C),** which is incised in line with the long axis of the femur and not in line with the skin incision. The fascial incision should be extended 2 cm proximal and distal to the skin incision. [45]

The gluteus medius muscle is divided in line with its fibers at the junction of the anterior third and posterior two thirds of the muscle taking care not to extend more than 4 cm proximal to the greater trochanter to avoid injury to the superior gluteal nerve, revealing the fibers of minimus which are orientated 40°-60° posterior to the line of the gluteus medius fibers. [1]



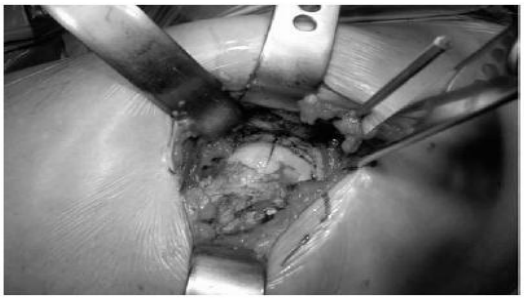
(Fig 34) Superficial dissection. (A) Anatomic landmarks for the incision. (B) The fascia lata is divided in the line of its fibers. (C) Exposure of the gluteus medius muscle.[1]

Proximally the gluteus minimus is incised along the line of its fibers and then distally this incision is curved laterally to exit in line with the incision in gluteus medius. **(Fig.35)**. [45]



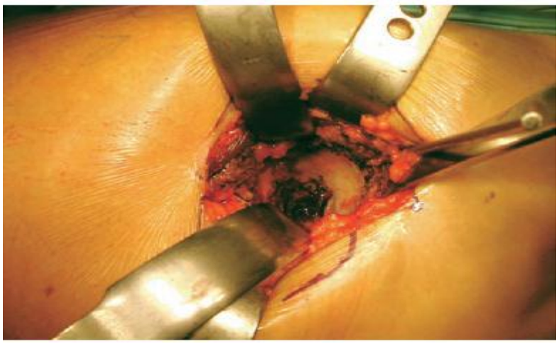
(Fig. 35) Dissection of the gluteal muscles. (A) The gluteus medius is incised in the line of its fibers at the junction of the anterior third and the posterior two thirds. (B) The fibers of the underlying gluteus minimus are orientated more vertically. Proximally it is divided in line with its fibers, and distally the incision is curved into line with the incision in gluteus medius. [45]

Having elevated the composite gluteus medius and minimus muscular flap, the hip is flexed approximately 20° and the leg is maximally externally rotated and adducted. Dissection deep to the gluteus minimus is extended proximally, anteriorly, and distally to expose the anterior and superior surface of the hip joint capsule. Followed by inserting one or two Steinman pins into the iliac bone proximally to retract the glutei, a Hohmann retractor is placed anteriorly over the anterior column, and a second retractor placed inferior to the femoral neck distally to improve exposure of the anterior surface of the hip joint. Capsulotomy or capsulectomy may be done **(Fig. 36).** [1]



(Fig. 36) An anterior capsulectomy gives wide exposure of the femoral head and neck. [1]

The hip is dislocated and neck is osteotomized first proximaly then final cut is done. To expose the acetabulum, the femur is placed in a relaxed position of 10° flexion, adduction, and external rotation. A retractor is placed over the posterior inferior margin of the acetabulum, which retracts the femur posteriorly, followed by a retractor directed over the anterior column of the acetabulum, and a Steinman pin may be reinserted above the acetabulum to improve exposure. This usually gives access to the acetabulum **(Fig. 37)**, but sometimes it is necessary to add another retractor placed over the anterior inferior aspect of the socket. [45]



(Fig. 37) Correct placement of retractors results in circumferential exposure of the acetabulum. [45]

Surgeons find that flanged retractors designed specifically for this approach are helpful in achieving optimum exposure **(Fig. 38)**. [33]

The long points of the retractors are placed as described previously and the assistant then can rotate the retractor handles around the axis of the point, which allows the broad flange to retract the soft tissues. In addition, some retractors are equipped with integral light leads to improve illumination in the larger patient. [33]

(**Fig.38**) Flanged retractors are useful for holding soft tissues back from the operative field. [1]

Special acetabular insertion instruments are manufactured with a curved or angled handle to facilitate acetabular reaming and insertion of acetabular component **(Fig. 39)**. [1]

The retractors and the Steinman pin are then removed in preparation for femoral exposure. The femur is exposed by the placing the leg into further flexion, adduction, and full external rotation, which delivers the proximal femur into the wound. [45]

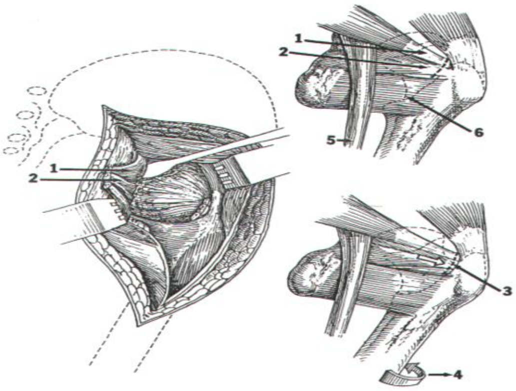
(Fig. 39) Acetabular instruments with curved handles avoid impingement of soft tissue during placement of the acetabular component. (A) A curved inserter for the acetabular component. (B) The cup is inserted using the curved inserter to which an external reference frame is attached that guides anteversion and abduction of the prosthesis. [1]

Minimal Posterolateral Approach (Modification of Kocher Langenbach)

The patient is placed in the lateral decubitus position. Then a 7-10 cm skin incision is done along the posterior aspect of the greater trochanter with 70% of the incision placed distal to tip of the greater trochanter and 30% proximal to it **(Fig. 40)**. [23]

(Fig.40) Minimal incision posterolateral approach to the left hip. (A) Skin markings showing greater trochanter and the planned skin incision. [37]

The subcutaneous tissue is divided in the line of the incision. The gluteus maximus muscle is bluntly split in the direction of its fibers, and the fascia lata is incised for a distance of 5-10 mm distal to the most distal end of the skin incision. A modified rectangular Charnley retractor is then placed. The limp is held in neutral extension, gravity adduction, forced internal rotation. The short external rotator tendons are divided with electrocautery at their insertion into the piriformis fossa **(Fig.41)**. [37]



(Fig.41) Insertions of the piriformis (1), obturator internus (2), and gemelli are released close (3) to the insertion on the trochanter with maximal internal rotation of the femur (4). Note the sciatic nerve (5) and quadratus femoris (6). [34]

The superior border of the piriformis is identified, and a radial capsulotomy is performed along the superior border of the piriformis to the acetabular rim. (For a right hip this is from the 10 o'clock to the 12 o'clock position), **(Fig. 42)**. [34]

(Fig.42) Development of posterior capsular flap. [34]

Now the hip is dislocated in flexion, adduction, and internal rotation, and the lesser trochanter is exposed for femoral neck cut to take place. Sometimes 5-10 mm of quadratus femoris must be incised to expose the lesser trochanter **(Fig. 43)**, adequate acetabular exposure requires precise placement of retractors **(Fig. 44)**, the first of which is placed over the anterior column and retracts the proximal femur anteriorly, a second retractor is placed over the posterior lip of the acetabulum retracting posterior tissues taking care not to a injure the sciatic nerve. A third retractor may be placed underneath the cotyloid notch, and it should be removed at the time of cup insertion. The acetabular labrum then is resected under direct vision and the remaining islands of acetabular cartilage are removed with a large acetabular curette. [37]

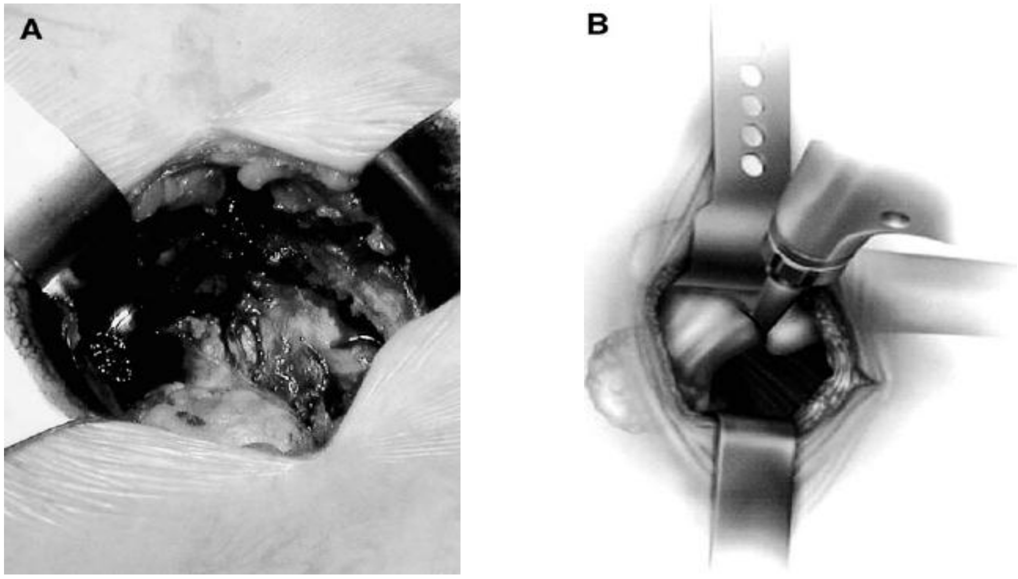


Fig.43. (A) Femoral head dislocated posteriorly. (B) Femoral neck osteotomy made with reciprocating saw. [37]

