PROSPECTIVE ANALYSIS OF PRE AND POST OPERATIVE ANTEVERSION, INCLINATION OF ACETABULUM, PELVIC TILT AND ITS RELATION TO FUNCTIONAL OUTCOME OF TOTAL HIP ARTHROPLASTY

Dissertation submitted to

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BRANCH-II: ORTHOPAEDIC SURGERY

GOVERNMENT MEDICAL COLLEGE,

OMANDURAR GOVERNMENT ESTATE,

CHENNAI-02

DEC-2024

CERTIFICATE BY THE HEAD OF THE DEPARTMENT

This is to certify that this dissertation titled "PROSPECTIVE ANALYSIS OF PRE AND POST OPERATIVE ANTEVERSION, INCLINATION OF ACETABULUM, PELVIC TILT AND ITS RELATION TO FUNCTIONAL OUTCOME OF TOTAL HIP ARTHROPLASTY" is a bonafide record of work done by Dr.S.PERUMAL, during the period of his Post graduate study from FEB 2023 to OCTOBER 2024 under guidance and supervision of Prof. A. SRINIVASAN M.S.ORTHO, in the GOVERNMENT MEDICAL COLLEGE,OMANDURAR GOVERNMENT ESTATE,CHENNAI -02, in partial fulfilment of the requirement for M.S.ORTHOPAEDIC SURGERY degree Examination of The Tamilnadu Dr . M.G.R. Medical University to be held in Dec 2024.

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DECLARATION

I declare that the dissertation entitled “PROSPECTIVE ANALYSIS OF PRE AND POST OPERATIVE ANTEVERSION, INCLINATION OF ACETABULUM, PELVIC TILT AND ITS RELATION TO FUNCTIONAL OUTCOME OF TOTAL HIP ARTHROPLASTY” submitted by me for the degree of M.S. Orthopaedics is the record work carried out by me during the period of FEB 2023 to OCTOBER 2024 under the guidance of Prof. A. SRINIVASAN M.S. Ortho, GOVERNMENT MEDICAL COLLEGE,OMANDURAR GOVERNMENT ESTATE,CHENNAI -02.

This dissertation is submitted to the Tamilnadu Dr . M.G.R. Medical University, Chennai, in partial fulfilment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in December -2024.

Place: Chennai-02 Signature of the Candidate

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CERTIFICATE

This is to certify that this dissertation work titled “PROSPECTIVE ANALYSIS OF PRE AND POST OPERATIVE ANTEVERSION, INCLINATION OF ACETABULUM, PELVIC TILT AND ITS RELATION TO FUNCTIONAL OUTCOME OF TOTAL HIP ARTHROPLASTY” of the candidate Dr.S.PERUMAL with Registration Number 120308 for the award of MASTER DEGREE in the branch of ORTHOPAEDICS. I have personally verified the ______________ for the purpose of plagiarism check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows ______of plagiarism in the dissertation.

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CONTENTS

INTRODUCTION

Total hip arthroplasty (THA) is considered to be one of the most successful orthopaedic surgical interventions of its generation. It is predicted that demand and volume of this procedure will increase in coming years due to higher demand for improved mobility and quality of life in an aging population.[1]

Primary total hip arthroplasty (THA) constitutes the standard of care for treatment of end-stage hip osteoarthritis. It provides pain relief , improved joint function and overall improved quality of life[1][2].

In 2007, the advancements in implants, surgical techniques, and overall success of the procedure earned it the distinction of "**Surgical Innovation of the 20th Century".**[3]

Patients experience substantial physical health improvements shortly after surgery, with a dramatic reduction in pain in the immediate postoperative period[4]. Long-term studies confirm that these benefits are enduring, reflecting not only in physical health but also in significant enhancements in mental and social well-being following total hip arthroplasty[5].

Pre op assessment of acetabular Anteversion and acetabular Inclination and pelvic tilt is important to position the cup intraoperatively in proper position within the normal limits, to provide the best functional outcome for the patients.[6]

Total hip arthroplasty was primarily focused on maintaining offset, limb length, and securing acetabular cup position in the safe zones described by **Lewinnek and Callanan**, 5° to 35° of anteversion and 25° to 55° of inclination is accepted[7]. Ranges outside this are considered as malposition. This safe zone range is very important in preventing dislocation and long term survival of implants. It should be emphasized that patients with suboptimal acetabular cup orientations, based on the Lewinnek safe zone, experienced higher metal wear and were more prone to adverse soft tissue interactions and effects in the hip joint.[8]

The sagittal plane relationship between the hip and spine prompts a variation in posture, which in turn alters the pelvic position and affects cup orientation[9] . Cup orientation influences joint kinematics, promoting the risk of impingement and thus pain, wear, and instability.

It's important to remember that the hip joint operates as a single axle within the interconnected spine-pelvis-hip complex. This system functions with some components moving in tandem while others move in opposition[7] . Proper function and coordination of this complex ensure that both the anatomical and functional alignment of the implants are optimal. Failure to achieve this synchronization can jeopardize the entire system, potentially compromising the functional positioning of the acetabular component.

AIM OF THE STUDY

Prospective analysis of pre and post operative anteversion, inclination of acetabulum, pelvic tilt and its relation to functional outcome of total hip arthroplasty by using clinically by Harris hip score and radiologically by X-ray and CT scan.

REVIEW OF LITERATURE

The primary goal of arthroplasty is to restore painless, mobile, and Stable to the joint [1]. Essentially, arthroplasty involves creating or reconstructing a joint to the extent possible, aiming to restore both the structural integrity and functional capability of a diseased joint.

Early aspects of hip surgery

Rogers et al., study shows that degenerative hip disease is documented in as early as Romano-British, and mediaeval skeletons [10,11]. Patients with degenerative changes could initially walk with the aid of a cane or crutches but often eventually had difficulty in day-to-day activities due to the progression of disease.

Gomez PF et al., stated that Anthony White (1782–1849) of Westminster Hospital in London is recognized for performing the first excision arthroplasty in 1821, although he did not make a personal report of the operation. This technique helped relieve pain and maintain mobility, though it sacrificed joint stability [12].

In the 1940s, Girdlestone G R et al**.,** study suggested the practice of femoral head excision, particularly for patients with tuberculosis and joint infections. Girdlestone, a man of profound religious conviction, likened his surgical approach to a biblical principle. As he put it, " ***If thine femoral head offend thee, pluck it out and cast it from thee.***"[13]

Early techniques for joint salvage

In 1826, Barton J R et al., carried out the pioneering osteotomy procedure on an ankylosed hip[14]. But changing the biomechanics in degenerative conditions does not prevent the disease progression and mild relief of symptoms only.

Bota et al., stated that various surgeons started exploring the treatment of joint surfaces using various materials or biological tissues for interposition, leading to the development of interposition arthroplasty.[15]

YEAR	SURGEON	INTERPOSITION MATERIAL
1840	Carnochan	Block of Wood[11]
1860	Auguste Stanislas Verneuil	first soft tissue interposition arthroplasty
1885	Leopold Ollier	Adipose tissue
1893	H.Helferich	Pedicle flap of muscles
1894	J.E. Pean	Thin platinum plate
1896	Foedre	Pig’s bladder
1902	J.B.Murphy	Fascia lata
1906	Hofman	Periosteum
1908	Lexer	Fascia
1912	R. Jones	Gold foil
1913	Loewe	Skin
1919	Baer	Chromicized submucosa of pig’s bladder
1920	Putti	Fascia lata

Bota et al., stated that Czech surgeon Viteslav Chlumsky (1867-1943) explored an array of interposition materials[15]. His experiments included muscle, celluloid, silver plates, rubber struts, magnesium, zinc, glass, pyres, decalcified bone, and wax.

In 1891, D Muster et al., created a ball-and-socket joint constructed from ivory[16], which was anchored to the bone using nickel-plated screws. Later, he utilized a combination of plaster of Paris, powdered pumice, and resin for additional stabilization

McKay et al., performed HIP CHIELECTOMY procedure – removal of osteophytes around the hip joint without addressing the joint surface of femoral head and acetabulum. He noticed the movements are somewhat increased but in the end it failed to prevent disease progression[17].

In 1923 Hernigou et al., stated that N. Smith-Petersen, in Boston, MA, USA, introduced the mould interposition arthroplasty using a synthetic material—Glass[18]. Glass material is well tolerated by the human body, it will stimulate the formation of fibrous layers around it. Glass molded femoral head in the acetabulum, stimulate the fibrous layer membrane around it will reduce the pain and provide stability in hip joint. He called it *“**guide nature’s repair**”* of the joint. Initially promising, the glass components quickly began to fracture[18].

Smith Peterson et al., was intrigued by the formation of a fibrous membrane and was motivated to test alternative materials, including celluloid, Bakelite, and Pyrex, **Vitalium** is the 1st non-reactive metal to the human body . After 15 years of experimentation, he achieved success with a component made of vitalium, having performed around 500 cases. He referred to this procedure as **"mold arthroplasty"**[19]

Baker et al., stated that the Smith-Petersen mould arthroplasty was shown to be superior to the acrylic-based Judet prosthesis in the relief of hip pain until supplanted by the introduction of the low friction arthroplasty[20]

Early attempts at joint replacement surgery

Gomez PF et al., stated that in 1919- Pierre Delbet's pioneering effort in joint surface replacement using a rubber prosthesis in 1919 could be described as an early instance of "rubber-based femoral head replacement" or "Delbet's femoral head prosthesis"[12]

1948- Robert and Jean judet brothers used an acrylic prosthesis[21]

1950- Thompson et al used Vitallium prostheses with a tapered collar and vertical intramedullary stem[22].

The road to modern arthroplasty

1950-Charnley's "Low-friction joint replacement approach," encompassing[23]:

1. Low-friction torque arthroplasty
2. Acrylic cement fixation
3. High-density polyethylene bearings

Gheiti AJ et al., concluded that Cemented femoral stem fixation is generally associated with excellent long-term results independent of the stem type used. Cemented fixation involves securing both the bone-cement and implant-cement interfaces[24]. Early techniques faced challenges due to their dependence on the surgeon's skill, with cement prepared on-site and applied using suboptimal methods.

In 1982, Krause et al. introduced the critical role of preparing the bone bed and the cement interface, this technique demonstrated the preparation of the cancellous bone surface had a considerable impact on both the tensile and shear strengths of the cement-bone interface[25].

In 1984, Askew et al., noted that pressurization enhances development of failure load capacity through more complete infusion and interlocking of the cement in the available pore space. The strength of the fixation achievable for any bone is limited by the intrinsic strength of the bone, linking this improvement to greater tensile and shear forces at the bone-cement junction. These methods are also relevant for cementing acetabular cups[26].

The 1970s Sameer jain et al., marked a period of significant advancements in stem technology, during which two main stem designs emerged: the taper-slip stem and the composite-beam (Fig.1) stem[27].

Kerboul et al., demonstrated that metal-on-PE Charnley-Kerboull total hip arthroplasty (THA) can deliver satisfactory and long-lasting outcomes for up to 20 years in 85% of patients under 50 years of age. These results are consistent with previously published data on Charnley total hip replacement (THR) with similar follow-up periods[28].

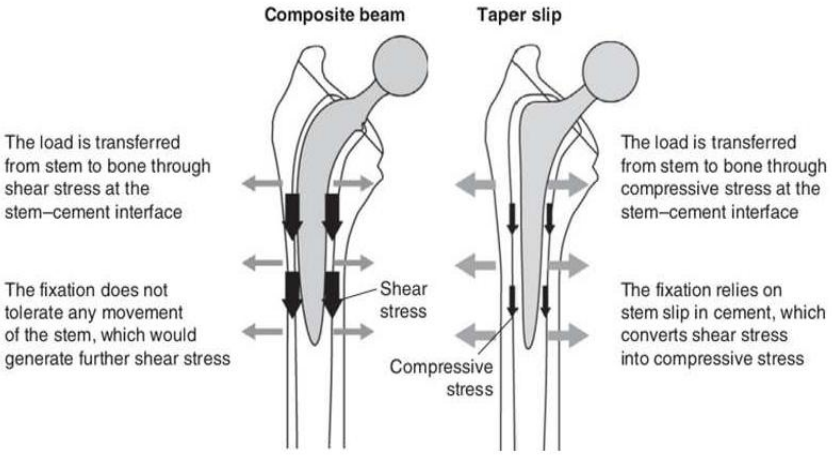


Fig 1: shows composite & taper stems

In the 1970s, Stephens TJ et al., identified the "**cement disease"**[29]. Harris WH et al., & Maloney WJ et al., observed microscopic PMMA cement particles within macrophages and giant cells at the bone-cement interface, leading to the conclusion that aseptic loosening resulted from inadequate cement fixation of the components[30][31].

In response to cement disease, the uncemented total hip replacement was developed. **Ring** pioneered this approach in the 1960s by using screws for acetabular fixation and placing the implant in valgus to enhance stability. Bobyn JD et al., concluded that Non-loaded porous-surfaced intramedullary implants become surrounded by and ingrown with osseous tissue in the absence of contact with endosteal cortical bone facilitated bony ingrowth[32] and successful implant integration.

MODERN FEMORAL STEM

Zhou XM et al., noted that In a strain-gauge study of anatomically shaped press-fit stems, vertical compressive strains in the proximal-medial region were reduced to 46-56% of the normal values, while circumferential (hoop) strains were increased to 125% of normal in press-fit femoral[33] and acetabular components.

"Press-Fit", which is rigid contact between the implant and the weight bearing cortical bone (gap <50 μm) and no micromotion (<30 - 150 μm).

Press-fit can occur at the *1) metaphysis* (the standard for primary hip replacements), or it can occur at the *2) meta-diaphysis* (when someone is very osteoporotic and the surgeon is not sure if they can rely purely on the softer metaphyseal bone for rigid fixation) or it can occur at the *3) diaphysis* (the standard for revision hip replacements, when the metaphyseal bone is gone).

Generally, femoral stems can be categorized into the following designs(Fig 3):

1. **Press-fit with Proximally Coated and Distal Tapered Stems**: These stems feature a press-fit design with proximal coating to enhance bone ingrowth and a tapered distal section, which can be dual or single tapered in medial-lateral and/or anterior-posterior planes.
2. **Press-fit with Extensively Coated and Diaphyseal Engaging Stems**: These stems are coated over a larger surface area and are designed to engage the diaphysis of the femur for increased stability and fixation.

Fig 2: Shows parts of femoral stem

3. **Press-fit Modular Stems**: These stems offer modularity at various junctions, including:
    - Head-neck
    - Neck-stem
    - Stem-sleeve
    - Mid-stem

4. **Cemented Femoral Stems**: Cobalt-chrome stems are commonly used in cemented designs due to their properties that enhance bonding with the cement.