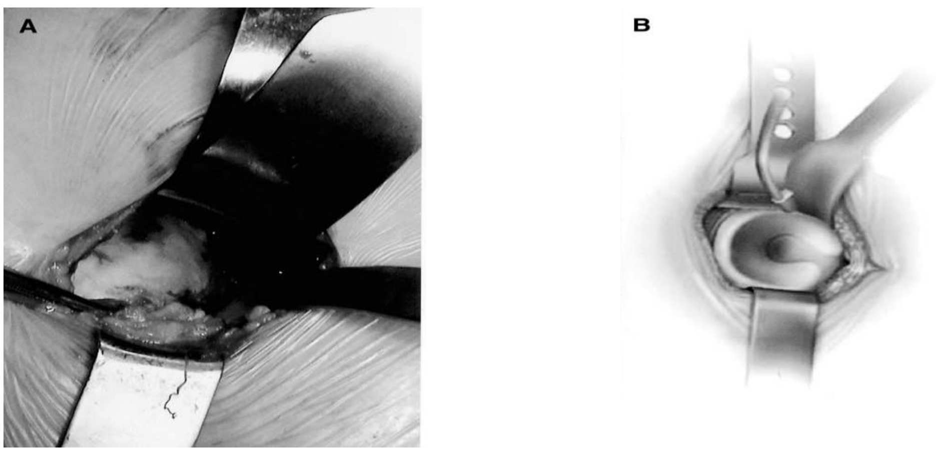
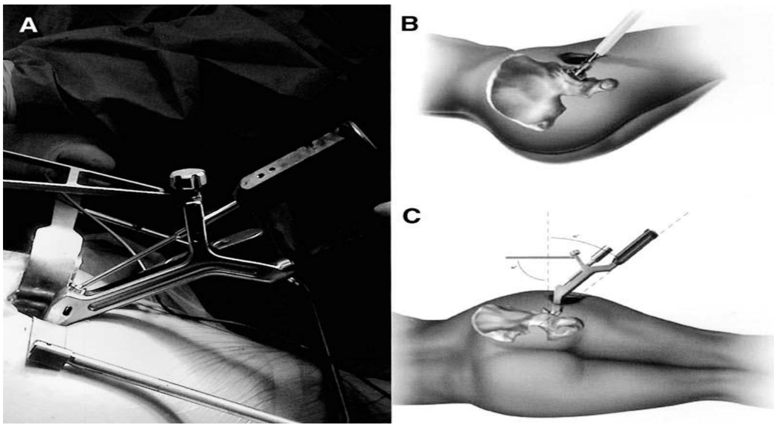


Fig.44. (A) Acetabular exposure with Holman retractor in place. (B) Drawing demonstrating proper placement of anterior Holman retractor. [37]

Acetabular reaming then is commenced with the largest reamer that will bottom out in the patient's socket, **(Fig.45, 46)**.[23]



(Fig.45) (A) Acetabular inserter in position. (B) Acetabular reamer in position. (C) Dogleg acetabular inserter in position. [23]

(Fig.46) Acetabular shell and liner inserted. [34]

To expose the femur, the acetabular retractors are removed and then the dependent leg is moved into 30°-45° of flexion, maximum adduction, and 90° of internal rotation. A femoral elevator is placed under the femoral neck, thus delivering the proximal femur into the wound. Placement of a retractor along the medial aspect of the calcar further improves access for preparation of the femoral canal. A gluteus medius retractor is also potentially helpful in allowing a properly lateralized entry point in the proximal femur. Then femoral preparation is done using special reamers and broaches to minimize impingement on the posterosuperior edge of the skin incision **(Fig. 47-49)**. [23]

Fig.47. Femoral broach is seated. [23]

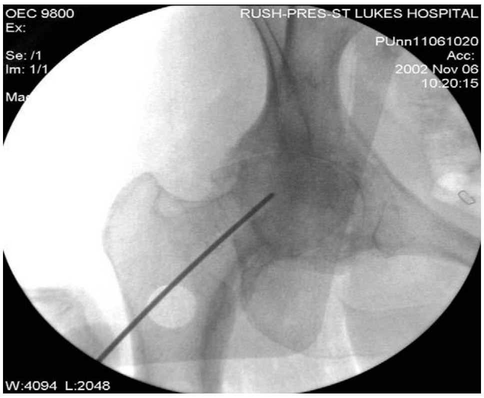
Fig.48. Femoral component is initially introduced in retroversion. [23]

Fig.49. Final components in position. [37]

The incision of this approach makes access to the proximal femur easy, but exposure of the acetabulum may be more limited. [37]

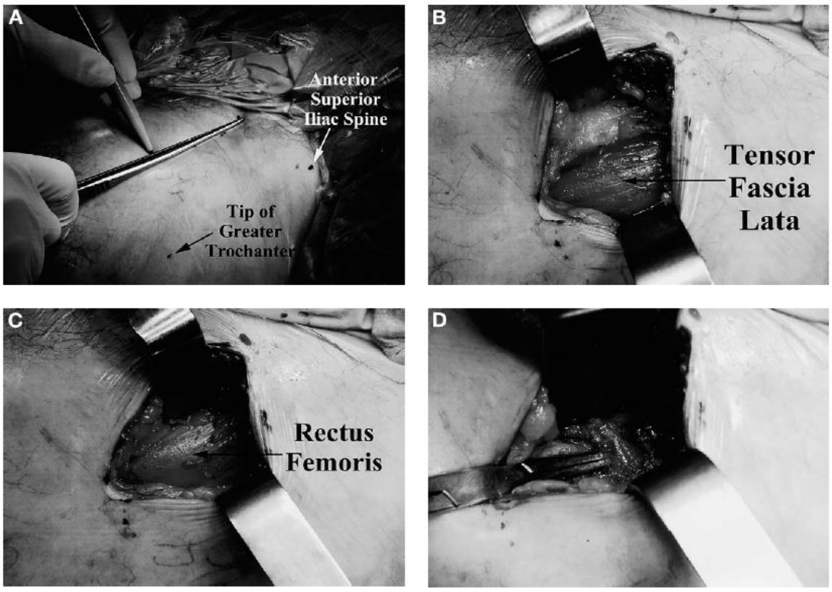
Minimal 2 Incisions Approach

The principle of this approach is two incisions, one for the acetabulum and one for the femur. The patient is placed in the supine position, and the line of skin incision lies three fingerbreadths distal to the line connecting anterior–superior iliac spine and greater trochanter which corresponds to the femoral neck extending from the head-neck junction to 2 inches distally and its position is confirmed by fluoroscopy using a metal marker **(Fig. 50)**. [8]



(Fig.50) A fluoroscopic image shows the incision site over the femoral neck. The incision is made from the base of the head approximately 1.5 inch to the base of the femoral neck. [8]

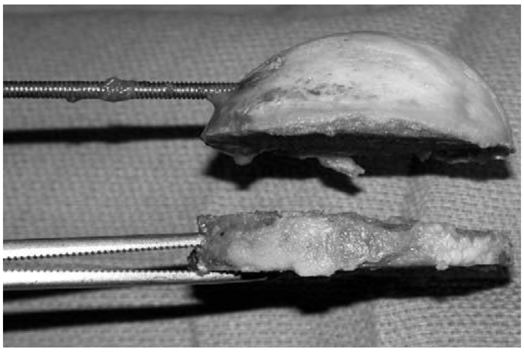
After the incision, the dissection is similar to the minimal incision anterior approach **(Fig. 51B-D)**, first between sartorius and tensor fascia lata taking care not to injure lateral femoral cutaneous nerve, then dissection between rectus femoris and gluteus medius retracting rectus femoris medially exposing lateral femoral circumflex vessels which are cauterized and exposing the hip joint capsule by placing retractors over the superolateral aspect of the femoral neck, inferomedial to the neck and over the front of the capsule heading medially to engage the anterior column. [63]



(Fig. 51) Acetabular exposure using the two-incisions minimally invasive approach. (A) The femoral neck lies three fingerbreadths distal to a line joining the anterior–superior iliac spine and the tip of the greater trochanter. The anterior skin incision is marked using fluoroscopy to guide the position. (B) The deep fascia is incised to reveal the underlying tensor fascia lata. (C) Tensor fascia lata is retracted to reveal rectus femoris. (D) Artery forceps have been placed under branches of the lateral femoral circumflex artery, which must be cauterized. [8]

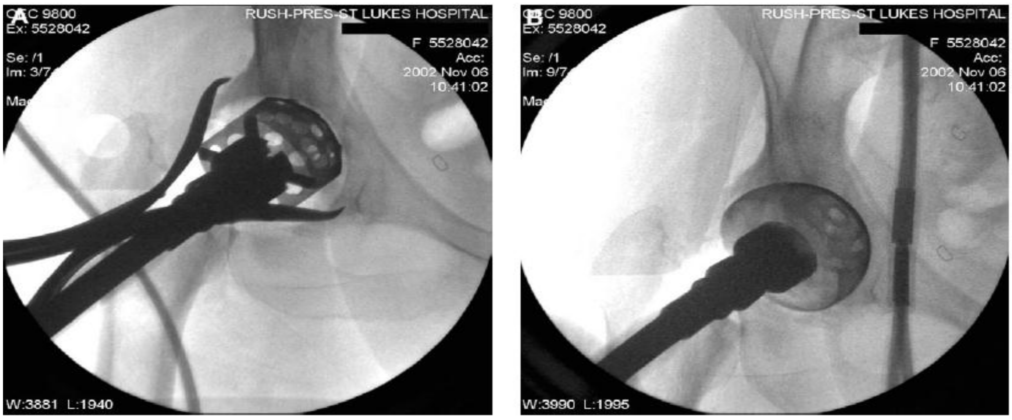
The capsule is incised along midline of femoral neck from edge of acetabulum to intertrochanteric line (H-shaped capsulotomy with elevation of flaps for later repair). The lip of the acetabulum is exposed and the retractors are replaced inside the capsule and around the neck of the femur to expose the head-neck junction of the femur. The hip usually cannot be dislocated at this stage and instead the neck osteotomy is made in situ. This is best done as two osteotomies, the first of which is made at the head-neck junction. The second osteotomy is made 1 cm distal to the first cut and the intervening "hockey puck" section of the neck is removed using a Schanz pin. This allows removal of the remaining femoral head from the socket by a Schanz pin or corckscrew **(Fig. 52, 53)**. [63]

(Fig. 52) Illustration shows the Hohmann retractors intracapsular around the femoral neck, exposing the femoral head and neck. [63]

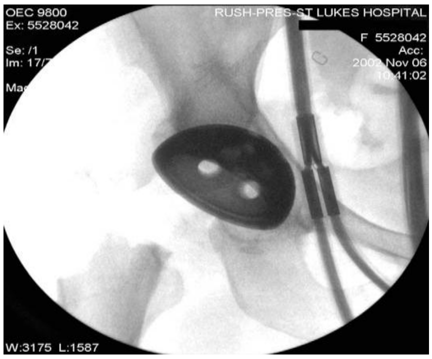


(Fig. 53) Photograph shows the removed femoral head and upper neck in two pieces. [8]

The acetabulum is exposed by placing one retractor over the anterior column, one over the posterior lip of the acetabulum, and a third placed anteroinferior to the acetabulum. With this exposure approximately one half of the acetabulum can be seen at one time, and to visualize the entire acetabulum the retractors are shifted slightly anteriorly or posteriorly as needed (intermittent complete visualization) unlike conventional exposure in which the entire acetabulum can be seen in one view (continuous complete visualization). Then acetabular reaming is done using specially designed, low profile reamers that are cut out on the sides and aggressive square cutting teeth, followed by insertion of acetabular component **(Fig. 54, 55, 56)**.[10]



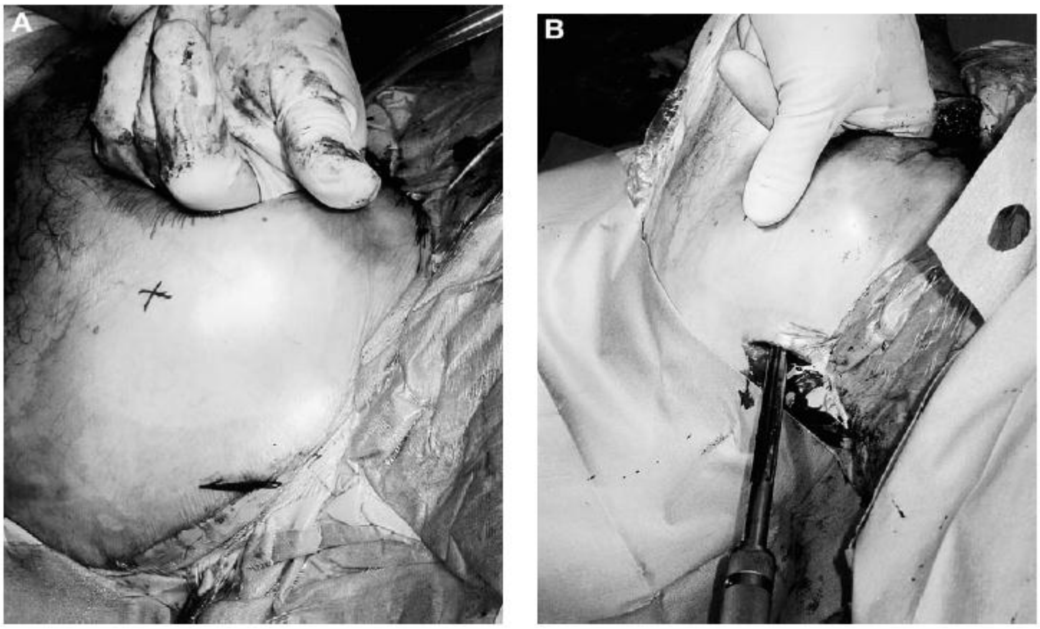
(Fig.54) Reaming the acetabulum. (A) Fluoroscopic view shows the reamer seated in the acetabulum to begin reaming. B) Fluoroscopic view shows the reamer seated in the acetabulum while reaming. During reaming, the cutout reaming appears hemispheric. [28]



(Fig. 55) Photograph shows the acetabulum being inserted through the skin and soft tissue**.** [8]

(Fig. 56) Fluoroscopic view of final acetabular component placement. [28]

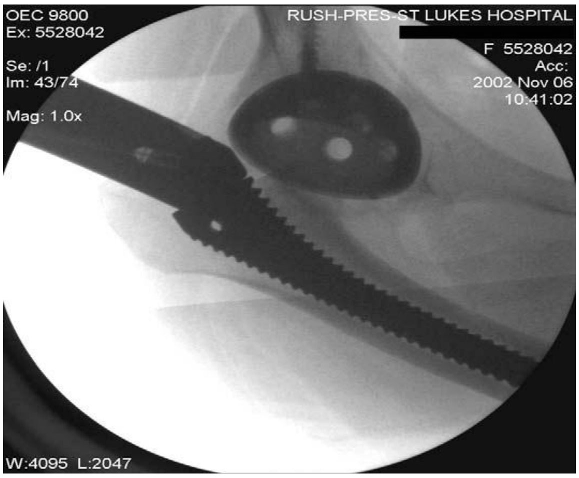
To access the femur, the surgeon passes a piriformis fossa guide or an index finger from the back of the proximal femur around the posterior aspect of the gluteus medius (between it and piriformis muscle) pointing proximally and posteriorly into the buttock. A 2 cm transverse incision is marked on the skin over the guide or the surgeon's finger if this is used instead. The surgeon's second index finger then passes through this incision to find the piriformis fossa and a taper pin awl is guided to the piriformis fossa and starts the entry point in the femoral canal **(Fig. 57).** [63]



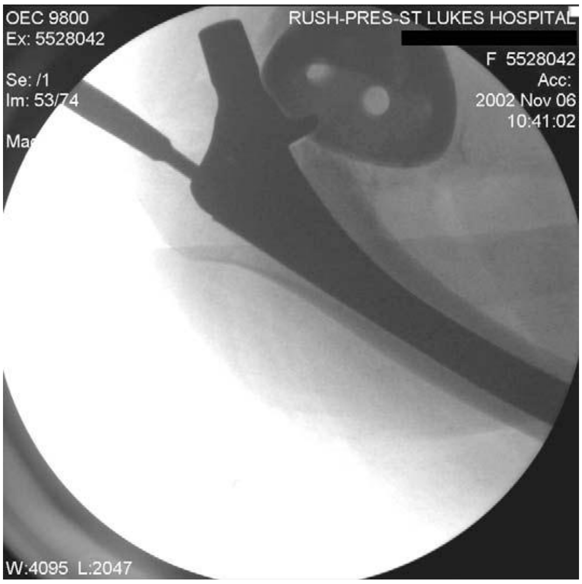
(Fig.57) Femoral exposure using the two-incision minimally invasive approach. (A) Marking the incision for the femoral approach. (B) A taper pin awl is used to locate the piriformis fossa and the femoral canal. [8]

Once the initial entry point is made, the femur is prepared using reamers and rasps inserted through the posterior incision, using fluoroscopy to guide depth of insertion of the instruments and to confirm their correct alignment **(Fig. 58, 59, 60, 61)**. The ideal location of this incision and the subsequent plane through the soft tissues is between the posterior border of the gluteus medius and the piriformis, down to their femoral attachments. [8]

(Fig. 58) Fluoroscopic view shows the lateralization reamer clearing the trochanteric bed, positioning for a neutral alignment. [28]



(Fig.59) Fluoroscopic view shows the final femoral rasp seated. [28]

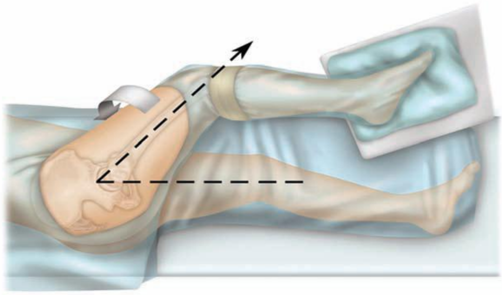


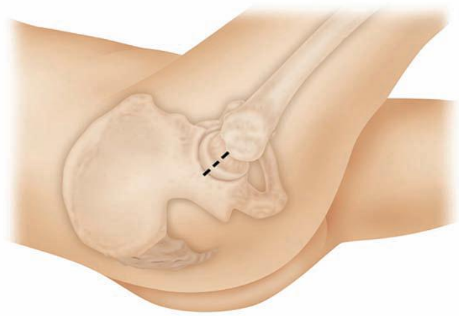
(Fig. 60) Fluoroscopic view shows the femoral component during insertion. The femoral component is seated in the final position. [28]

(Fig. 61) Postoperative radiograph showing with the minimally invasive two-incisions THA reconstruction. [63]

Minimally invasive incision using a superior capsulotomy

The patient is placed in a lateral position with the leg placed in the position of sleep (60° of flexion, 15° of internal rotation, and maximum adduction), with the foot resting on a padded Mayo stand. A 6- to 8-cm incision is made starting at the tip of the greater trochanter and extending proximally, in line with the femoral shaft axis **(Fig. 62)**. [57]





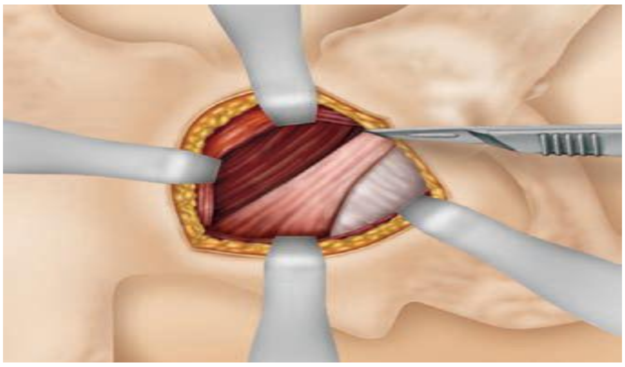
(Fig.62) A

The patient is placed in a lateral position. Most of the procedure is performed with the leg in the position of sleep (60" of flexion, 15° of internal rotation, and maximum adduction) (A). [57]

(Fig.62) B

The skin incision is typically 6- to 8-cm long and made in line with the femoral shaft axis, starting proximal to the greater trochanter (B). [57]