Each design aims to optimize fixation, stability, and integration with the surrounding bone to improve the long-term success of the hip implant.

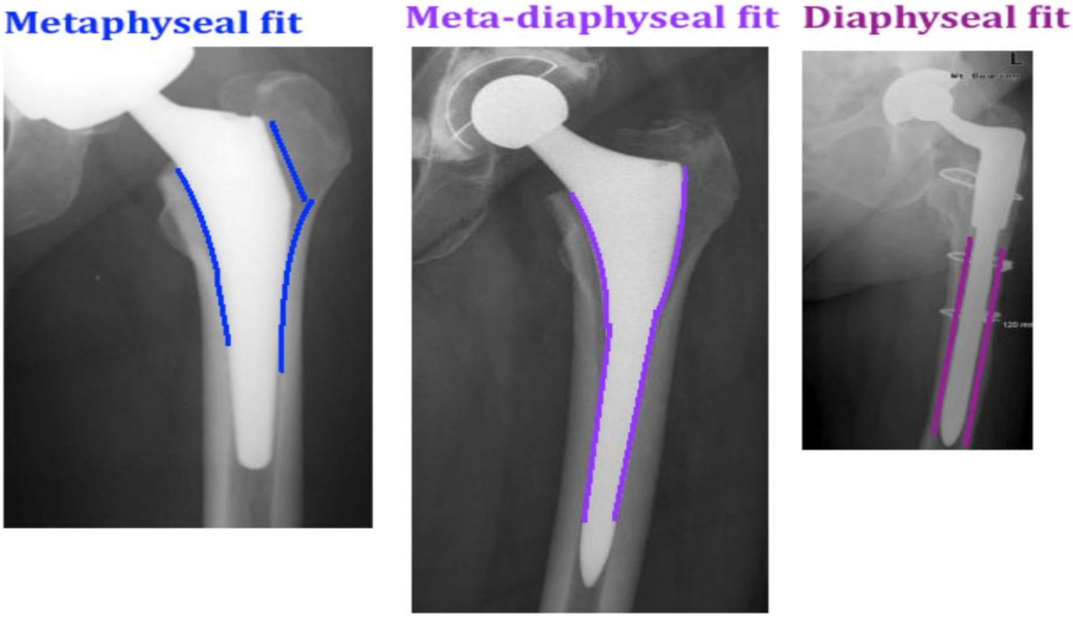


Fig 3: Different stem types

Zagra L et al., stated that [34]**,** Ceramic-on-Ceramic (CoC): CoC is renowned for having the best wear properties among all THA bearing surfaces. It provides exceptional durability and minimal wear over time. but it has 2 disadvantages; squeaking & less forgiving.

Ceramic-on-Ceramic (CoC): CoC is renowned for having the best wear properties among all THA bearing surfaces. It provides exceptional durability and minimal wear over time.

Mellon SJ ET AL., stated that Metal-on-Polyethylene (MoP): MoP has the longest history among bearing surfaces and is known for its cost-effectiveness. It remains a widely used option due to its proven track record [35].

Mellon SJ ET AL., stated that Metal-on-Metal (MoM) demonstrated superior wear properties compared to MoP, including lower linear wear rates and reduced particle generation. Even though usage of MoM declined due to concerns over pseudotumor development; metallosis reactions; Type IV delayed hypersensitivity reactions. MoM is also contraindicated in pregnant women; individuals with renal disease; patients at risk of metal hypersensitivity[35].

In recent years, hip arthroplasty has become less invasive, utilizing improved materials that are more wear-resistant and biocompatible. Advances in perioperative management, pain control, anaesthesia, and rehabilitation have significantly enhanced outcomes and reduced complications.

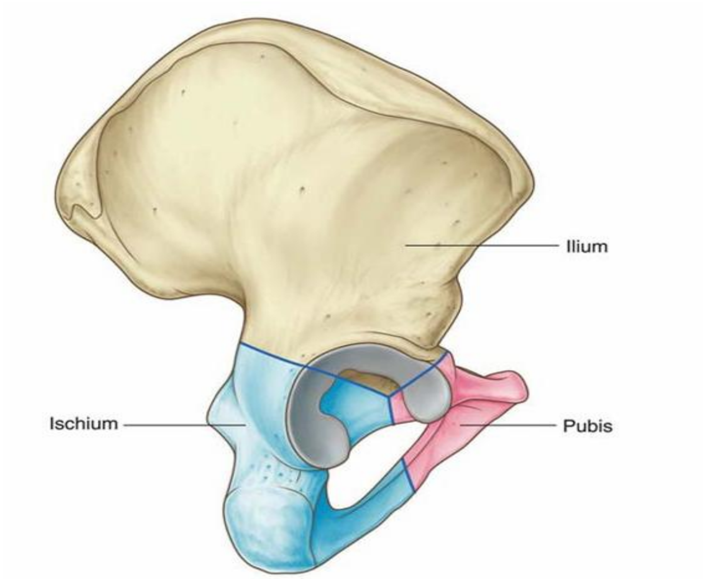
ANATOMY OF THE HIP JOINT

The hip joint is a true ball-and-socket structure, supported by strong and well-coordinated muscles[36], which allows for extensive movement across multiple planes while maintaining exceptional stability. Serving as the critical connection between the lower extremities and the axial skeleton, the hip transmits forces from the ground upwards and also supports forces from the trunk, head, neck, and upper body. This makes the hip essential for athletic activities, where it frequently endures forces that exceed normal axial and torsional loads.

The hip is a classic ball-and-socket joint (Fig 4) and exemplifies all four characteristics of a synovial or diarthrodial joint[37]:

1. joint cavity
2. its surfaces are lined with articular cartilage
3. it contains a synovial membrane that secretes synovial fluid
4. and it is encased by a ligamentous capsule

The cup-shaped acetabulum is formed by the innominate bone, comprising contributions from the ilium (40%) , the ischium (40%), and the pubis (20%)[38].



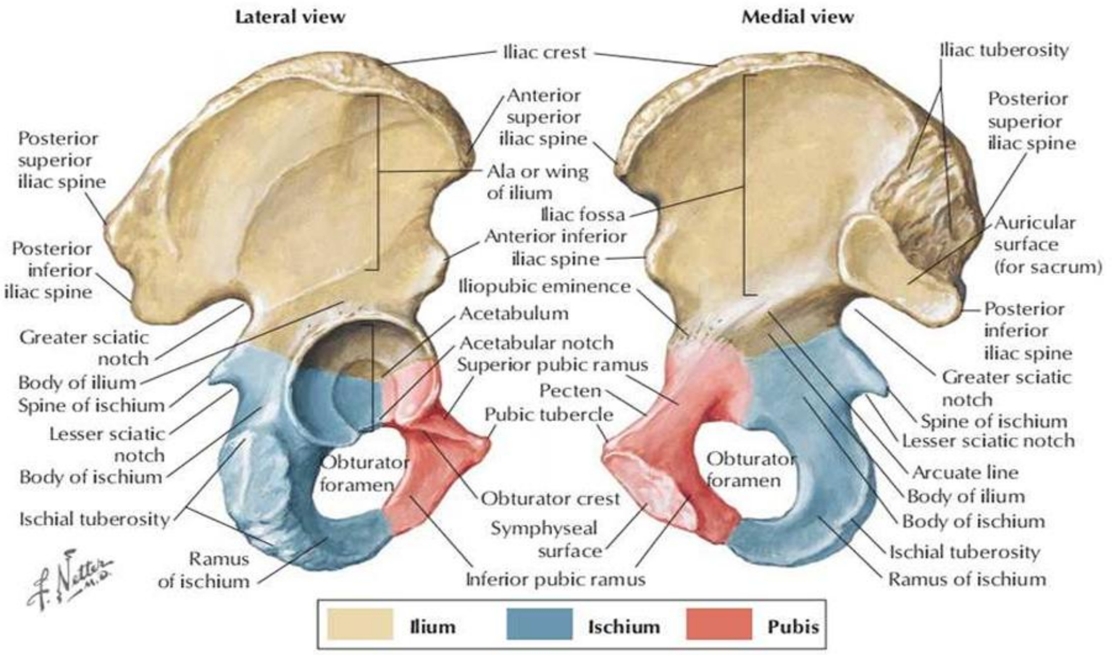


Fig 4: Bony anatomy of hip joint

EMBRYOLOGY & DEVELOPMENT OF HIP:

At 6 weeks - 12 mm in length, with areas of mesenchyme beginning to condense and outline the ilium, ischium, pubis, and femoral shaft. Rapid differentiation then ensues[39].

7 weeks- 17 mm long, an interzone forms between the femoral head and the acetabulum[40][41].

8 weeks-30 mm, and blood vessels have begun to infiltrate the ligamentum teres[40].

11 weeks- 50 mm in length. The femoral head is spherical, with a diameter of 2 mm, and is distinctly separate from the acetabulum. The neck-shaft angle (NSA) is now between 140-150 degrees, femoral anteversion ranging from 5 to 10 degrees..

16 weeks- 120 mm in length. The hip muscles are distinct and well-developed, allowing for kicking and movement. While early ossification begins in the femoral shaft's cartilage, the femoral head and trochanters remain cartilaginous until some time after birth[40].

In utero, fetal hips are typically positioned in flexion, abduction, and external rotation, with the left hip often more rotated. The femoral head primarily receives blood supply from the epiphyseal and metaphyseal vessels

Acetabular growth is intricate: the triradiate cartilage accounts for 70% of this development, increasing in both diameter and depth. The triradiate cartilage generally closes around age 11 in girls and a year later in boys[41][42].

The development of the proximal femoral chondro-osseous epiphysis and physis is among the most complex in the appendicular skeleton[42]. Key features include

(1) the persistence of epiphyseal and physeal cartilage along the posterosuperior neck for much of postnatal development
(2) limited capital femoral blood vessels running intracapsularly

Secondary ossification in the capital femur typically starts between 4 and 6 months postnatally (with a range of 2 to 10 months). This process begins as a central sphere of ossification that expands centrifugally, eventually taking on the hemispheric shape of the articular surface by the age of 6 to 8 years[42].

Initially, the primary spongiosa formed during neck development does not fully align with the biological forces across the hip joint. As the secondary spongiosa develops, it begins to form typical trabecular patterns (Fig 5) aligned with compression and tension forces, a process that becomes more prominent in the second decade of life. The region between these primary and secondary osseous patterns is known as Ward’s triangle.

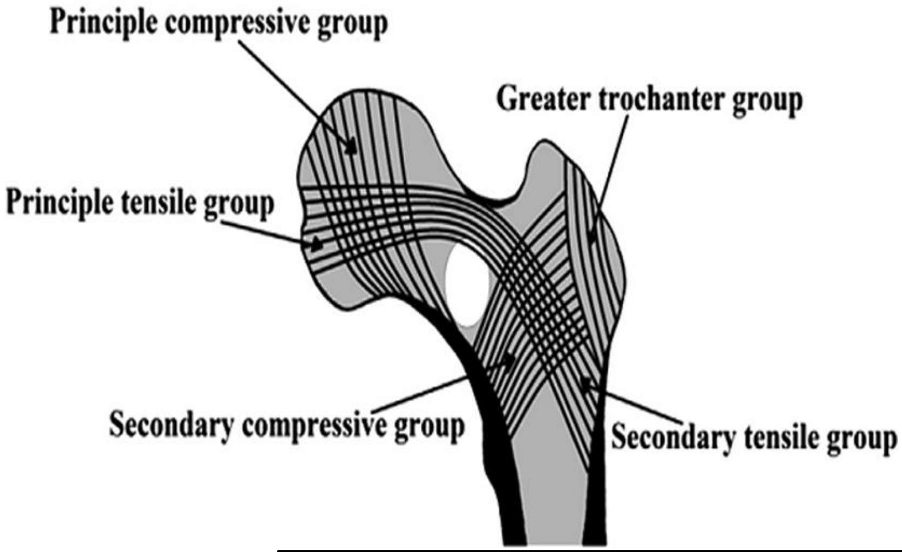


Fig 5: Trabecular patterns in femoral head

In individuals who are still growing, the three pelvic bones are separated by the **triradiate cartilage**[42]. Fusion of this cartilage generally begins around ages 14 to 16 and is usually complete by age 23.

The native acetabulum is oriented in 16 to 21 degrees of anteversion and 40 degrees o f abduction. femoral neck is oriented in 15 to 20 degrees of anteversion and is angled 125 ±5 degrees with respect to its diaphysis.

The articular surface of the acetabulum is crescent-shaped from within. Inside this crescent is the central inferior acetabular fossa(Fig 6), which houses a synovial-covered fat pad and the origin of the ligamentum teres[43]. The inferior transverse acetabular ligament completes the hip socket.

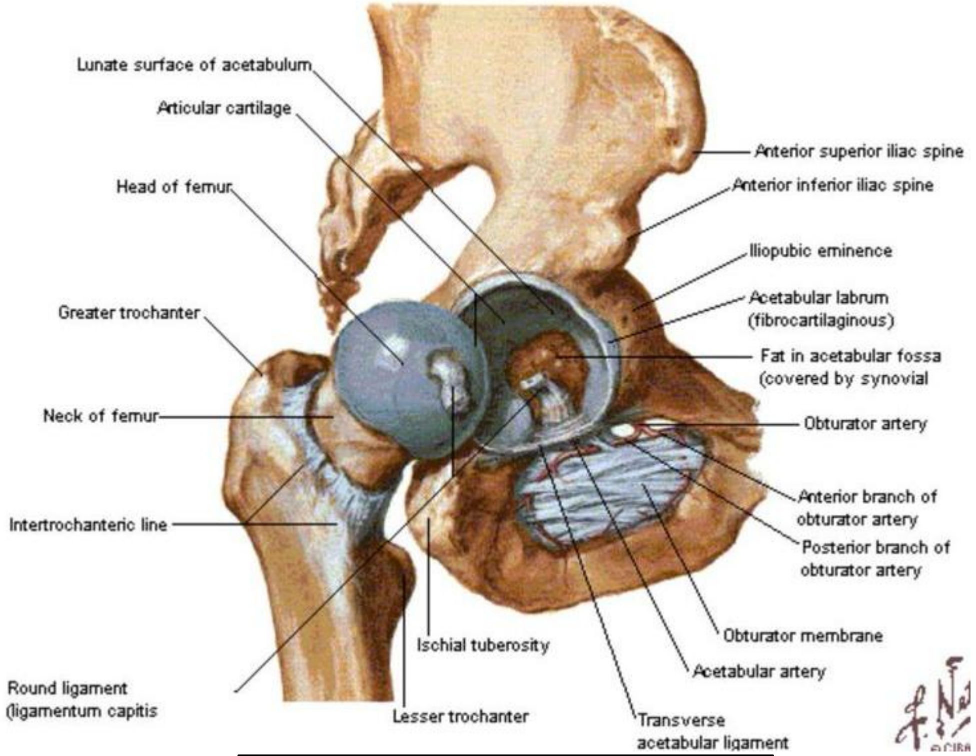


Fig 6: Hip joint opened lateral view

Additionally, a robust fibro-cartilaginous **labrum** is attached to the acetabular rim, The labrum encircles the acetabulum, with the transverse acetabular ligament crossing the acetabular fossa at its inferior part[44].   playing a crucial role in

1.force distribution and joint stability.