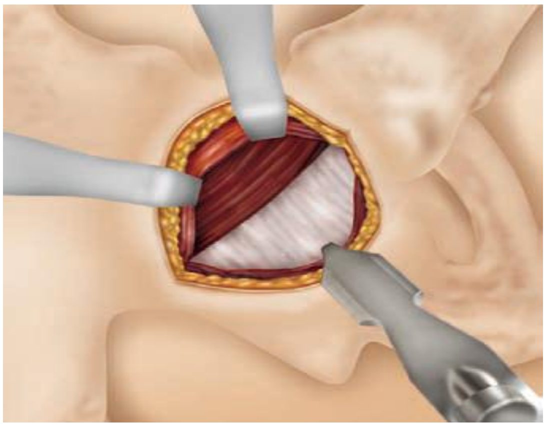
The gluteus maximums fibers are bluntly spread in line with their fibers to reveal the thin bursa tissue overlying the gluteus medius. The posterior border of the gluteus medius is mobilized anteriorly to expose the piriformis tendon,the anterior border of the piriformis tendon is developed to reflect the piriformis posteriorly. **(Fig. 63)**. [41]

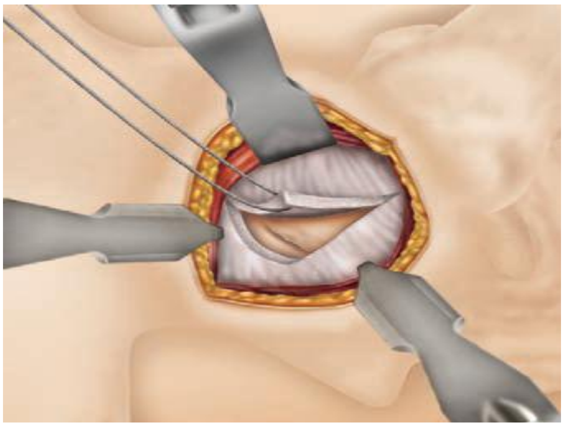


(Fig.63)

Right hip, with the gluteus medius retracted anteriorly to reveal the piriformis and gluteus minimus. [41]

The insertion of the piriformis can be released and repaired as necessary. A blunt homan retractor is placed between the short external rotators and the posterior capsule **(Fig. 64).** The posterior border of the gluteus minimus muscle is identified and the minimus is mobilized anteriorly. Another blunt homan retractor is placed around the anterior femoral neck between the minimus and capsule. The two blunt homans placed around the anterior and posterior capsule provide excellent exposure of the trochanteric fossa **(Fig. 65)**. [41]

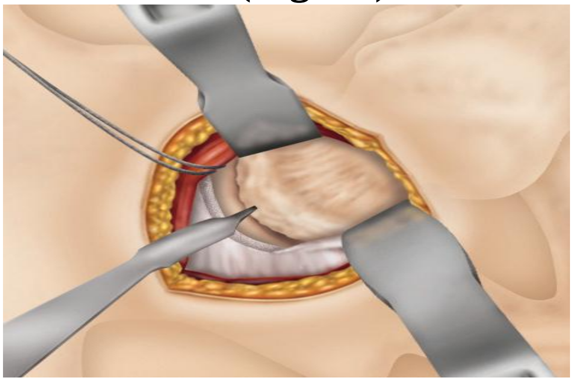




(Fig.64) Right hip with the piriformis tendon incised at its insertion and retracted posteriorly with a blunt homan retractor placed between the short external rotators and posterior capsule. The gluteus minimus is then mobilized anteriorly, leaving its origin and insertion intact. [57]

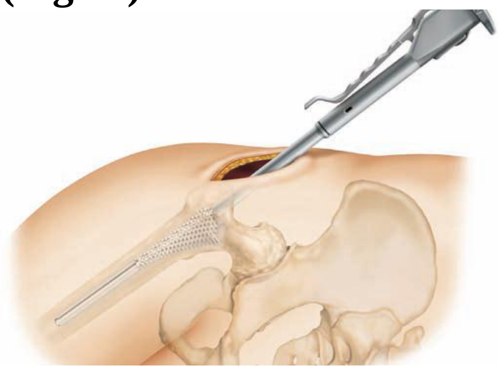
(Fig.65) The superior capsulotomy, leaving the posterior capsule intact.[57]

Another 2 spiked human retractors are placed into the ilium to maintain the proximal portion of the exposure. One is placed anteriorly, protecting the medius and minimus. The other should be placed just above the posterosuperior rim of the socket, taking care to stay away from the sciatic notch. A vertical capsulotomy is done from the trochanteric fossa to the acetabular rim with an anterior capsular flap developed. The retractors are replaced intracapsular anterior and posterior to the femoral neck **(Fig. 66)**. [57]



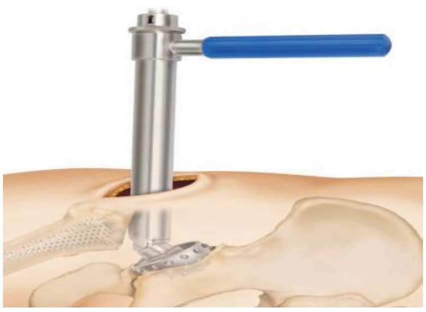
(Fig.66) Blunt homan retractors are placed inside the hip joint capsule around the anterior and posterior femoral neck. The femur is now in position for reaming and broaching. [57]

Femoral preparation is the done with the head and neck left in place (provided there is no external rotation deformity), because the head provides stability to the femur during preparation and the neck provides a fulcrum for leverage retractors and also reinforcement to the calcar region, reducing the likehood of femoral fractures during femoral preparation **(Fig.67).** [41]



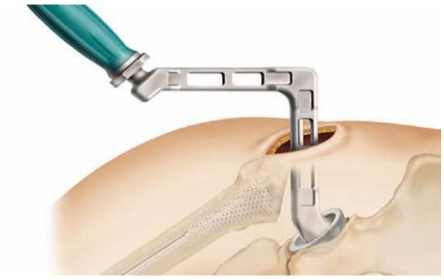
(Fig.67) The superior portion of the head and neck are removed to allow reamers and broaches to pass into the femur. The head is normally left in situ to maintain stability of the femur and to allow the use of leverage retractors. [41]

In the typical situation where the head and neck are left in place, a reamer is placed through the superior part of the femoral neck into the medullary canal. After the diaphysis is reamed to size, the superior portion of the head and neck are removed with an osteotome or saw to allow the femur to be prepared with broaches. Then blunt homan retractors are placed around the acetabulum anteriorly and also posteriorly in the lesser sciatic notch so the entire acetabulum can be seen and remnants of the labrum are excised. A very low-profile 45°-angled reamer is then used to prepare the acetabulum **(Fig. 68).** A Z-shaped acetabular impactor is used to insert the acetabular component **(Fig. 69)**. [57]



(Fig 68)

After the femur is prepared, the femoral head is removed to allow preparation of the acetabulum using a 45° angled reamer. [57]



(Fig.69)

An acetabular impactor with multiple angles is used to allow impaction of the cup in line with the cup axis, while exiting the incision above the greater trochanter. [57]

After the cup is inserted the trial or real acetabular liner is inserted and the trial neck is reduced into the trial head in situ. Trial reduction should produce a hip that cannot be dislocated in any direction without traction. After satisfactory trial reduction, the trial components are removed, the real acetabular liner and femoral head are inserted, the real femoral component is inserted, and the femoral neck is again reduced into the femoral head in situ as before. The hip joint capsule is closed, the piriformis tendon may be reattached on the trochanteric fossa, and the gluteus minimus and medius return to their native positions when the retractors are removed. The fascia overlying the gluteus maximus is closed before subcutaneous and skin closure **(Fig. 70).** [41]

(Fig.70) Photograph of the 7.5 cm incision at 6 weeks following the procedure. The procedure has been performed leaving the abductors and posterior capsule fully intact. [41]

Navigation System in MITHR

The hip navigation system includes two distinct components: preoperative planning and intraoperative guidance. In the preoperative plan, the position and orientation of the cup is planned using the CT scan model of the pelvis. The implant size is selected by fitting a sphere in the acetabulum using three orthogonal cross sections of the CT scan. With the sphere placed in the chosen location, the size and center of the cup is selected. In the second step, orientation of the cup is selected by rotating the cup around its center. This is performed within the CT scan derived source model of the pelvis. To assist the process, the range of motion (ROM) simulation is performed interactively for selected cup orientation and preselected leg motion paths, so that the cup orientation can be optimized with respect to the implant impingement **(Fig. 71, 72)**. [50]

During surgery, the acetabular cup is placed in the position selected in the preoperative plan using the image guided system. [35]

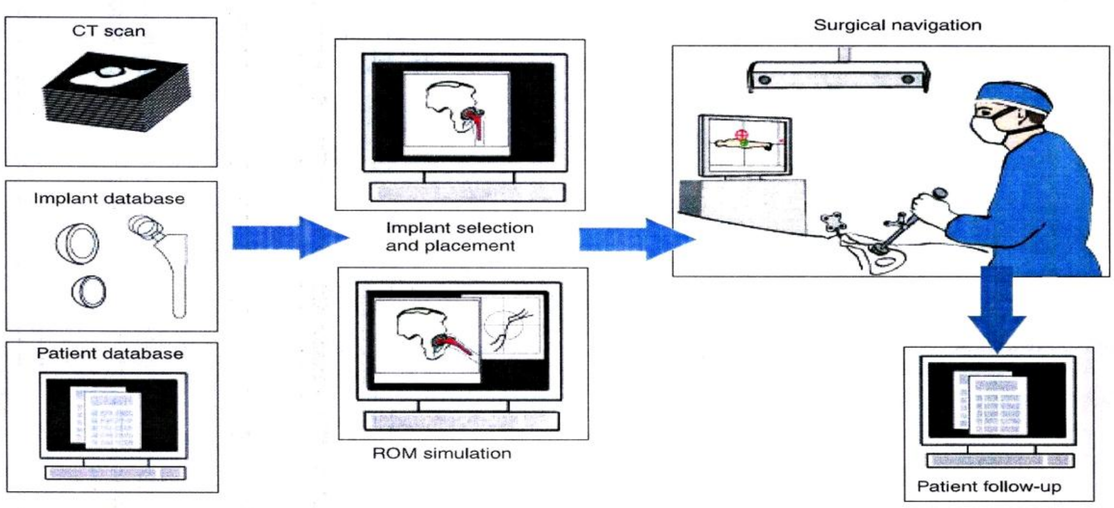


Fig.71. Schematic representation of an image- based navigaton system. [35]

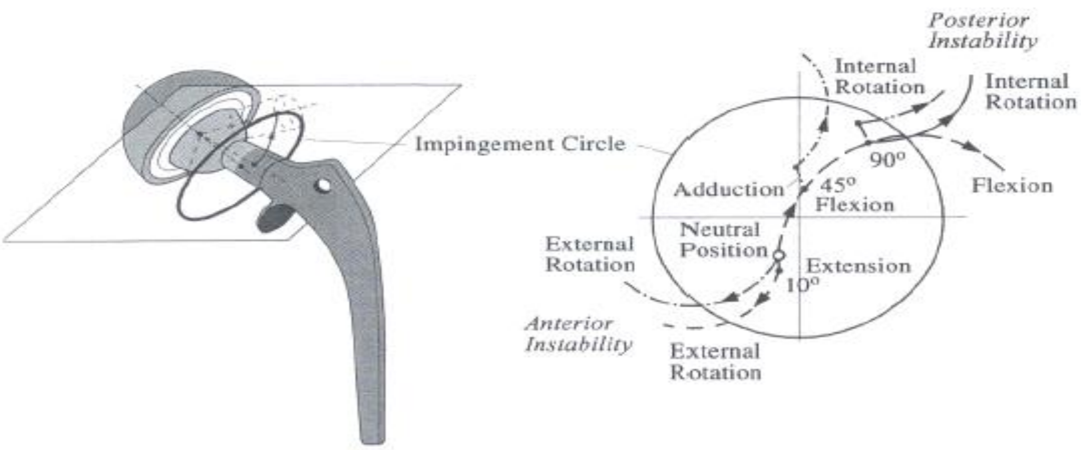
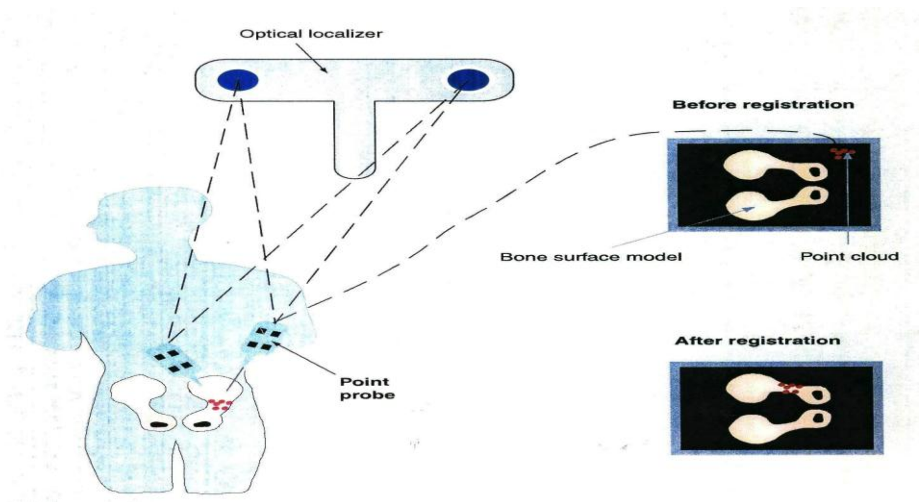


Fig.72. Preoperative planner and ROM simulator defining an envelope of safe ROM. [51]

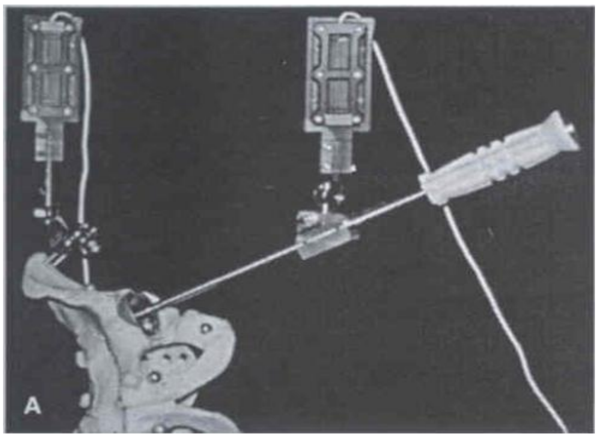
Image guided technology relies on the infrared light emitting diode markers that are tracked continuously using the optical camera (Optotrak, Northern Digital Inc, Waterloo, Ontario, Canada). One such marker is attached rigidly to the pelvis and another to the cup positioning guide. [51]

Registration is performed to establish the proper transformation between the position of the pelvis in the operating room and its CT based surface model in which the cup orientation is planned preoperatively. This is achieved by minimizing a distance between the intraoperatively acquired cloud of points and the CT based surface model of the pelvis. The points on the pelvis are acquired by touching around the acetabulum using the pointing probe **(Fig. 73)**. After the registration is complete, the pelvis can be tracked continuously during the surgery **(Fig. 74)**. [44]

The cup then is placed in the planned position using a standard cup positioning tool with attached optical markers and with the aid of a simple computer interface. Orientation of the positioning tool relative to the pelvis is measured continuously. In addition to precise placement of the cup, this allows measurement of other cup placement techniques, namely, the placement using the mechanical vide provided by the implant manufacturer, and the surgeon’s own technique which combines global and local clues and landmarks . The measurement of the final cup position is somewhat different from the planned one, because the press fitting procedure affects the final seating of the cup. After the cup is placed into its final position, and the liner is inserted, the cup orientation is measured again by inserting the tool with optical markers attached. The end of the tool matches exactly the shape of the cup liner, and the measurement is taken after fitting the tool to the cup liner. This is done to verify the final measurement of the cup positioning, and to measure whether the acetabular screws have affected the final cup position. [50]



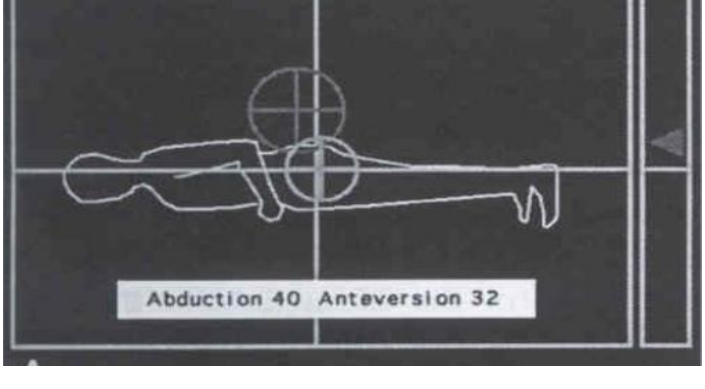
(Fig.73) Schematic of tracking and registration process. [35]



(Fig.74) Intraoperative tracking of the pelvis and surgical tools. [50]

A limitation of most registration systems currently used is the need fear fiducial pins or screws that are implanted surgically into bone before preoperative images are acquired. This is done by using surface geometry to perform registration. Multiple points on the surface of the pelvis are collected with an optically tracked digitizing probe during surgery. These intraoperative data create a cloud of points which then is matched to a geometric description of the bony surface derived from the CT images already used to plan the surgery. Using this approach, the unique surfaces of a bone (such as the pelvis) can be used to align accurately the intraoperative position of the patient to the preoperative plan without the use of pins or other invasive procedures. After registration, the movement and position of the pelvis and any of the instrumented surgical tools can be monitored continuously throughout surgery, eliminating the need for rigid fixation of the pelvis. [51]

Navigational feedback is provided via a television monitor. A digital display on the same screen continuously reports the actual measurement of abduction and anteversion of the implant which the surgeon also can use interactively to align the cup **(Fig. 75)**. [50]

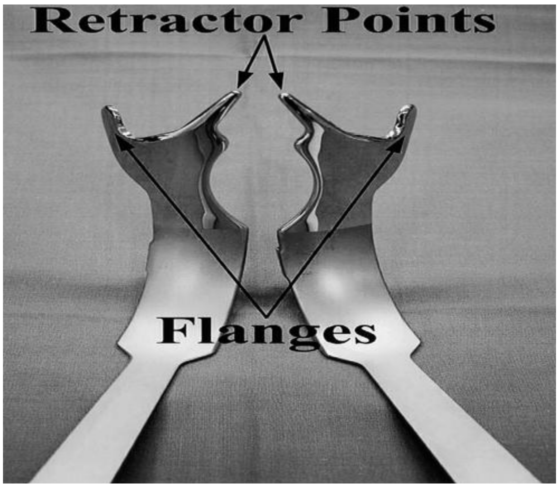


(Fig.75)

Intraoperative navigational feedback provided to the surgeon to measure and align the acetabular component and operating room set up. [50]

INSTRUMENTATION FOR MINIMALLY INVASIVE TOTAL HIP ARTHROPLASTY

Achieving the correct exposure is one of the major challenges, for which several companies have developed specialized retractors. These retractors have long handles, angled at approximately 90˚ to the blade, so that the assistant's hands are kept at a distance from the wound and do not obscure the surgeon's view. It is preferable to keep to a minimum the number of retractors that are inside the wound at any one time, and for this reason the use of flanged retractors may be helpful **(Fig. 76)**. The flanges allow retraction of surrounding soft tissue when the handle is rotated about the axis of the retractor point, and they are therefore more efficient than standard retractors. Several of the retractors also have the capability for the attachment of an additional light source. [4]

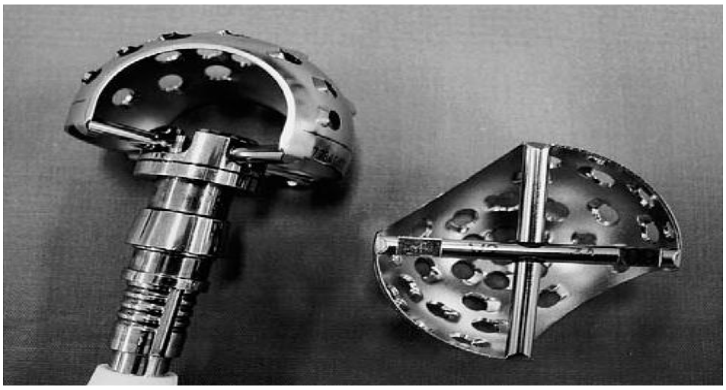


(Fig.76) Angled flanged retractors are efficient in clearing soft tissue when twisted about the axis of their points. [4]