2.restrict the movement of synovial fluid to the peripheral compartment of the hip, creating a negative pressure effect within the joint.

3.It is attached to the bony rim of the acetabulum and is distinct from the capsule attachment.

Young patients with labral tears can get moderate OA earlier in life due to abnormal joint mechanics secondary labral tears[45].

The femoral head is covered with articular cartilage extending beyond the acetabular rim to support the full range of motion, covering 60 to 70% of a sphere. The central uncovered area, known as the fovea capitis, serves as the insertion site for the ligamentum teres. Although the ligamentum teres[44] is intra-articular, it is extra-synovial and does not contribute to joint stability.

Capsule and ligaments:

A robust fibrous capsule encircles the hip joint, contributing to its stability. Proximally, the capsule attaches to the acetabular rim about 6 to 8 mm from the labrum[46]. Distally, the anterior capsule connects to the intertrochanteric line and greater trochanter, while the posterior capsule attaches just above the posterior intertrochanteric crest. Most of the capsular fibers run longitudinally along the femoral neck, but a subset known as the zona orbicularis forms a circular band around the femoral neck(Fig 7). This group of fibers helps reinforce the hoop stresses on the acetabular labrum.

Fig 7: Hip joint capsule

Thick anterosuperior part- Maximum tension

Thin and loosely attached posteroinferiorly

2 types of fibers:

Outer longitudinal fiber
Inner circular (Zona orbicularis)

3 main ligaments around hip joint[47]: (Fig 8, Fig 9)

1. Iliofemoral ligament(ligament of Bigelow)
2. Pubofemoral ligament
3. Ischiofemoral ligament

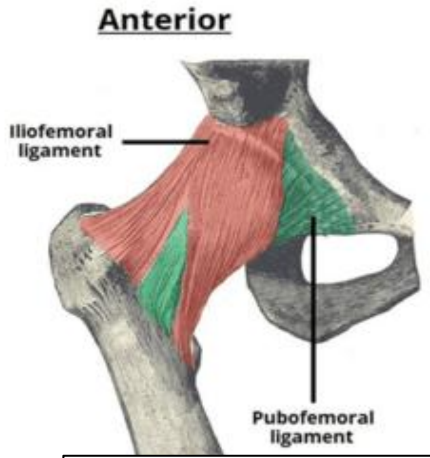


Fig 8: Ligament around hip joint

Fig 9: Ligament around hip joint (posterior view)

The iliofemoral ligament, also known as the ligament of Bigelow, is the strongest of the three hip ligaments. It runs from the anterior inferior iliac spine to the anterior intertrochanteric line in an inverted-Y shape, primarily resisting hip hyperextension.

The pubofemoral ligament, extending from the superior pubic ramus to the inferior femoral neck, resists hip hyperabduction.

The ischiofemoral ligament, the thinnest, spans from the ischial rim of the acetabulum across the posterior-inferior aspect of the joint to the femoral neck, stabilizing the hip in extension

Nerve supply:

The hip joint is innervated by several nerves, primarily affecting the hip capsule[48].

1. The posterior articular nerve, a branch of the nerve to the quadratus femoris, supplies the most extensive innervation, including the posterior and inferior capsule regions and the ischiofemoral ligament.
2. The superior gluteal nerve innervates the superior part of the capsule, while the anterior capsule receives its primary innervation from direct branches of the femoral nerve.
3. Medial articular nerve, stemming from the anterior division of the obturator nerve, supplies the anteromedial and anteroinferior regions
4. The ligamentum teres is innervated by the posterior branch of the obturator nerve. The acetabular labrum contains sensory nerve endings and free nerve endings.

Blood supply:

Branches of the internal iliac artery supply Acetabulum(Fig 10).

The superior gluteal artery -the superior and posterior portions of the acetabulum,

The inferior gluteal artery provides blood to the inferior and posterior regions.

The acetabular branch of the obturator artery is the main source of blood for the medial acetabulum[49].

The foveal artery, a smaller terminal branch of the posterior division of the obturator artery, traverses the ligamentum teres to supply a small area of the femoral head.

The recess between the capsule and labrum is lined with highly vascularized, loose connective tissue. A few small blood vessels, typically three to four, are arranged in a circumferential pattern within the labrum and along its junction with the bone.

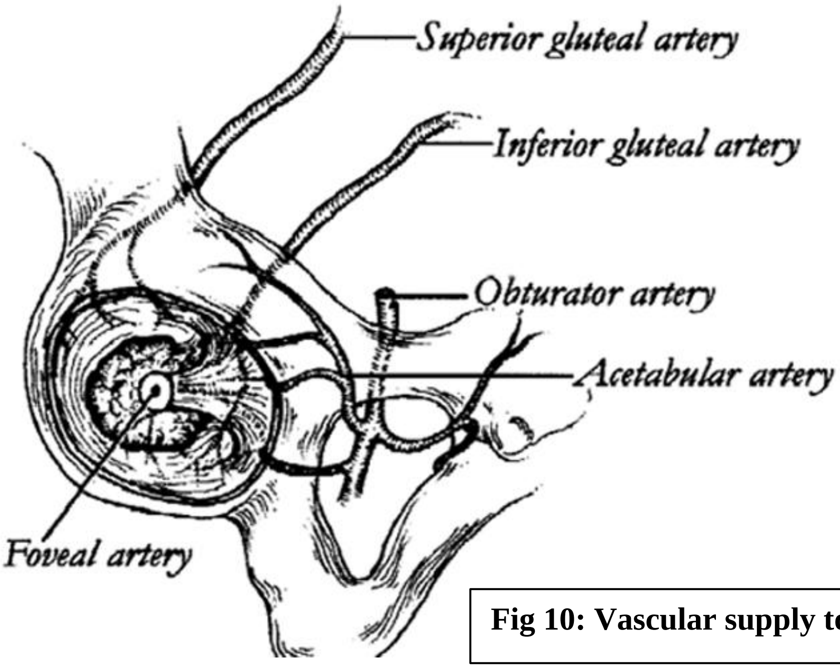


Fig 10: Vascular supply to acetabulum

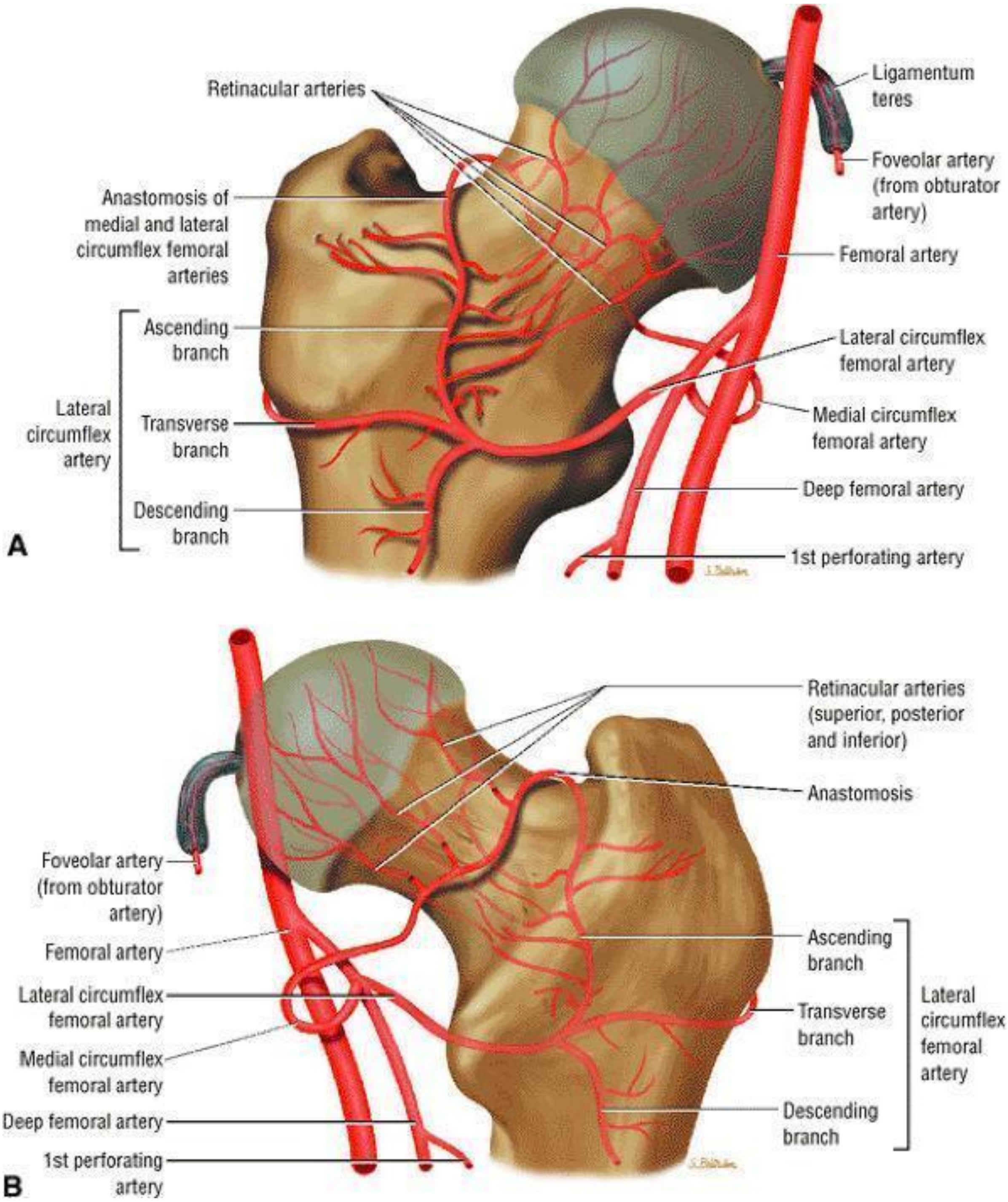
The arterial supply to the proximal femur **Crock's** description is considered the most appropriate due to its three-plane analysis and standardized anatomical nomenclature[50]. Crock categorized the arteries of the proximal femur into three groups(Fig 11):

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

(b) ascending cervical branches of this ring on the surface of the femoral neck.

(c) the arteries of the round ligament.

Fig 11: Vascular supply to femoral head



The extracapsular arterial ring is formed posteriorly by a large branch of the medial femoral circumflex artery and anteriorly by branches of the lateral femoral circumflex artery, with minor contributions from the superior and inferior gluteal arteries.

The ascending cervical branches, arising from this ring, penetrate the hip joint capsule at the intertrochanteric line anteriorly and pass beneath the posterior orbicular fibers of the capsule. These branches, known as retinacular arteries and initially described by Weitbrecht, travel upward beneath the synovial reflections and fibrous extensions of the femoral head from its neck.

The ascending cervical arteries are categorized into four groups—anterior, medial, posterior, and lateral—based on their location relative to the femoral neck. Among these, the **lateral group** supplies the majority of blood to the femoral head and neck. At the articular cartilage margin on the femoral neck, these vessels form a **secondary ring, known as the subsynovial intra-articular arterial ring** as described by **Chung.** From this ring, epiphyseal arterial branches arise and enter the femoral head.

Once the arteries from the subsynovial intra-articular ring penetrate the femoral head, they are referred to as epiphyseal arteries. Trueta and Harrison (1953) identified two distinct groups[51] within the femoral head: the lateral epiphyseal and inferior metaphyseal arteries. However, Crock later reported that both groups actually originate from the same arterial ring and are thus both considered epiphyseal arteries.

The artery of the ligamentum teres, a branch of either the obturator or the medial femoral circumflex artery[52], has shown variable functional significance in the literature. Howe et al. found that while these vessels do supply blood to the femoral head, they are often insufficient to provide major nourishment, particularly after a displaced femoral neck fracture.

Venous outflow from the femoral head and neck occurs through the lamina capsular veins, which may be single or double and run infero-medially along the trochanteric line to drain into the obturator vein. There is no venous drainage through the ligamentum teres

MUSCLES ACTING ON THE HIP JOINT:

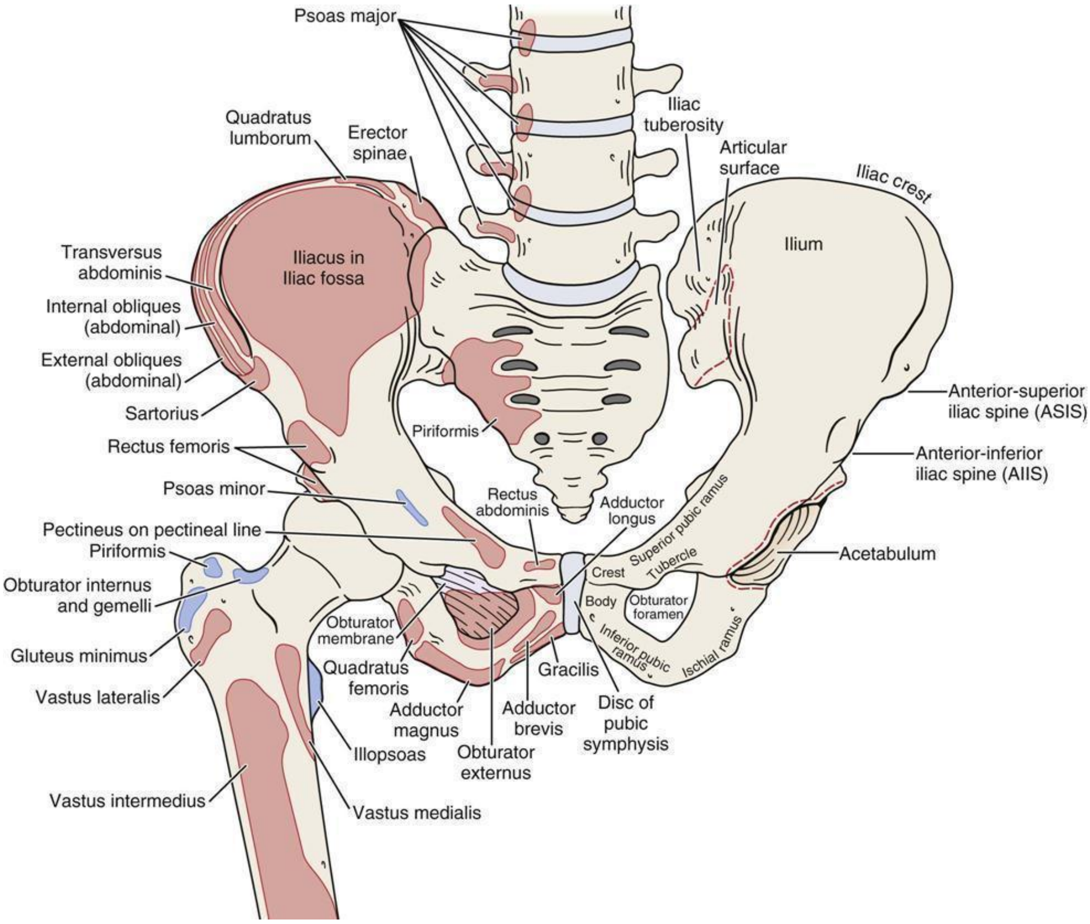


Fig 12: muscles around the hip joint

The hip's geometry facilitates a wide range of motion in all planes, requiring numerous muscles that originate from a broad surface area to ensure stability. The twenty-one muscles (Table 1) acting on the hip joint both stabilize it and generate the forces needed for movement[53].

Table 1: muscles around hip joint & actions

Action	Muscle	Origin	Insertion	Innervation
Flexion	Iliopsoas (iliacus, psoas major, psoas minor)	T12-L5 transverse processes, iliac crest, and sacrum	Lesser trochanter	Femoral nerve
	Rectus femoris	AIIS and anterosuperior acetabulum	Superior patella	Femoral nerve (L2-L4)
	Tensor fascia latae	ASIS and iliac crest	Iliotibial tract	Superior gluteal nerve (L4, L5)
	Sartorius	ASIS	Anteromedial tibial plateau	Femoral nerve (L2, L3)
Extension	Gluteus maximus	Outer cortex of ilium, posterior sacrum and coccyx	Posterior iliotibial tract and gluteal tuberosity	Inferior gluteal nerve (L5, S1, S2)
	Biceps femoris	Ischial tuberosity	Fibular head and posterolateral tibial plateau	Tibial branch of sciatic nerve (L5, S1, S2)
	Semimembranosus	Ischial tuberosity	Posteromedial tibial plateau	Tibial branch of sciatic nerve (L5, S1, S2)
	Semitendinosus	Ischial tuberosity	Anteromedial tibial plateau	Tibial branch of sciatic nerve (L5, S1, S2)
Abduction	Gluteus medius	Anterior gluteal line	Lateral surface of greater trochanter	Superior gluteal nerve (L4, L5, S1)
	Gluteus minimus	Outer cortex of ilium	Anterior surface of grater trochanter	Superior gluteal nerve (L5, S1)
	Tensor fascia latae	ASIS and iliac crest	Iliotibial tract	Superior gluteal nerve (L4, L5)
Adduction	Adductor magnus	Inferior pubic ramus, ischial tuberosity	Gluteal tuberosity and adductor tubercle of medial femur	Obturator nerve (L2, L3) and sciatic nerve (L2-L4)
	Adductor longus	Body of pubis	Middle third of linea aspera	Obturator nerve (L2-L4)
	Adductor brevis	Inferior ramus and body of pubis	Proximal linea aspera and pectineal line	Obturator nerve (L2-L4)
Internal Rotation	Gluteus medius	Anterior gluteal line	Lateral surface of greater trochanter	Superior gluteal nerve (L4, L5, S1)
	Gluteus minimus	Outer cortex of ilium	Anterior surface of grater trochanter	Superior gluteal nerve (L5, S1)
	Tensor fascia latae	ASIS and iliac crest	Iliotibial tract	Superior gluteal nerve (L4, L5)
External Rotation	Obturator internus	Inner surface of obturator membrane	Medial greater trochanter	Nerve to obturator internus (L5, S1)
	Obturator externus	Outer surface of obturator membrane, pubic ramus, and ischium	Trochanteric fossa	Obturator nerve (L3, L4)
	Superior gemellus	Ischial spine	Posterior greater trochanter	Nerve to obturator internus (L5, S1)
	Inferior gemellus	Ischial tuberosity	Posterior greater trochanter	Nerve to quadratus femoris
	Piriformis	Anterior surface of the sacrum and sacrotuberous ligament	Posterosuperior grater trochanter	Ventral rami of S1 and S2
	Quadratus femoris	Lateral border of ischial tuberosity	Quadrate tubercle	Nerve to quadratus femoris

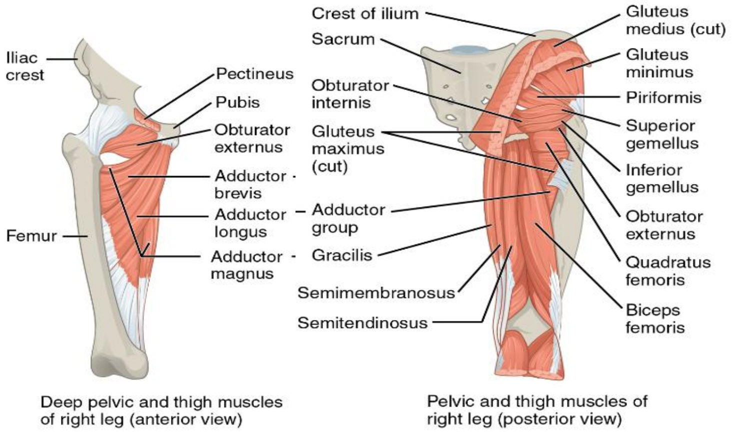


Fig 13: muscles around hip joint

MOVEMENTS:

Joint motion involves rotations and translations in the x, y, and z planes, encompassing six degrees of freedom: abduction, adduction, flexion, extension, internal rotation, and external rotation [54].

Flexion – 120°

Extension- 5° - 20°

Adduction- 25°

Abduction- 40°

Internal rotation- 45° in 90 flexion°, 35° in extension

External rotation- 45° in flexion & extension.

BIOMECHANICS

Hip motion occurs in three planes—sagittal, frontal, and transverse—thanks to its ball-and-socket structure. However, some researchers have noted that the femoral head has a conchoid (or ellipsoid) shape[55] . This specific shape reduces the likelihood of subluxation compared to a perfectly spherical ball-and-socket joint.

KINEMATICS

As an orthopaedic surgeon, understanding the hip motion ranges for daily activities is crucial. Kuo AD et al., reviewed the principles of mechanics play a key role in human walking, with the dynamic movement of the limbs being just one component of the overall walking pattern [56].

Rehabilitation, however, is not focused solely on this single aspect. Instead, it addresses the integrated function of both the central nervous system (CNS) and the musculoskeletal system working together to restore normal gait [56].

For instance, tying shoelaces with the feet on the floor requires up to 125° of hip flexion, 19° of external rotation, and 15° of abduction. Ascending stairs typically demands a mean hip flexion of 70°, while descending requires about 35°. Gait, a hallmark of human movement [56], involves a series of imbalanced phases that are far more intricate than they appear to the naked eye.

In the sagittal plane, the hip joint reaches a maximum flexion of 35°–45° during the late swing phase of gait, Hip extends as the limb moves forward for heel strike, peaking at heel-off [56]. In the frontal and transverse planes, the hip abduction during the swing phase, peaking just after toe-off, and adducts during the stance phase. The hip externally rotates in the swing phase and internally rotates to align the foot at strike, with internal rotation gradually decreasing as the contralateral hip advances.

Pelvic motion, including sagittal, axial, and frontal plane movements, varies among individuals and is influenced by factors such as walking speed, pelvic and hip anatomy, and spinal flexibility [56].

KINETICS:

The bone structure of the proximal femur exhibits distinct patterns of compression and tension due to bending stresses acting on it at the hip. Frost HM et al., reviewed Wolff's law. This law states that reduced mechanical usage (MU) and sudden disuse lead to bone loss near the marrow, while normal and intense mechanical usage contribute to bone reservation. Bone adapts its structure in response to the mechanical forces it encounters. The alignment of these stress trajectories is influenced by the loading conditions and the shape of the proximal femur[57].

Similarly, the bone structure in the acetabulum is shaped by both its form and the mechanical loads it bears. Sánchez Egea AJ et al., demonstrated that even minor changes in the neck-shaft angle, femoral anteversion angle, or acetabular anteversion can increase the mechanical loads borne by the hip joint cartilage at the chondrolabral junction When the area subjected to load is smaller and the overall load is higher, there's a greater tendency for the formation of sclerotic regions in the bone. This means that with increased stress concentration in a smaller area, the bone becomes denser and more robust to handle the increased force[58].

The femoral neck has two key angular relationships with the femoral shaft that are crucial for hip joint function. Gilligan I et al., stated that At the population level, NSA variation is influenced by climate, aligning with well-established climatic patterns observed in other aspects of human body shape, as outlined by Bergmann's rule. The average NSA for modern humans is 127°, Asia's median is 129°[59].

The angle of inclination in the frontal plane, known as the neck-to-shaft angle

1. The angle of anteversion in the transverse plane.
   The neck-to-shaft angle, which tilts the femoral shaft laterally away from the pelvis, plays a significant role in allowing a greater range of motion at the hip joint

Asayama I et al., stated that abductor muscles are the primary stabilizers of the pelvis in the coronal plane[60]. The total compressive force on the hip joint is the sum of body weight and the tension in the abductor muscles.

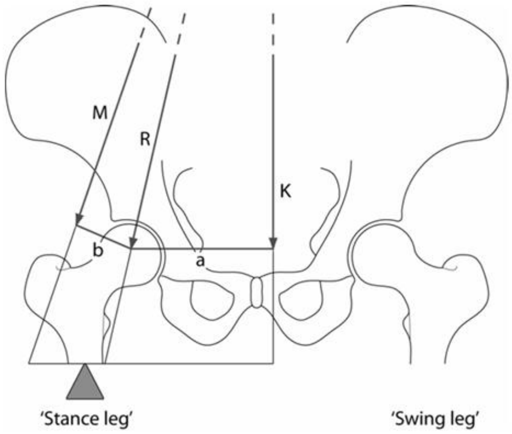


Fig 14: Illustration of joint reaction force

K- body weight, R- Joint reaction force, M- Abductor muscle force

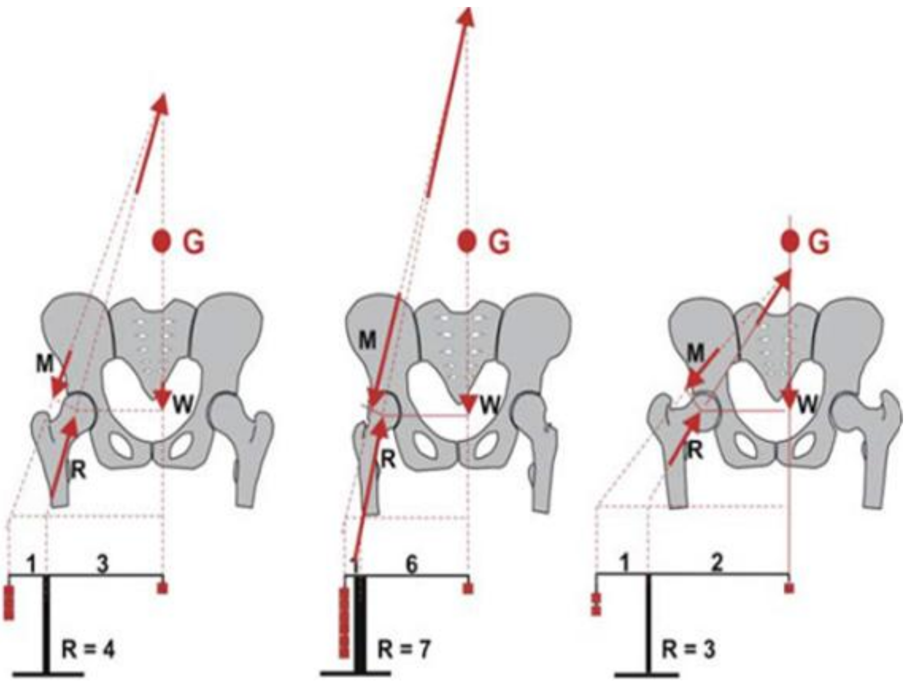
b- Abductor moment arm, R- Joint reaction force, a- Body moment arm

Joint reaction force (JRF) = Body Weight (K) * Body moment arm(a) – Abductor force(M) * Abductor moment arm (b)

Lever arm ratio : a:b

Understanding the contact forces in the hip joint is essential for evaluating implant strength, fixation, wear, and friction. It is also crucial for optimizing the design and materials of implants through computer simulation, as well as for providing guidance to patients and physiotherapists on which activities should be avoided following a joint replacement[61].

During a single-leg stance, the forces typically reach three times body weight, which corresponds to a lever arm ratio of 2.5 . An increase in the lever arm ratio raises the required abductor muscle force for walking, thereby increasing the force on the femoral head. Individuals with shorter femoral necks experience higher hip forces under similar conditions. More notably, those with wider pelvises also endure greater hip forces[60].



A B C

Fig 15: Schematic view of the forces in the hip according to Pauwels

A in the normal hip, B valgus hip and C varus hip. The diagram shows the effect produced by a change in the lever arms on the acting forces

Asayama et al., stated that a typical hip, the resultant force on the hip is about four times body weight. When the femoral neck angle is greater than normal(>135°), leading to a shorter lever arm for the abductors, the resultant force increases. In contrast, with coxa vara, where the femoral neck angle is reduced(<125°), the lever arm of the abductors becomes longer, resulting in a decrease in the resultant force[60].

Asayama et al., stated that in a simple 2D model, when standing with equal weight distribution, each femoral head supports half of the body weight, with no additional muscle forces involved. However, during a single-legged stance, approximately five-sixths of the body weight is borne by the supporting femoral head, with the weight vector being vertical. Concurrently, the abductor muscle force acts medially and superiorly at an angle of about 30° from the vertical. The lever arms of both the body weight and abductor muscles can be measured on an anterior-posterior pelvis radiograph[60].

To maintain pelvic stability, the external moment created by the abductor muscles must equal the internal moment created by body weight. Since the lever arm of the abductor muscles is much shorter than that of the body weight, the abductor muscle force must be significantly greater than body weight. Consequently, peak hip joint forces during gait can reach 1.8 to 4.3 times body weight, and can increase up to eight times body weight during activities such as running or skiing[61].