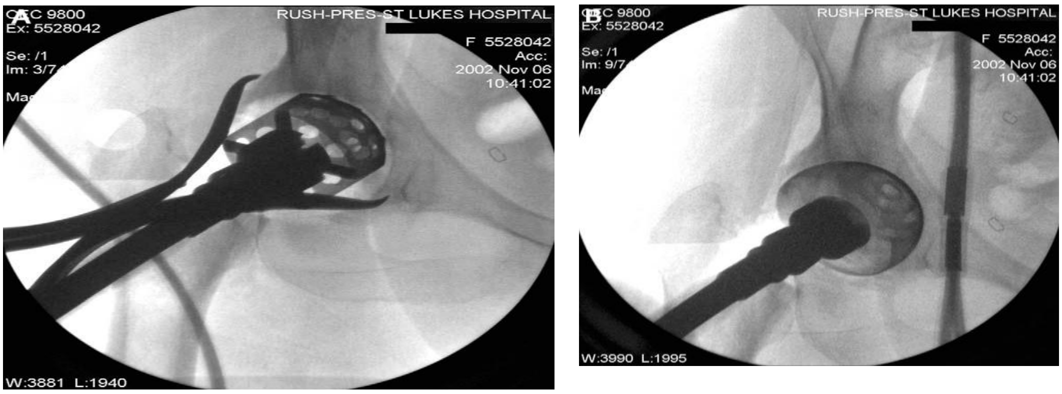
Preparation of the acetabular surface using straight reamer shafts may be a problem in MITHA, particularly in the larger patient in whom soft tissue impingement may impede the surgeon and predispose to reaming in an abducted position. The use of a curved reamer shaft that accommodates the soft tissues in the middle portion while the reamer face and handle end remain aligned may avoid this problem and allow proper acetabular preparation. The use of an angled reamer shaft is an alternative approach in which the handle is orientated vertically and the correct abduction angle is built into the shaft **(Fig. 77)**.[1]

(Fig.77) A curved acetabular reamer and impact or can accommodate soft tissues. An angled reamer is an alterative approach to overcome soft tissue impingement. [1]

The development of specialized reamers that have a reduced area of cutting, either by cutting down the reamer or by having blunt areas of the hemisphere, and this allows the reamer to be passed through the wound while minimizing soft tissue trauma **(Fig. 78, 79)**. [54]

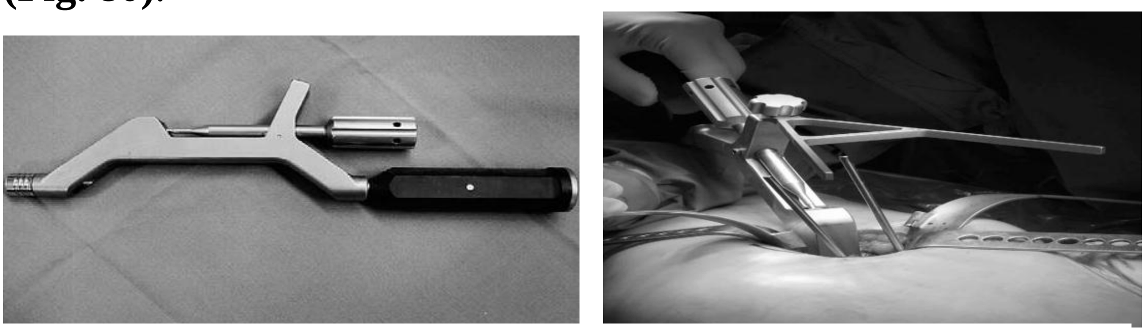


(Fig.78) Modifications made to the reamer face to reduce trauma to skin edges. [1]



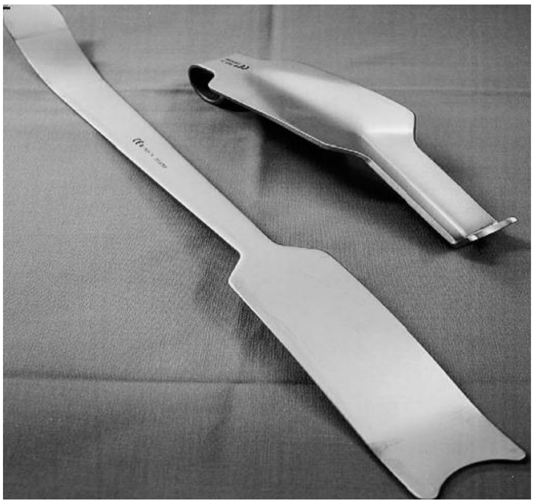
(Fig.79) Reaming the acetabulum. (A) Fluoroscopic view shows the reamer seated in the acetabulum to begin reaming.
(B) Fluoroscopic view shows the reamer seated in the acetabulum while reaming. During reaming, the cutout reaming appears hemispheric**.** [48]

Difficulties during introducing the acetabular component can be overcome through the use of angled instruments, many of which have built-in alignment guides to optimize cup position **(Fig. 80)**. [48]



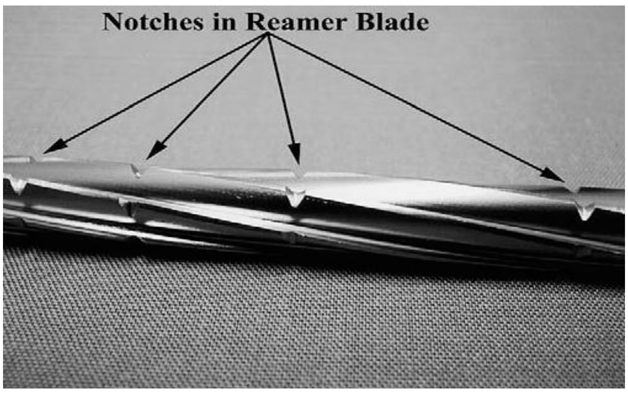
(Fig.80) Acetabular instruments with curved handles avoid impingement of soft tissue during placement of the acetabular component. (A) A curved inserter for the acetabular component. (B) The cup is inserted using the curved inserter to which an external reference frame is attached that guides anteversion and abduction of the prosthesis. [54]

Exposure of the femoral shaft using the minimal incision posteriolateral and anterior approaches may be optimized through the use of a femoral elevator **(Fig. 81)** that delivers the femur into the wound while the flanges protect surrounding soft tissue. [54]



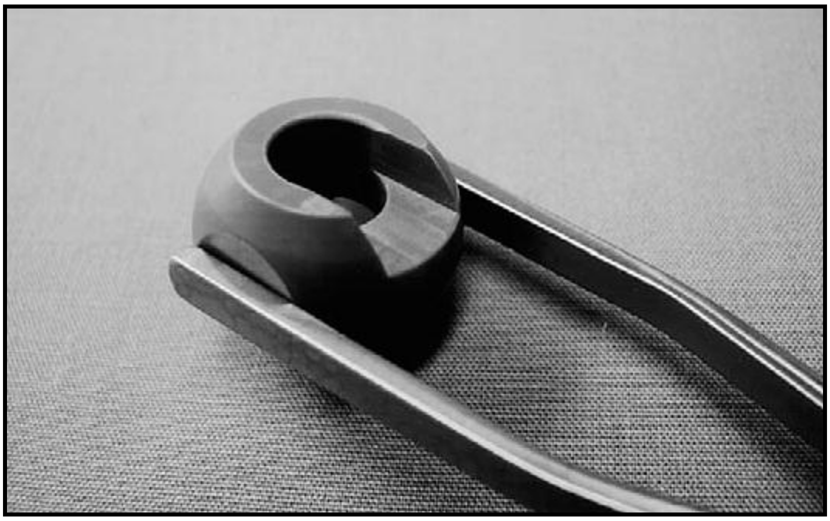
(Fig. 81) Two designs of femoral elevator used in mini-invasive T.H.A. [54]

Further preparation of the femoral canal requires no special instruments. Preparation of the femoral canal using the two-incisions technique is done under fluoroscopic guidance. Notches on the reamers, easily visualized by fluoroscopy, assist in guiding the extent and depth of reaming **(Fig.82).** [1]



(Fig.82) The femoral reamers are notched so that insertion depth can be controlled using fluoroscopy. [28]

Insertion of trial femoral heads through these smaller incisions can be awkward and time consuming, and the use of side loading trial heads **(Fig.83)** may make this step easier. [28]



(Fig. 83) Side entry mechanism for easy application of trial femoral heads. [28]

ADVANTAGES OF MINI INVASIVE TOTAL HIP ARTHROPLASTY

Minimally invasive total hip arthroplasty has the potential to benefit patients in several ways, as a consequence of the reduced tissue dissection associated with the surgical access. [10]

As a result of decrease tissue dissection there will be shorter duration of surgery, less postoperative pain, and consequently less postoperative narcotics, also there will be less intra and postoperative blood loss decreasing the incidence of blood transfusion and disease transmission. The striking advantage here is the reduction in hospital stay and early recovery and return to everyday activities helped by rehabilitation programs. [19]

Another striking advantage is the better cosmetic appearance; surgeons don’t suggest that cosmosis should take priority over assuring optimal component alignment and fixation. Indeed there is no excuse for sacrificing component position or fixation for the sake of a shorter scar. Cosmosis is certainly a low priority. However, according to the patients cosmosis is not meaningless. If the primary goals of the arthroplasty can be effectively and reliably accomplished through a smaller incision, the already extremely satisfied patient population undergoing hip arthroplasty may be even more pleased with the outcomes. [10]

In a group of patients who had the 2 incisions MIS occupational and physical therapy were initiated at 5 to 6 hours postoperatively. Patients were weight bearing as tolerated on the surgically treated extremity. All patients were first taught bed and chair transfers. They received teaching for walking first with crutches, then with a cane, and finally without any assistive device the day of surgery. Lastly patients were taught stair ascent and descent; first with crutches and then without any assistive devices. Patients were discharged from the hospital once strict criteria were met including the ability to independently transfer out of and into bed from a standing position, rise to and from a chair to a standing position, walk 100 feet, and ascend and descend a full flight of stairs. Once these criteria were met, patients were discharged from the hospital, and not to other care facilities. [19]

The average time to discontinue the use of crutches was 6 days (range, 0–19 days). The average time to discontinue oral narcotics was 6 days (range, 0–28 days). The average time to drive, for the 98 patients who drove, was 6 days (range, 2–18 days). The average time to return to work, for the 78 patients who worked, was 8 days (range, 1–20 days). The average time to walk independently without an assistive device was 9 days (range, 3–25 days). The average time to resume activities of daily living was 10 days (range, 1–27 days). The average time to walk 1⁄2 mile, for the 87 patients who could or wanted to, was 16 days (range, 2–35 days). The average time to resume driving was 6 days with no complications following such early activity unlike standard THA where patients are not ready to drive until 4-8 weeks postoperatively. [48]

Also mini-incision THA is considered less invasive than standard THR on the basis of laboratory data as shown in table 1. [31]

Table.1. Laboratory data. [31]

Factor	Time	Mini-incision	Standard incision
CRP (mg/dl)	Preoperative	0.14 ± 0.09	0.16 ± 0.1
	1 week(postoperative)	1.8 ± 1.2	3.3 ± 2.6
	2 weeks(postoperative)	0.66 ± 0.51	1.1 ± 1.09
ESR (mm/h)	Preoperative	22 ± 11	25 ± 13
	1 week(postoperative)	52 ± 20	66 ± 22
	2 weeks(postoperative)	41 ± 20	50 ± 20
CPK (IU/L)	Preoperative	81 ± 30	87 ± 36
	Postoperative	178 ±78	257 ± 247
	1 day(postoperative)	269 ± 169	373 ± 305
	1 week(postoperative)	80 ± 40	123 ± 114

DISADVANTAGES AND COMPLICATIONS of MITHA

The introduction of a new surgical technique always has the potential for advantages and disadvantages, and MIS hip arthroplasty is no exception. [62]

Being a new technique it need special instruments designed to perform this new technique through a smaller skin incision for example; curved acetabular reamer and impactor and special retractors supplied with light source. [11]

This technique provides inadequate exposure of the whole field at any one time giving the appearance of a mobile rectangular window which is moved to see the entire filed at more than one view giving what's called (intermittent complete visualization) or (snap shots). As a result to inadequate exposure there will a restriction in teaching the technique because only one person is able to access a good view of the anatomy at any one time. [3]

Also it may predispose to eccentric reaming of the acetabulum with the resultant component malposition (vertical cup). Also it will be limited to thin patients with low BMI and will not be the operation of choice in larger patients. [47]

At first the operation time will be much longer than the standard approach because the surgeon is inexperienced about this new approach and is still training to improve his skills. Although later on it will take less time than the standard approach as the surgeon will be well trained and also will have a small wound to close. Although some surgeons found no difference in the operative time between MIS patients and control patients. Some others found that MIS operative times were significantly shorter. [54]

Mini-incision hip arthroplasty will not be suitable in obese patients (high BMI), patients undergoing revision THA or having congenital defects in the hip joint as these conditions require wider exposure. [19]

Complications which may occur in mini-incision approach include intra operative femoral fracture, acetabular component loosening, and dislocation. The incidence of these complications in comparison to standard THA is statistically insignificant as shown in table 2. [62]

Table. 2. Distribution of complications according to each group.21]

	Groups, by length of incision		
Complication	Mini (n = 115) i < 10mm	Short (n = 70) i > 10mm but < 15mm	Conventional (n = 27) i > 15mm
DVT	0	2	0
Fracture	1	1	0
AC loosening	1	2	1
Dislocation	3	1	1

MINI-INVASIVE TOTAL HIP ARTHROPLASTY Vs STANDARD TOTAL HIP ARTHROPLASTY

T.H.A using a short skin incision has been associated with great controversy, whether it is more safe and efficient or not for patients regarding intraoperative blood loss, operative time, narcotic requirements, length of hospital stay, use of walking aids and Harris hip score, a lot of studies have been done comparing a group of patients undergoing standard T.H.A. with another group undergoing mini-invasive T.H.A. Some of these studies will be illustrated in this chapter. [39]

Study 1:

A study was done to compare the results of mini-incision total hip replacement (MITHR) with posteriolateral approach using 60 patients with osteoarthritis of the hip underwent total hip replacement utilising a mini-incision technique. They were compared to a matched cohort of patients who received the standard posterior approach. The average follow-up period was 14 months and demographics of each group are shown in **Table (3)**. [61]

Table (3) Demographics of the 2 groups of patients. [61]

	MITHR	Standard
No. of patients	60	60
Sex (M/F)	24/36	28/32
Mean age (range) [years]	61 (41–83)	64 (48–81)
Mean weight (kg)	84	86.5
Diagnosis	Osteoarthritis	Osteoarthritis

Results:

The mean follow-up period was 14 months (range, 9–26 months) and no patients were lost to follow-up. The mean length of the skin incision was 9.2 cm for the MITHR technique as compared to 20 cm for the standard posterior approach. Statistically significant differences were found between the 2 groups in terms of intra-operative blood loss, length of hospital stay, as well as the use of walking aids. Results of the study are summarized in **Table (4)**. [61]

Table (4) Results of 2 groups of patients. [61]

	MITHR	Standard
Mean length of skin incision (range) [cm]	9.2 (6–11)	20.0 (15–28)
Mean operating time (range; SD) [min]	49.0 (35–65; 9.4)	55.1 (30–90; 17.9)
Mean blood loss (range; SD) [ml]	136.0* (75–250; 41.1)	200.5 (95–300; 65.2)
Mean length of narcotic use (days)	2.2	2.64
Mean length of hospital stay (range; SD) [days]	4.41† (3–7; 1.1)	5.34 (4–9; 1.4)
Mean period with walking aids (range; SD) [days]	21.4‡ (14–30; 4.8)	24.8 (14–30; 5.4)
Mean Harris hip score	95.5	93.5

There were no dislocations in either group at short-term follow-up. In addition, there were no obvious implant insertion errors or cases of component malalignment. All femoral stems were within 3 degrees of neutral alignment with respect to the femoral shaft axis, and all acetabular components were inserted within the 40- to 50-degree abduction angle range. [61]

Discussion:

The MITHR approach has significantly reduced intra-operative blood loss, length of hospital stay, and the use of walking aids. There was little difference in the operating time, postoperative Harris hip score, or complication rates. Most importantly, the dislocation rate was not increased. There were no cases of nerve palsy, wound problems, or component malposition. Radiologically, all components were inserted within the limits of acceptability; all femoral components were within 3 degrees of neutral alignment and all acetabular components within 5 degrees of the 45 degrees abduction. [61]

Conclusion:

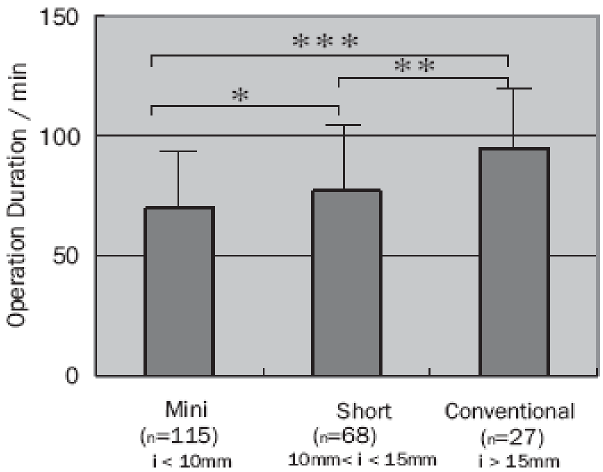
In retrospect, authors found that in MITHR, uncemented total hip replacement can be effectively performed through a much smaller incision than the standard posterior approach without increasing the risk of component malposition or complications. Less intraoperative blood loss and shorter hospitalisation are significant benefits of this less invasive surgery. [61]

Study 2:

Another study was done to compare results of standard T.H.A. and mini-incision T.H.A. using anterior approach and patients were divided into 3 groups according to the length of skin incision; skin incision less than 10 cm "mini", incision of 10-15 cm "short", and incision more than 15cm "conventional". And results were compared as regard to operative time, preoperative blood loss, and complications. [21]

Results:

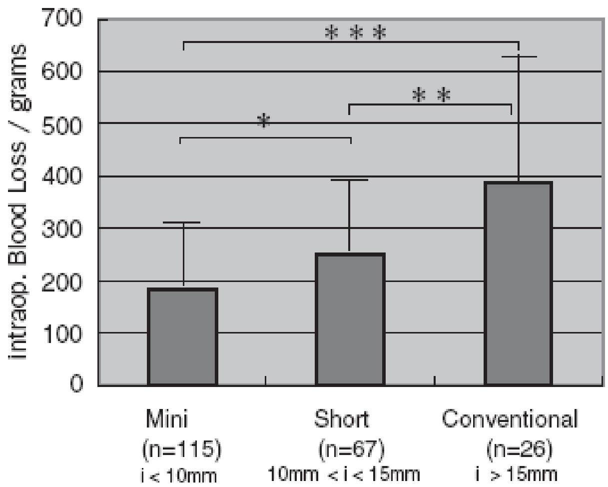
The average operative duration for patients in the mini group was 69.7 ± 15.4 min (range 45–120 min), for the short group 77.1 ± 24.3 min (range 45–230min), and for the conventional group 94.9 ± 29.8 min (range 45–170min). The operative duration showed statistically significant differences: the shorter the incision, the shorter the duration (Fig. 84). [21]



(Fig. 84) Operative duration for the each group. Statistical Analysis. [21]