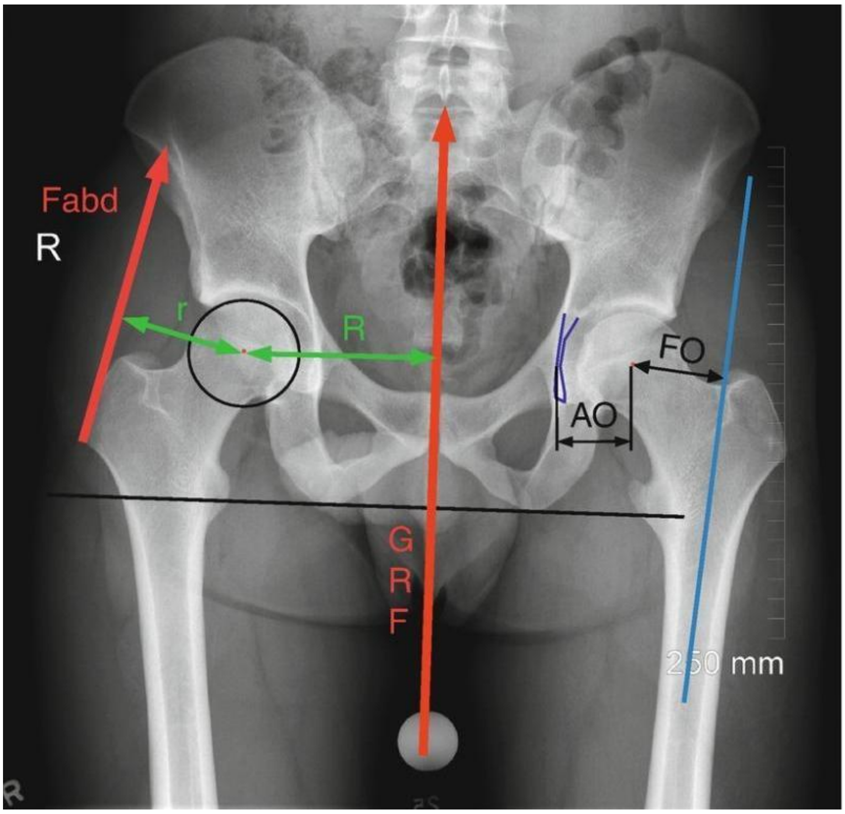


Fig 15: abductor lever arm, body lever arm

abd -Abductor muscle force, *GRF* -Ground Reaction Force, *FO*- Femoral Offset, *AO*- Acetabular Offset, *r* -Abductor lever arm, *R*- Body weight lever arm

Hart AJ et al., found that the acetabular inclination angle was strongly positively correlated with the rate of wear. Their study also indicated that components with high wear rates were implanted outside Lewinnek's safe zone. Femoral version was weakly negatively correlated with the rate of wear. These parameters are particularly relevant because they can be altered through total hip replacement (THR) surgery[62].

Specifically, increasing the abductor lever arm reduces the force required from the abductors to keep the pelvis horizontal, thereby decreasing hip joint reaction forces. Conversely, a wider pelvis extends the body-weight lever arm, leading to higher joint contact forces during single-legged stance[62].

In a prosthetic joint, factors such as **femoral head diameter, articular clearance, and cup orientation** significantly impact the contact area between the head and acetabulum, thereby influencing hip joint contact forces.

A larger femoral head diameter generally results in a bigger contact patch. However, the actual contact area is closely related to the cup's inner diameter and the clearance between the head and cup.

Underwood RJ et al., stated that excessive clearance can reduce the contact patch area and increase wear rates. Conversely, lower clearance provides a more conformal contact with a larger contact patch, but also reduces the distance between the patch's edge and the cup rim, raising the risk of edge loading and wear[63].

Angadji A et al., stated that Edge loading, where the contact patch extends over the rim of the cup, leads to increased local pressure, disruption of lubrication, and higher wear. Clearance is a critical factor in this phenomenon, particularly for large-diameter metal-on-metal (MoM) bearings. To minimize excessive wear, a cup abduction angle of 45° or less is recommended[64].

During hip reconstruction, the surgeon can modify the following dimensions:

- The length of the body weight lever arm
- The length of the abductor lever arm
- The offset of the prosthesis
- The varus or valgus alignment of the prosthesis within the femur.

Component Positioning:

Aim of hip replacement to achieve sustainable restoration of hip mobility without pain. Component positioning plays a role in every aspect of the clinical outcomes: function, wear rate, occurrence of complication, and components lifespan.

CENTER OF ROTATION:

Scheerlinck T et al., found that "optimal" positioning of the cup in total hip arthroplasty plays a crucial role in improving hip function while reducing wear, impingement, and dislocation. Cup position refers to both the spatial relationship between the hip rotation center and the pelvis, as well as the orientation of the cup around this center. The first parameter is key to maintaining hip balance, and if not properly managed, it can lead to poor function and leg length discrepancies[65].

Lecerf G et al., noted that Medializing the acetabular component reduces the body moment arm, which lowers the force required from the abductors and decreases joint reaction forces. However, excessive medialization can reduce abductor muscle tension, which may require adjustment of the femoral offset to restore the global offset (the sum of acetabular and femoral offsets) and maintain proper abductor muscle tension[66].

A decrease in global offset results in reduced abductor tension and instability, while an increase can lead to excessive abductor tension, causing trochanteric pain and higher torque on the femoral stem, potentially resulting in loosening or periprosthetic fractures[66].

De Fine M et al., systematic review found that restoring femoral offset during total hip arthroplasty include reduced wear on the bearing surfaces; lower rates of implant loosening; decreased risk of dislocation. in cases of reducing the femoral offset also shortens the abductor lever arm, necessitating greater force from the abductors to stabilize the pelvis, which increases joint reaction forces and wear on the bearing surfaces[67].

CUP ORIENTATION:

Hip prosthetic surgery involves removing the labrum and reducing the femoral head size, which impacts hip stability. The native acetabulum covers the femoral head by 170°, while a prosthetic acetabular cup typically provides 180° coverage. Bhaskar D et al., state that proper cup positioning is crucial to maintain stability and prevent impingement[68].

Two key parameters for positioning the cup around its center of rotation are

1. Inclination

2. Anteversion

The **inclination** affects edge loading by altering the contact patch center-to-rim distance (CPCR) and contact patch edge-to-rim distance (CPER); a less inclined cup increases CPCR, reducing edge loading and associated wear.

Anteversion, which affects stability, helps prevent posterior dislocation, but hip stability also depends on other factors such as the surgical approach, prosthetic design, head diameter, and prosthetic neck anteversion.

Lewinnek et al the safe zone Concept[7]**:** (Fig 16)

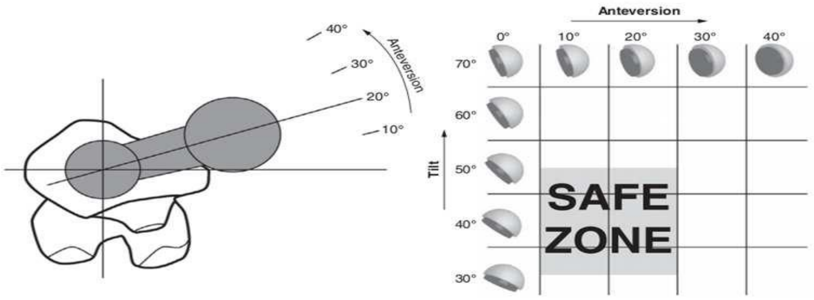


Fig 16: Lewinnek et al safe zone

Acetabular anteversion =15° ± 10°

Acetabular inclination = 40° ± 10°

Walter WL et al., study support Lewinnek et al the safe zone Concept; he noted squeaking in the hips typically began after an average of 14 months usually associated with acetabular cup malposition[70].

Murphy WS et al., found that prioritizing the assessment of preoperative pelvic tilt and ensuring accurate placement in operative anteversion are crucial. By refining patient-specific cup orientation goals and improving acetabular component placement, the use of CT data to further define a safe zone could help reduce the incidence of cup malposition and its related complications[69].

FEMORAL STEM POSITIONING

Belzunce MA et al., state that Accurately predicting the femoral version in the preoperative plan is crucial, as a well-fitting uncemented stem will, by definition, press-fit into a version determined by the anatomy of the proximal femur. Incorrect positioning of the femoral stem can disrupt the restoration of native hip anatomy and biomechanics[71].

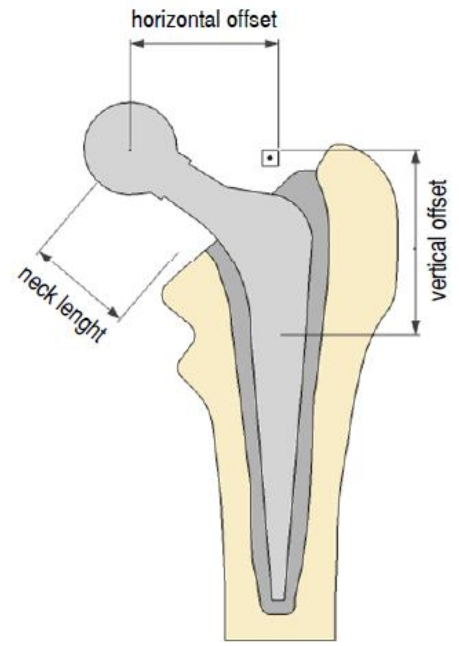


Fig 17: Femoral stem offset

Fessy MH et al., stated that endo femoral canal can exhibit various shapes, as assessed by the femoral flare index and the cortico-medullary index (Fig.). This variation is particularly important in cementless fixation, where achieving a close bone–prosthesis interface is crucial[72].

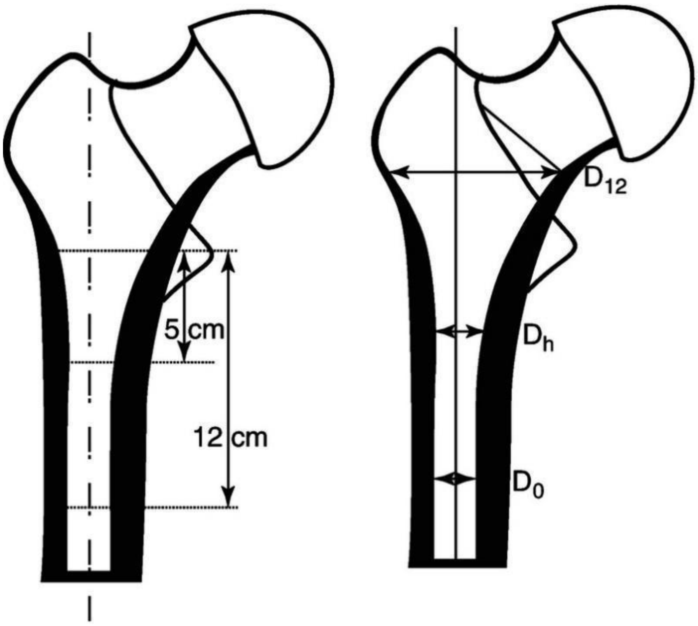


Fig 18: Femoral Flare Index = D0/D12

Cortico-medullary Index = Medial + Lateral cortical thickness/D0

FFI: The CFI is calculated by dividing the diameter of the femoral canal at the isthmus by the diameter of the medullary canal 20 mm above the lesser trochanter(Fig 18). [72]

< 3 - stovepipe

3- 4.75 - normal

> 4.75 - canals with champagne flute appearance.

FEATURES OF THR COMPONENTS:

Component positioning can alter both the native anatomy and biomechanics of the hip joint. Additionally, the prosthetic components themselves differ from the natural anatomical features. Menschik F et al., revealed that a normal femoral head is conchoid in shape. Research indicates that the conchoid shape reduces the likelihood of joint subluxation compared to a true ball-and-socket joint. These shapes might also affect stress distribution and magnitude in an optimal way[73].

The removal of the labrum during hip replacement surgery further highlights how anatomical principles are modified. In a healthy hip joint, the labrum plays a vital role by maintaining a layer of pressurized intra-articular fluid that aids in lubrication and load distribution. Its seal around the femoral head also enhances hip stability through a suction effect.

Normal adult femoral head size 53mm for men, women-49mm, Hall et al. [74] found that the initial rate of impingement on the rim of the polyethylene liner in 22-mm femoral head retrievals was 25%. Furthermore, once wear led to a 2 mm penetration of the femoral head into the polyethylene, the rate of impingement rose to 46%

Burroughs BRet al., observed head sizes of 32 mm or larger effectively prevent component-to-component impingement. whereas the diameter of prosthetic femoral heads typically ranges from 22 to 36 mm[73].

Meermans G et al., randomized study revealed, transverse acetabular ligament can be utilized to achieve the correct anteversion when positioning the acetabular component during total hip replacement (THR), but it does not guide the inclination of the acetabular component[75].

Lazennec JY et al., stated that posterior pelvic tilt, as seen in the sitting position (with a decrease in sacral slope), is associated with an increase in functional acetabular anteversion. Conversely, anterior pelvic tilt, as observed in the standing position (with an increase in sacral slope), is associated with a decrease in functional acetabular anteversion. Recognizing this variations in sacral slope on lateral pelvic X-rays is important for planning total hip arthroplasty and assessing the risk of impingement, as the lumbosacral posture affects the functional anteversion of the acetabulum[78]

HIP PARAMETERS RELATED TO TOTAL HIP ARTHROPLASTY

Cup Inclination:

Murray DW et al., stated that **“**The radiographic inclination (RI) is defined as the angle between the longitudinal axis and the acetabular axis when this is projected onto the coronal plane” [76]. The method described by Widmer KH et al. (Fig. 19) illustrates the measurement of acetabular inclination using the Widmer technique[77].

Normal values: 40°±10°

Fig 19: acetabular cup inclination

Cup Anteversion:

A CT scan provides highly accurate and reliable measurements due to its detailed imaging capabilities. In this context, the CT scan often employs a **modified version of**

Murray's concept, Wako M et al., mentioned that the acetabular version is measured on the axial slice of the acetabulum that corresponds to the center of the femoral head[80].

In an axial CT image displaying both hips, first, draw a line connecting the centers of the acetabular cavities of both hips. Next, draw a second line perpendicular to the first line, passing through its midpoint. Then, draw a third line connecting the most anterior and most posterior points of the acetabular cup. The angle between the second and third lines represents the acetabular version(Fig 20).