The average blood loss at operation was 184.3±120.2 g (range 10–605g) in the mini group, 250.2 ±140.0 g (range 60–

645 g) in the short group, and 388.2± 263.5 g (range 100–645 g) in the conventional group. The blood loss at operation also showed statistically significant differences: the shorter the incision the less volume **(Fig. 85)**. [21]



(Fig. 85) Intraoperative blood loss for each group. Statistical analysis. [21]

The average postoperative bleeding was 515.1±264.2g (range 20–1610g) in the mini group, 532.3± 203.4 g (range 68–1430 g) in the short group, and 545.2± 278.1 g (range 10–920 g) in the conventional group. There were no significant differences among these values **(Fig. 86)**. [21]

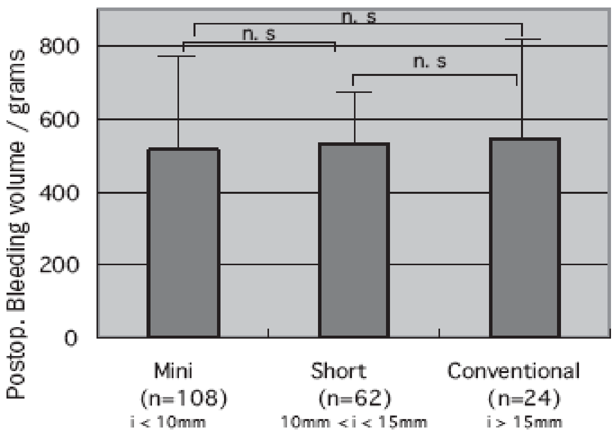
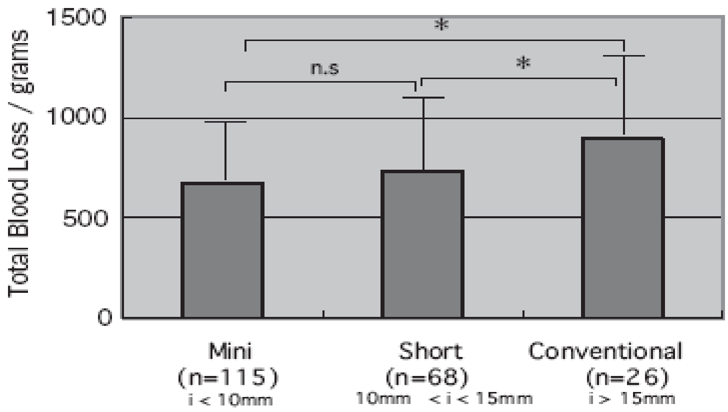


Fig. 86. Postoperative bleeding volume for each group. Statistical analysis. [21]

The total blood loss was calculated by the blood loss at surgery plus postoperative bleeding. The average total blood loss was 668.0 ± 317.2 g (range 35–1735 g) in the mini group 731.8 ± 304.5 g (range 68–1430 g) in the short group, and 891.5 ± 416.6 g (range 60–1555 g) in the conventional group. The total blood loss was significantly less in the mini/short combined group than in the conventional group **(Fig. 87)**. [21]



(Fig. 87) Total blood loss for each group. Statistical analysis. [21]

Complications:

Complications are shown in table 5. [21]

Table (5) Distribution of complications according to each group. [21]

	Groups, by length of incision		
Complication	Mini (n = 115) i < 10 mm	Short (n = 70) i > 10 mm but < 15 mm	Conventional (n = 27) i > 15 mm
DVT	0	2	0
Fracture	1	1	0
AC loosening	1	2	1
Dislocation	3	1	1

The incidence of complications in these groups did not reveal any statistically significant difference. [21]

Conclusion:

Patients were subjected to significantly less surgical invasiveness with regard to length of incision, blood loss, and operative duration. Complications did not appear to be statistically increased, even with a shorter skin incision and early rehabilitation. [21]

Study 3:

A group of 42 primary total hip arthroplasties performed through an abridged surgical incision (group I) was prospectively compared to a cohort of 42 primary total hip arthroplasties performed through a standard posterolateral incision (group II). [27]

The length of the incision was 8.8±1.5 cm for group 1 and 23.0+2.1 cm for group 2. The groups were not significantly different with respect to age, height, preoperative Harris Hip scores (HHS) **(Table. 6)**. [27]

Table.6. Preoperative patient values. [27]

Patient Variable	Abridged Incision (Group 1)	Standard Incision (Group 2)	*P* Value
Cases (n)	42	42	—
Incision length	8.8 ± 1.5 cm	23.0 ± 2.1 cm	<.01
Age	64.2 ± 15.1 y	65.0 ± 8.2 y	.76
Weight	71.4 ± 20.6 kg	80.9 ± 18.7 kg	.03
Height	168.9 ± 11.5 cm	167.8 ± 8.2 cm	.62
Body mass index	24.4 ± 5.7 kg/m^2	28.3 ± 6.1 kg/m^2	<.01
Preoperative HHS	39.1 ± 12.9	40.6 ± 10.8	.60

Abbreviation: HHS, Harris Hip Score.

Results:

Results are shown in table7. [27]

Table .7 Surgical and Postoperative outcome measures. [27]

Outcome Variable	Abridged Incision (Group 1)	Standard Incision (Group 2)	P Value
Length of follow-up	5.08 ± 0.33 y	5.17 ± 0.37 y	
Estimated blood loss	151.8 ± 53.9 mL	173.2 ± 57.5 mL	0.08
Operative time	71.4 ± 11.2 min	77.7 ± 13.2 min	0.02
Hospitalization duration	6.12 ± d	6.07 ± d	0.92
Component malposition	0	0	—
Wound healing complications (septic and aseptic)	0	0	—
Dislocations	0	1	—
Postoperative HHS	86.9 ± 4.1	84.2 ± 6.4	0.042

Patients in group 1 have expressed remarkable enthusiasm for the cosmetic appearance of the surgical incisions as shown in table 8. [27]

Table. 8. Assessment of cosmoses by patients. [27]

Satisfaction with Appearance of Incision	Abridged Incision (Group 1)	Standard Incision (Group 2)
Enthusiastic	16	3
Satisfied	15	17
Indifferent	6	14
Disappointed	0	5
Would be more pleased if incision shorter	41%	67%
Would be less pleased if incision longer	73%	49%

Discussion:

This study suggests that total hip arthroplasty can be performed safely and effectively through an abridged surgical incision with excellent patient satisfaction and no significant adverse sequel at 5-year follow-up evaluation. As would be anticipated, the shorter incision was more cosmetically appealing to patients. Our intention is not to suggest that cosmosis should take precedence over assuring optimal component alignment and fixation. Indeed, there is no excuse for sacrificing component position or fixation for the sake of a shorter scar. [27]

CONCLUSION

Minimally invasive surgery represents one of the most recent techniques that have emerged within THA. In conventional THA, the incision typically measures 20-30 cm depending on the patient, while in MIS is less than 10 cm. Although conventional THA affords wide exposure of the hip joint, it also leads to a predictably large blood loss and significant rehabilitation time. Potential advantages of minimally invasive THA include reduced hospital stay, faster rehabilitation, and reduced blood loss and transfusion requirements. Minimizing the recovery process is becoming increasingly desirable in a society that demands an individual to return to normal activities after a short recovery.

SUMMARY

The last 3 decades have seen the development of minimally invasive surgery (MIS) in T.H.A. by which we mean smaller skin incision and reduced tissue damage than that in standard T.H.A. Total hip arthroplasty is divided according to the length of the skin incision into 3 groups; "mini" with skin incision less than 10 cm, "short" with skin incision 10-15, "conventional" with skin incision more than 15 cm.

The principle in this new technique is the better cosmetic appearance and the reduced tissue trauma with the resultant advantages of reducing blood loss, operative time, opiod consumption, hospital stay, with speedy recovery and early return to everyday activities.

Several techniques of MITHA have been described, and we can divide the various MITHA approaches into two main categories: the minimal incision approaches and the two-incisions approach. The minimal incision approaches are modifications of the standard posteriolateral, anterior, lateral and superior capsulotomy approaches that are performed through wounds 7-10 cm in length. The two-incisions approach include anterior incision for acetabulum and posterior incision for the femur and it constitutes a new approach for hip replacement, using intermuscular planes to gain access to the hip joint and minimizing the dissection of muscles and tendons aiming to achieve a faster recovery of normal function.

The MITHA was greatly facilitated by the introduction of image guided systems in total hip replacement surgery which provided the ability to plan precisely the alignment of the acetabular cup before surgery, and to perform mini-invasive T.H.A. with the same efficacy as standard T.H.A. Preoperative planning based on three-dimensional medical images allows optimal placement of acetabular cup during surgery based on simulated preoperative planners for cup insertion and its orientation without the need for wider exposure.

MITHA has been accompanied by the development of specialized instruments designed to facilitate exposure and bony preparation like the curved acetabular reamers and impactors, and flanged retractors supplied by light source for illumination.

The surgical trials of MITHA done have shown more satisfying results than standard T.H.A. for both the patient and the surgeon; including less blood loss, operative time was prolonged at first due to lack of training and experience about this new technique, later on it took less time due to adequate surgical training and less time taken to close a smaller incision. This in addition to no significant difference in component positioning and alignment, rapid rehabilitation and allowance of application of an accelerated rehabilitation program and early return to everyday activities especially driving and walking unaided and climbing stairs. In addition to a better and more accepted cosmetic appearance by the patients.

Studies suggest that total hip arthroplasty can be performed safely and effectively through a smaller surgical incision with no adverse sequel at follow up evaluation and excellent patient satisfaction regarding the cosmetic appearance. Our intention is not to suggest that cosmoses should take precedence over assuring optimal component alignment and fixation. Indeed there is no excuse for sacrificing component position or fixation for the sake of a shorter scar. Cosmoses is certainly a low priority. However, according to the patients cosmoses is not meaningless. If the primary goals of the arthroplasty can be effectively and reliably accomplished through a smaller incision, then the already extremely satisfied patient population undergoing hip arthroplasty may be even more pleased with the outcomes.

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