Normal values :15°±10°

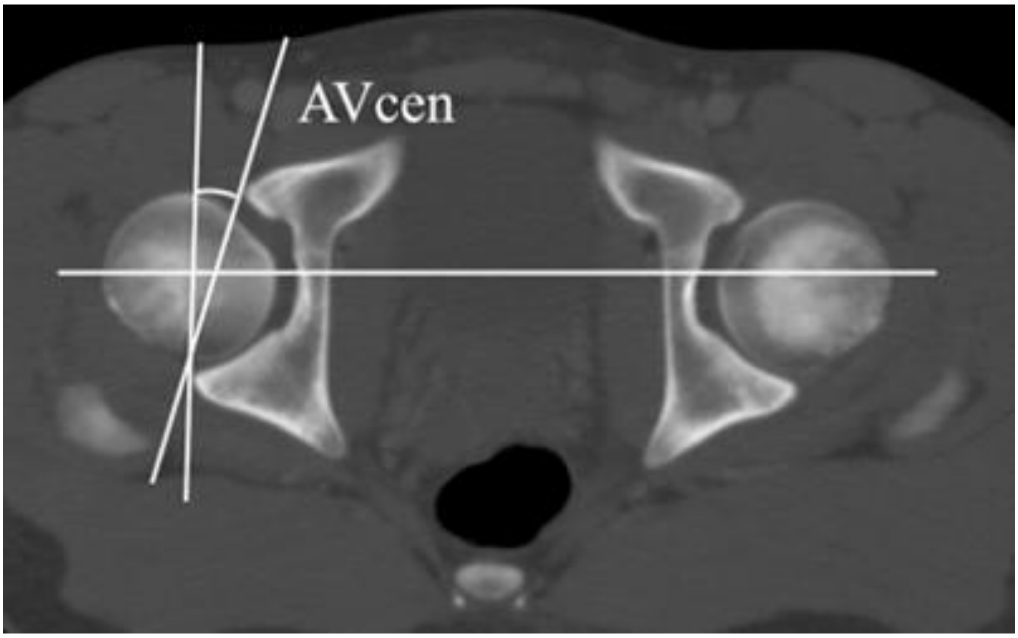


Fig 20: acetabular anteversion

Spinopelvic pelvic tilt (SPT or PT):

The angle between the line from the midpoint of the sacral plate to the midpoint of the bicoxofemoral axis and the reference vertical(Fig 21). Indicates the orientation of the pelvis over the femoral heads in the anteroposterior direction[78].

Normal values: PT standing < 22°

$\Delta PT \approx 20^\circ$ Pelvic Arc of movement: $5^\circ - 70^\circ$

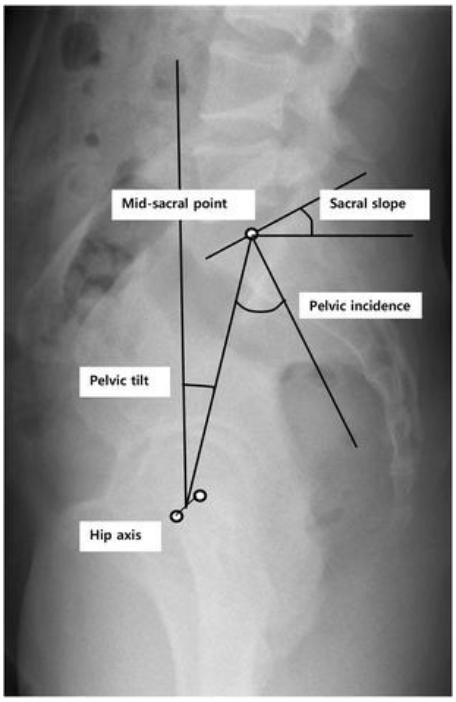


Fig 21: Pelvic tilt

Pelvic Incidence (PI):

perpendicular to the tangent of the S1 superior end plate at its center and a line connecting the same point to the midpoint of the bicoxofemoral axis. It is a static anatomic relationship between the hips and the sacrum[78]. PI = SS + PT (Fig 22).

Normal values :55° +/- 10°

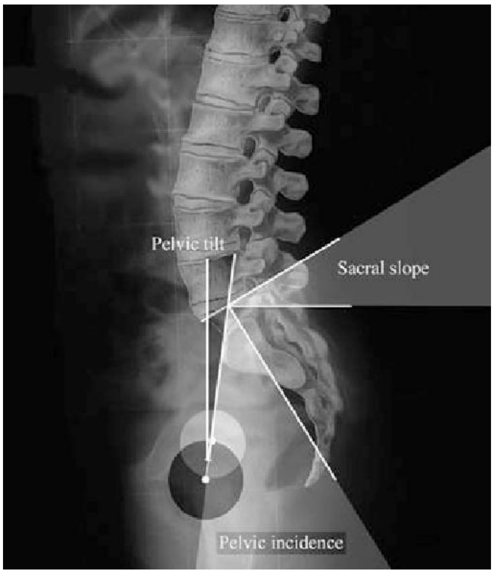


Fig 22: Pelvic incidence

Sacral Slope (SS)

The angle between a horizontal line and the line tangent to the S1 superior endplate. The movement at the L5S1 endplate determines the pelvis sagittal tilt during postural change (Fig 22).

Normal values : SS standing > 30°

SS sitting 5° – 30° (0.75 X PI = SS)

Femoral Anteversion

Fig 23: Femoral anteversion

The angle made by the femoral neck and the trans-epicondylar axis of the distal femur[79]. Contributes to the version of the hip joint (Fig 23).

Normal values : 5 - 20°.

SURGICAL APPROACH

Direct lateral approach (or transgluteal approach)

Position: lateral decubitus position with the operative side up (Fig 24)

Landmarks: palpate the anterior superior iliac spine by feeling upward from below. Locate the lateral aspect of the greater trochanter. feel along the line of the femur, which will present as a resistance under your hand[81].

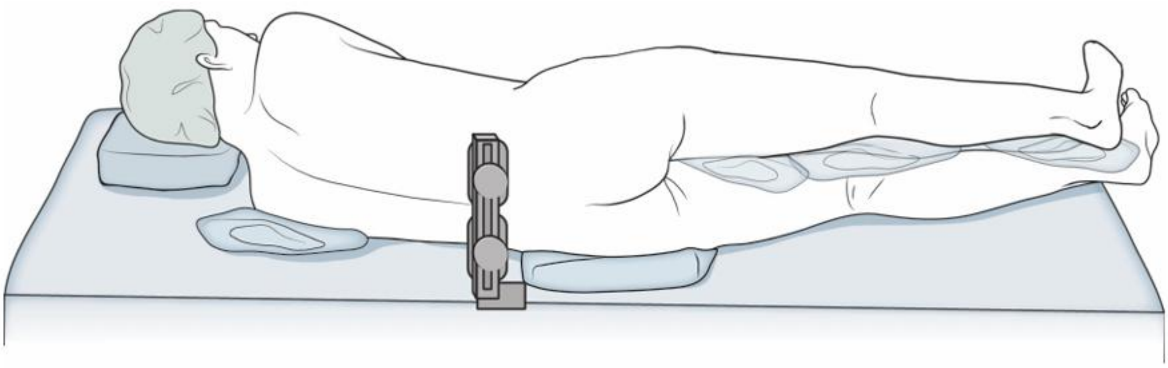


Fig 24: Patient positioning

Incision: 5 cm above the tip of the greater trochanter. Make a longitudinal incision that passes over the center of the tip of the greater trochanter and extends down the line of the shaft of the femur for approximately 8 cm (Fig 25).

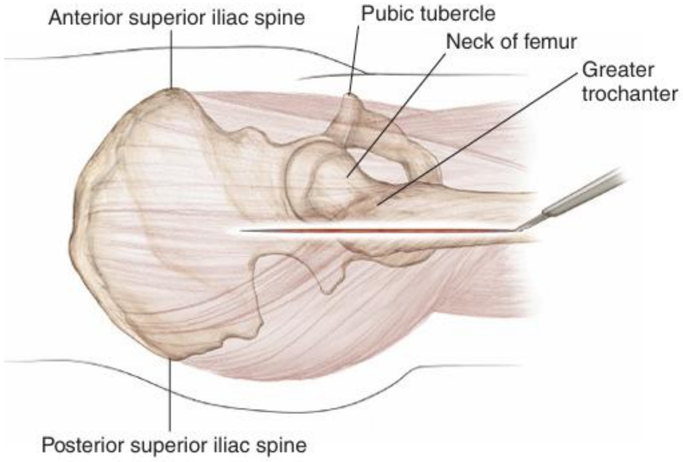
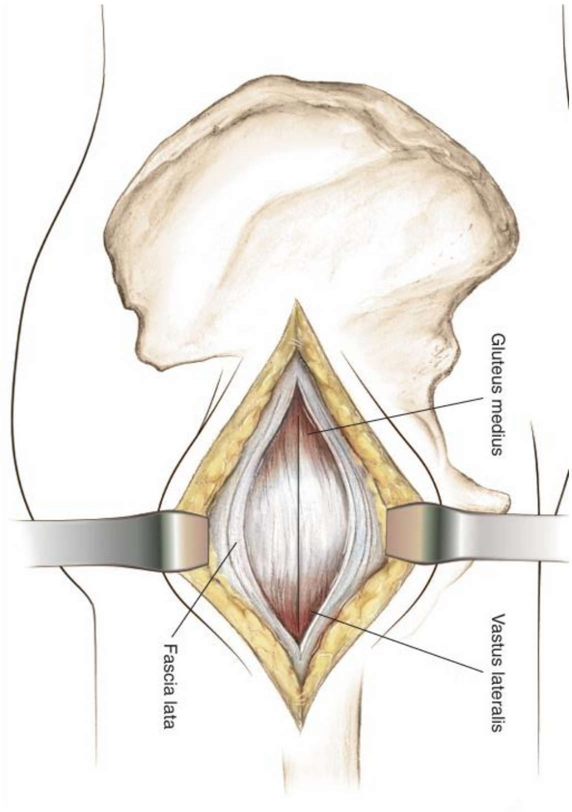


Fig 25: Skin incision



Internervous plane: There is no true internervous plane.

Surgical dissection : Incise the fascia over the tensor and the gluteus maximus to retract the tensor fascia anteriorly and the gluteus maximus muscle posteriorly, The gluteus medius and vastus lateralis are exposed (Fig 26).

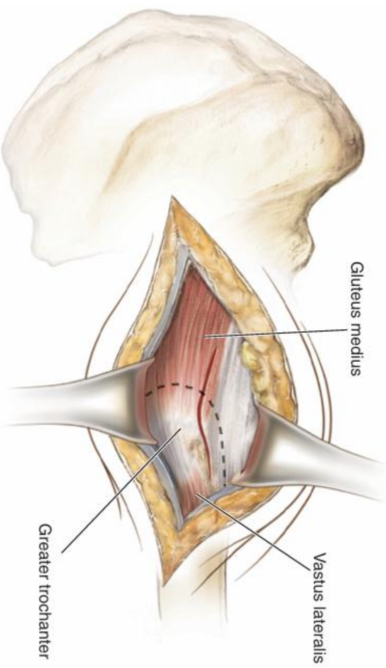


Fig 26: Deep dissection

The gluteus medius and vastus lateralis sling of tissue is exposed. The incision is carried no more than 5 cm(Fig 27) from the tip of the trochanter[82]. Proximal dissection should remain within 5 cm of the tip of the greater trochanter to avoid endangering the superior gluteal nerve.

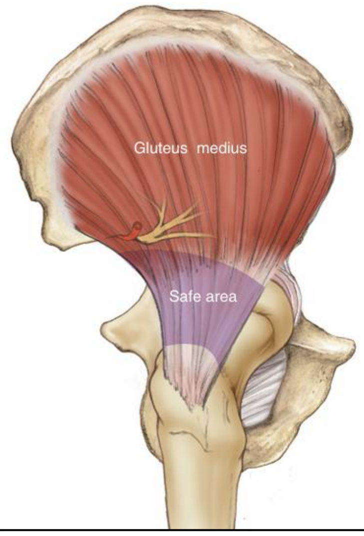


Fig 27: safe area for dissecting gluteus medius

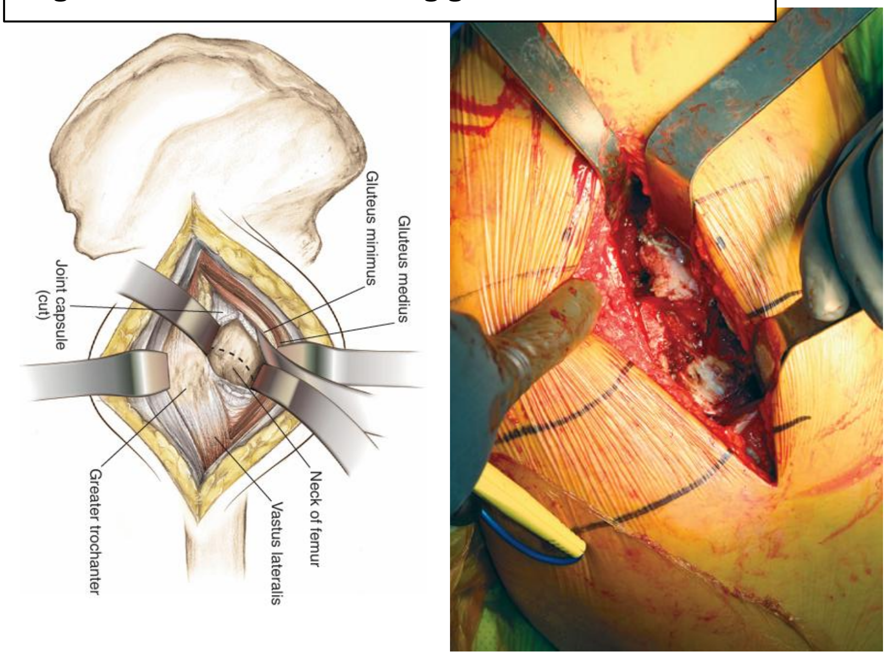


Fig 28: capsulotomy

Hip joint capsule identified and T shaped capsulotomy done(Fig 28). Femoral head delivered (Fig 29) out by Adduction and external rotation[82].

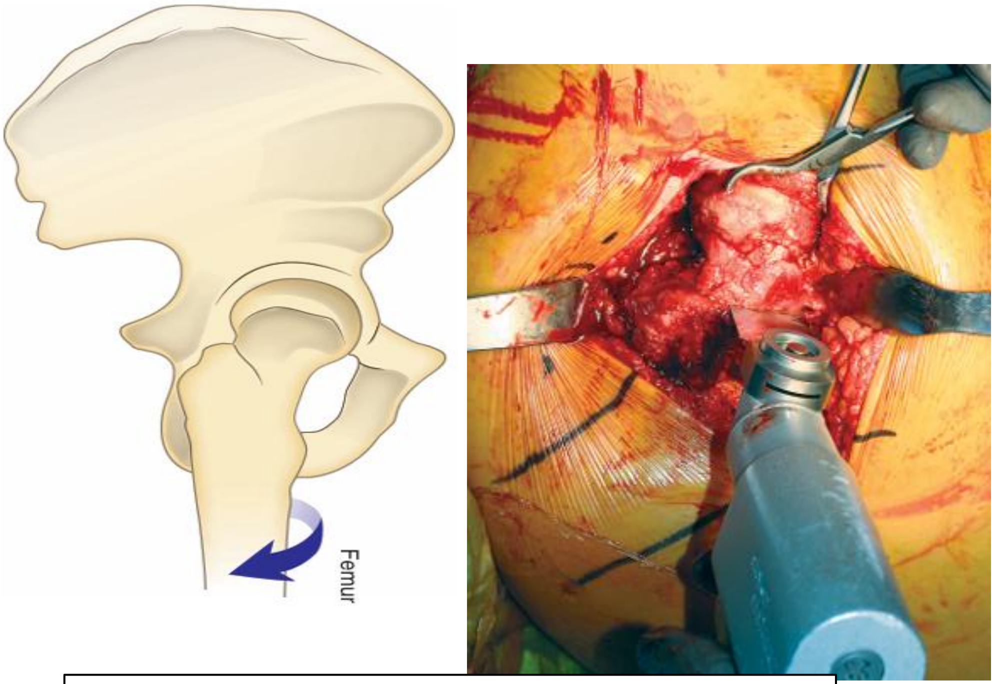


Fig 29: Femoral head delivered out

MATERIALS AND METHODS

- Study Population: 30 HIPS.
- Selection method: Patients admitted for total hip arthroplasty in Government Omandurar medical college
- All patients admitted for Total hip arthroplasty will undergo Pre OP & Post OP X ray pelvis with both hip, CT hip for clinical and radiological assessment and Harris Hip Score was calculated both Pre OP and Post OP period.
- After obtaining X-ray and CT images of the hip, the acetabular cup anteversion, acetabular cup inclination, and pelvic tilt were calculated for both the preoperative and postoperative periods.
- Patients are informed about the benefits, risks, and potential complications of the procedure, and written consent is obtained.
- All patients underwent clinical assessment and their Harris Hip Scores were recorded at the end of 3 months. These scores were then matched with the parameters listed in the Harris Hip Score proforma.
- All postoperative patients were followed up regularly to assess functional outcomes and monitor for any postoperative complications.

MATERIALS:

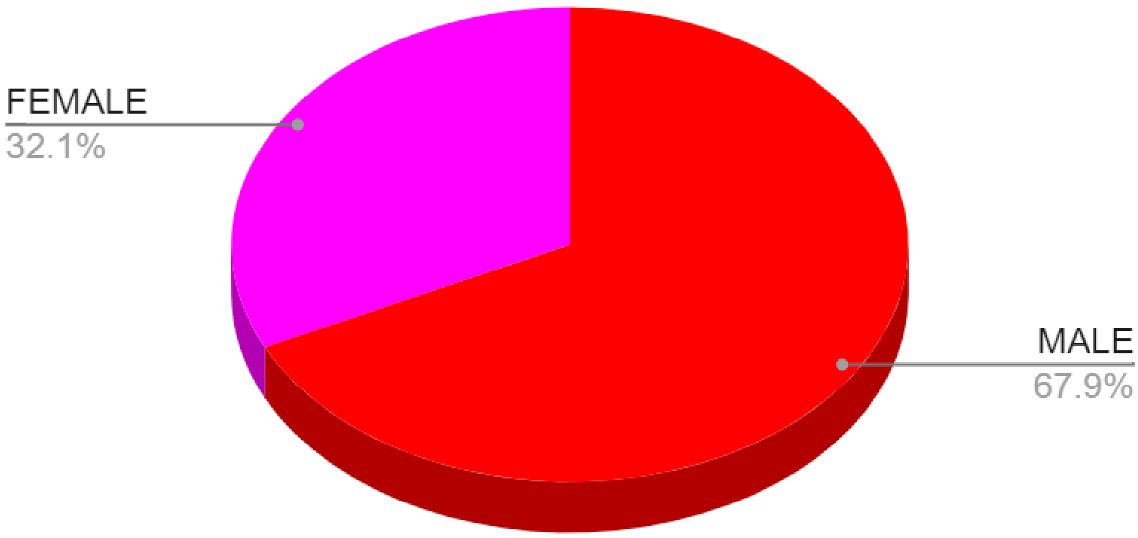
Total number of cases : 28

Total number of Hip : 30

SEX DISTRIBUTION:

MALE: 19

FEMALE: 09

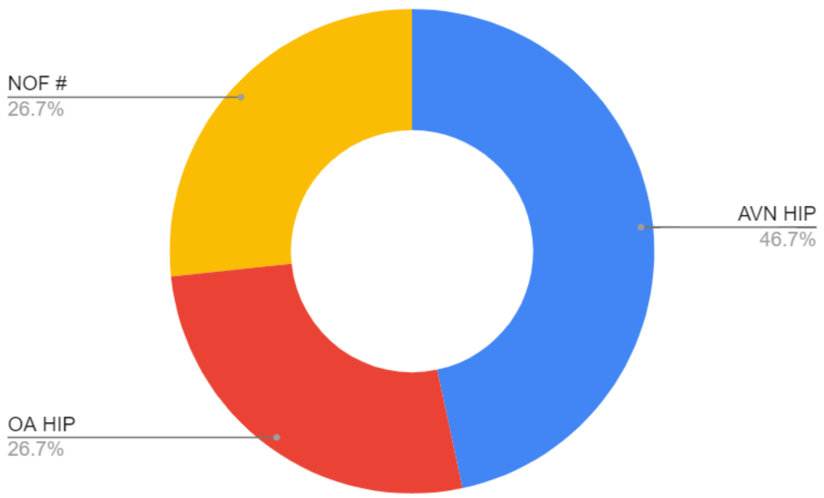


INDICATIONS FOR THR : NUMBER OF PATIENTS

AVASCULAR NECROSIS OF FEMORAL HEAD : 14

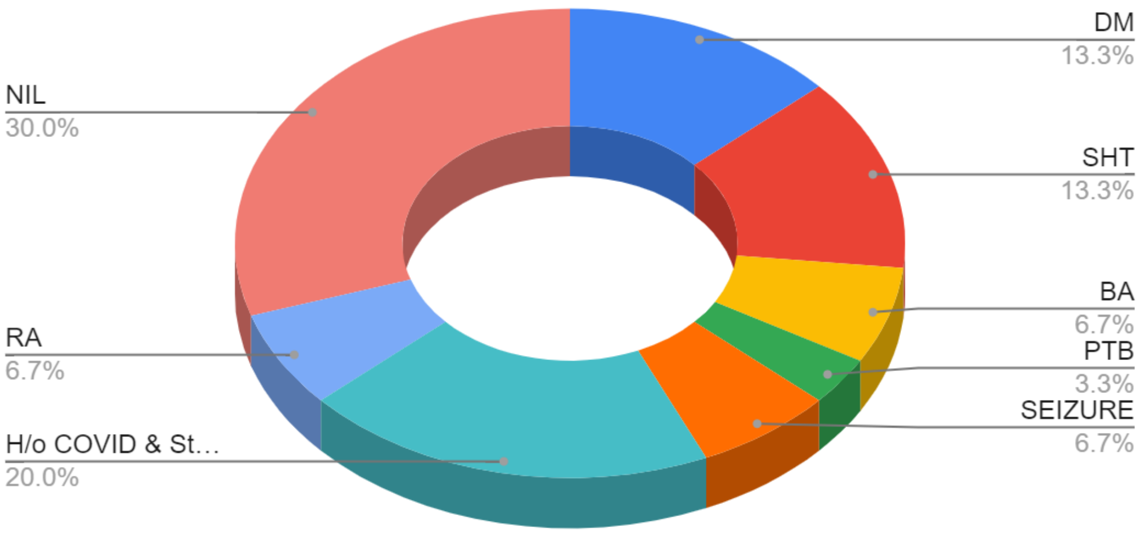
NON-UNION NECK OF FEMUR FRACTURE : 08

OSTEOARTHRITIS HIP JOINT : 08



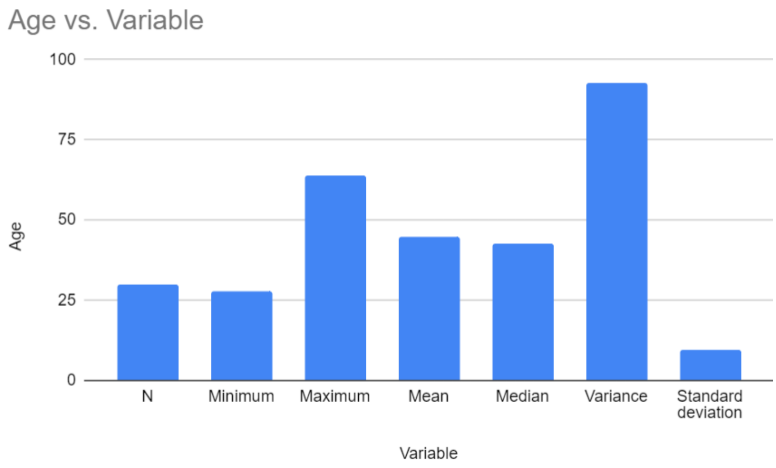
COMORBIDITY:

Hypothyroidism	1
DM	4
SHT	5
BA	2
PTB	1
SEIZURE	2
H/o COVID & Steroid intake	6
RA	2
NIL	10



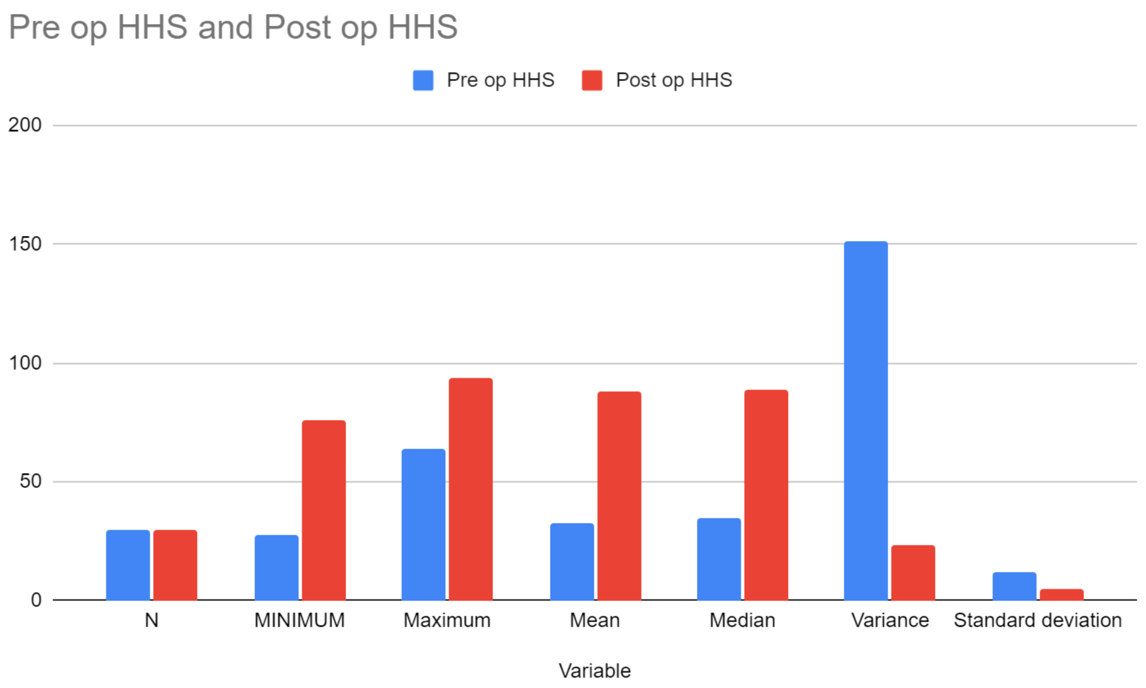
DISTRIBUTION OF AGE:

Variable	N	Minimum	Maximum	Mean	Median	Variance	Standard deviation
Age	30	28	64	44.9	42.5	92.78	9.63



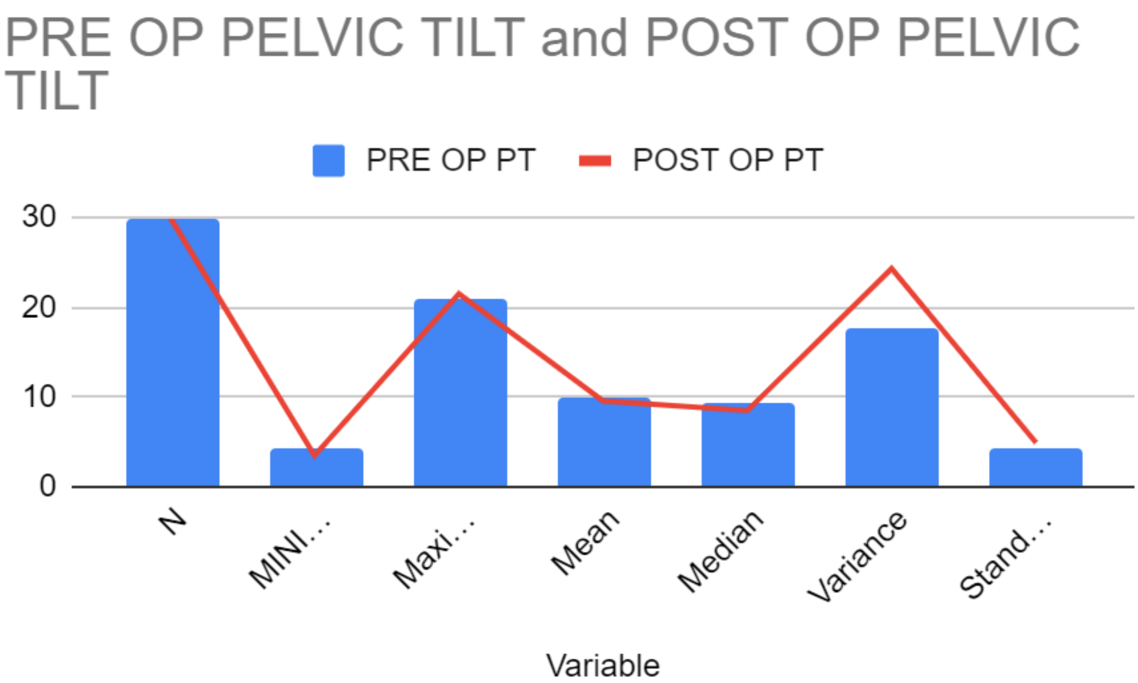
Clinical Harris Hip Score:

Variable	N	MINIMUM	Maximum	Mean	Median	Variance	Standard deviation
Pre op HHS	30	28	64	32.63	35	151.27	12.29
Post op HHS	30	71	94	87.9	88.5	23.33	4.83



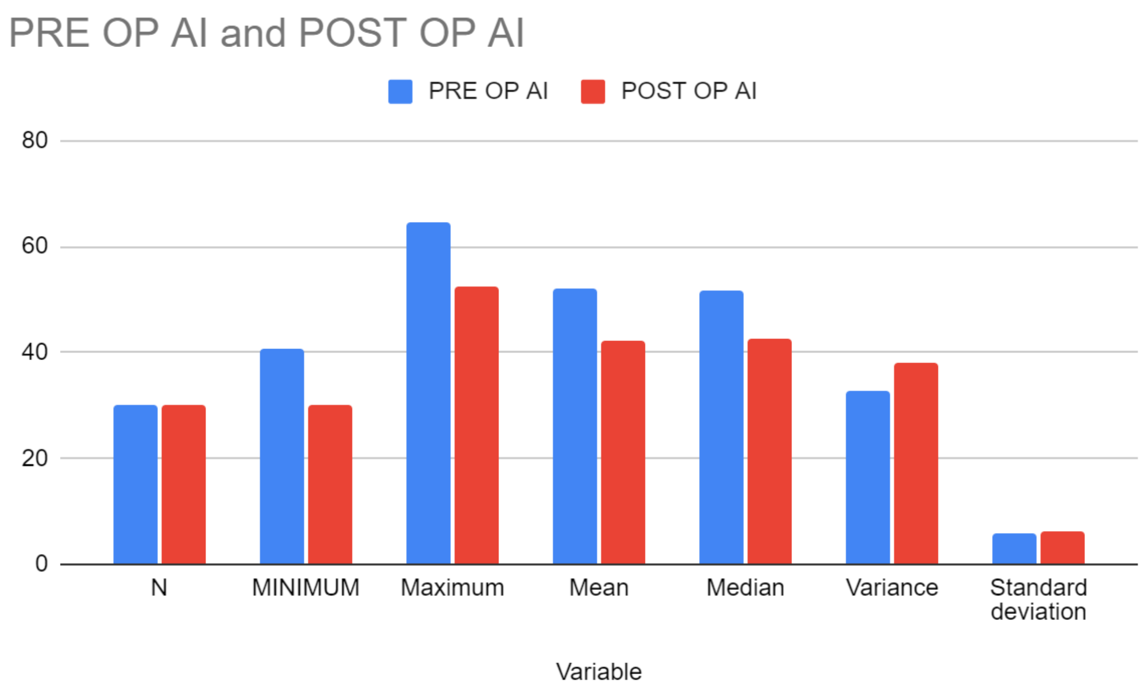
PELVIC TILT:

Variable	N	MINIMUM	Maximum	Mean	Median	Variance	Standard deviation
PRE OP PT	30	4.2	20.8	10.01	9.35	17.54	4.18
POST OP PT	30	3.5	21.5	9.57	8.5	24.32	4.93



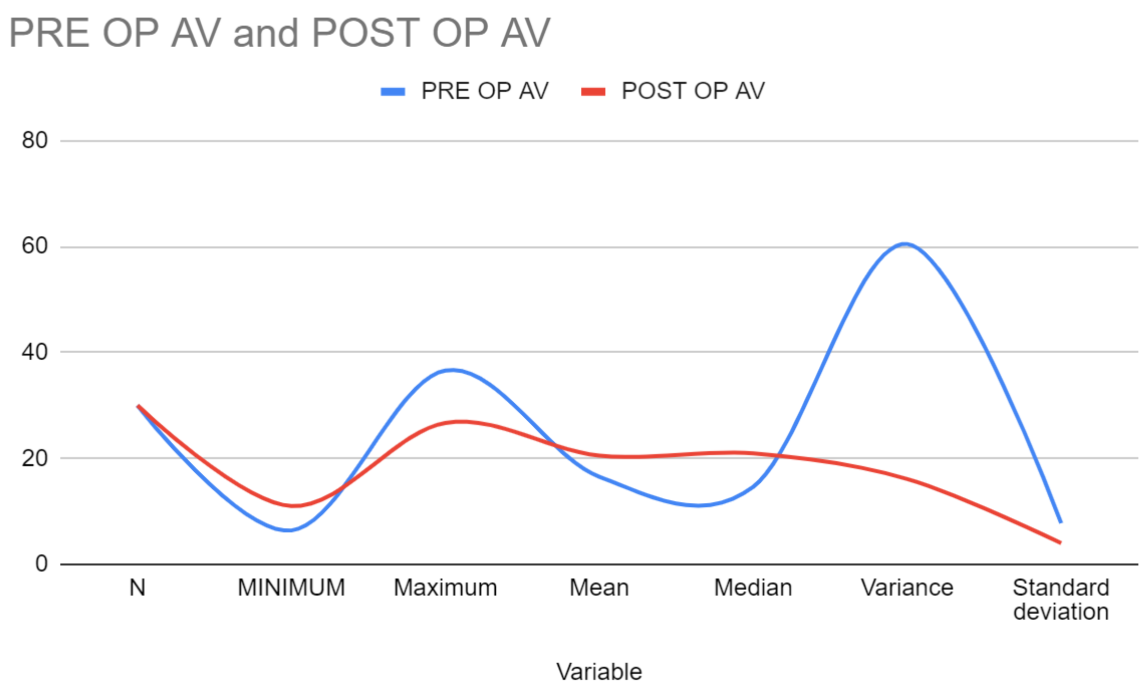
ACETABULAR CUP INCLINATION:

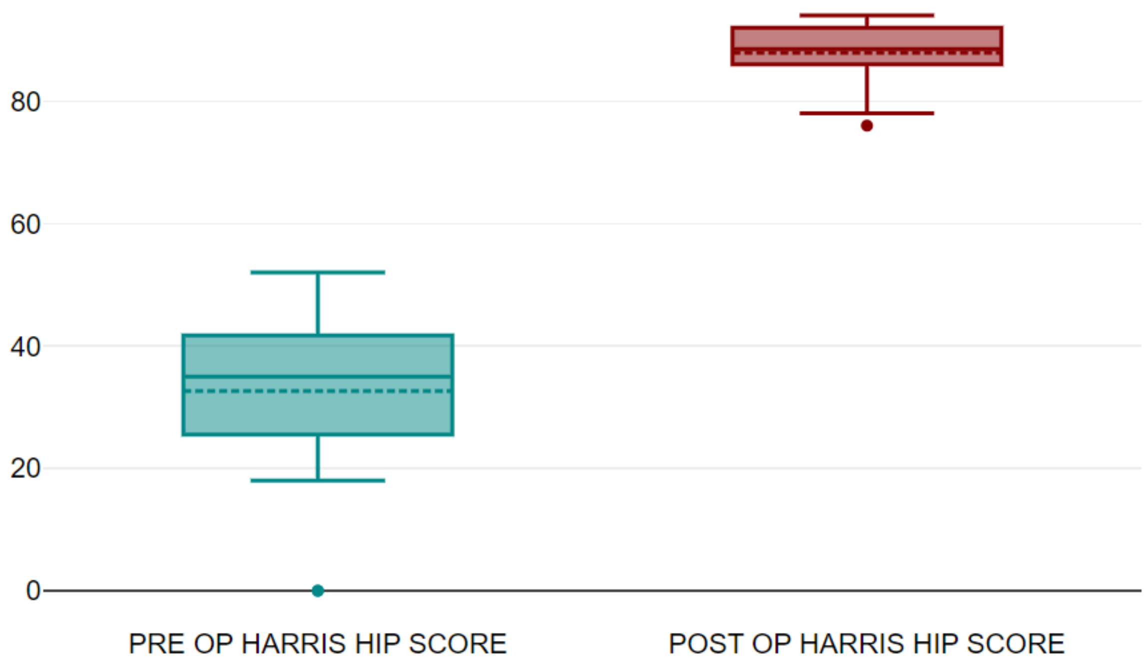
Variable	N	MINIMUM	Maximum	Mean	Median	Variance	Standard deviation
PRE OP AI	30	40.6	64.7	52.26	51.75	32.65	5.71
POST OP AI	30	30	52.3	42.27	42.75	38.09	6.17



ACETABULAR CUP ANTEVERSION:

Variable	N	MINIMUM	Maximum	Mean	Median	Variance	Standard deviation
PRE OP AV	30	6.4	36.6	16.54	14.65	60.48	7.77
POST OP AV	30	11	26.7	20.53	20.95	16.11	4.01


PRE OP AV and POST OP AV
PRE OP AV
POST OP AV
80
60
40
20
0
N
MINIMUM
Maximum
Mean
Median
Variance
Standard deviation
Variable

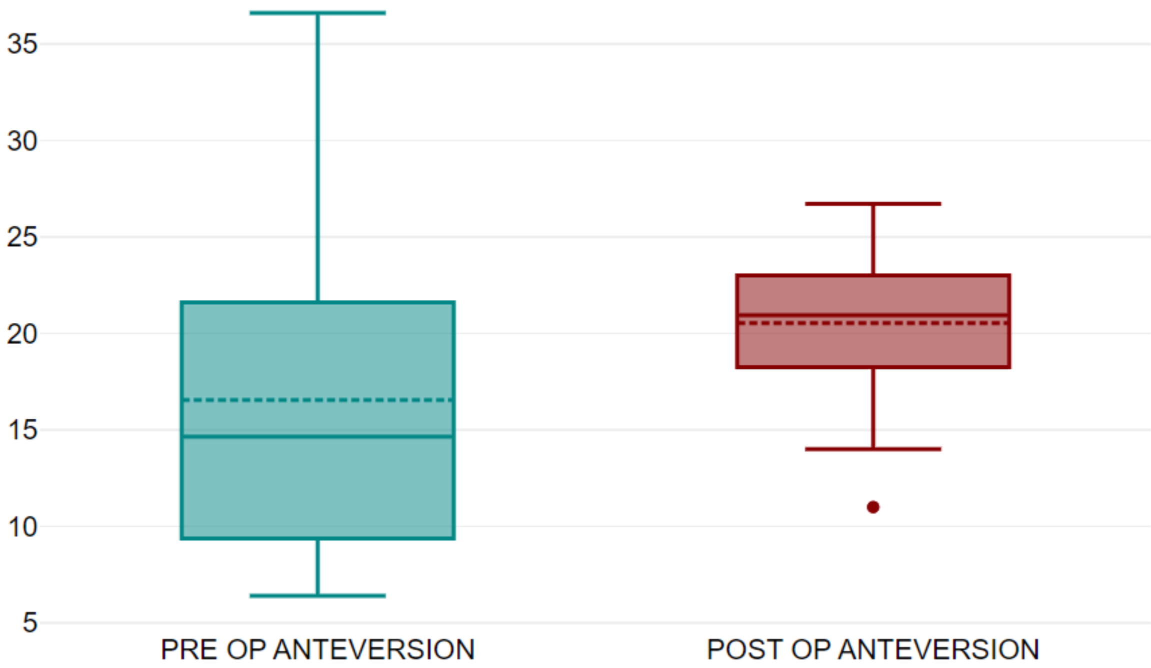

80
60
40
20
0
PRE OP HARRIS HIP SCORE
POST OP HARRIS HIP SCORE

95% Confidence Interval of the Difference:

	Mean	Standard deviation	Standard error mean	Lower limit	Upper limit
PRE OP HHS - POST OP HHS	-55.27	11.78	2.15	-59.67	-50.87

t-Test for paired samples:

	T	Df	P	Cohen's d
PRE OP HHS - POST OP HHS	-25.69	29	<0.001	4.69

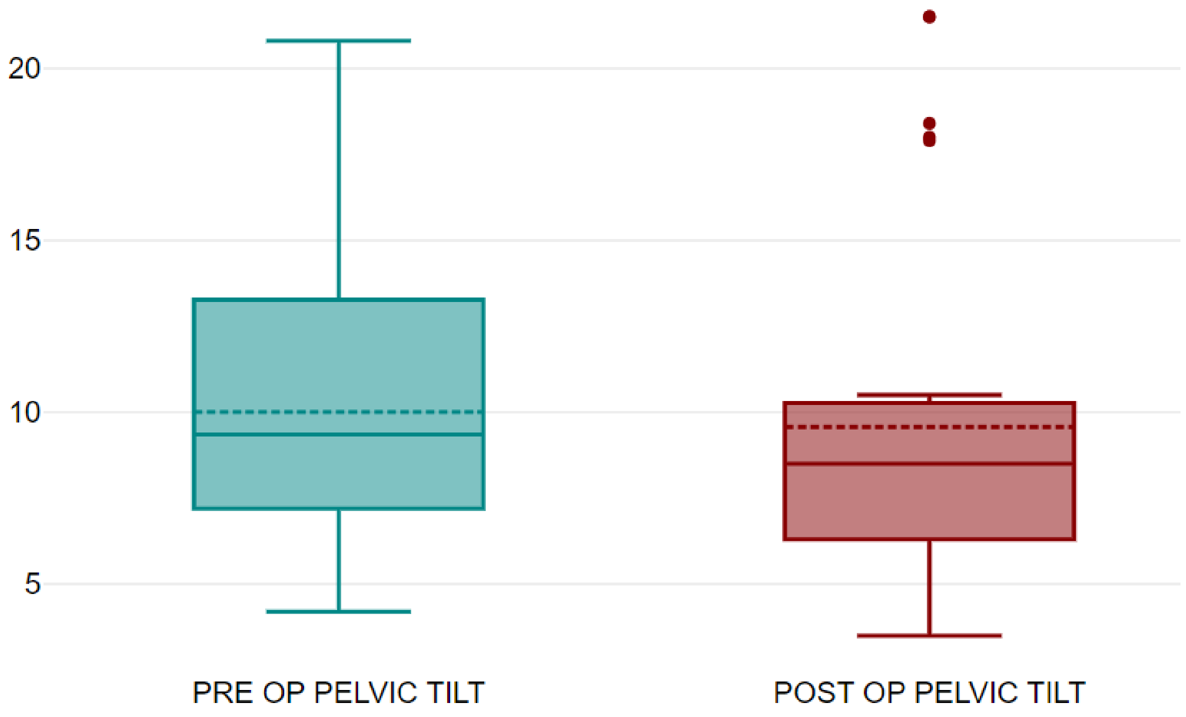


95% Confidence Interval of the Difference:

	Mean	Standard deviation	Standard error mean	Lower limit	Upper limit
PRE OP ANTEVERSION - POST OP ANTEVERSION	-3.99	9.13	1.67	-7.4	-0.58

t-Test for paired samples:

PRE OP ANTEVERSION - POST OP ANTEVERSION	T	Df	P	Cohen's d
	-2.39	29	0.024	0.44

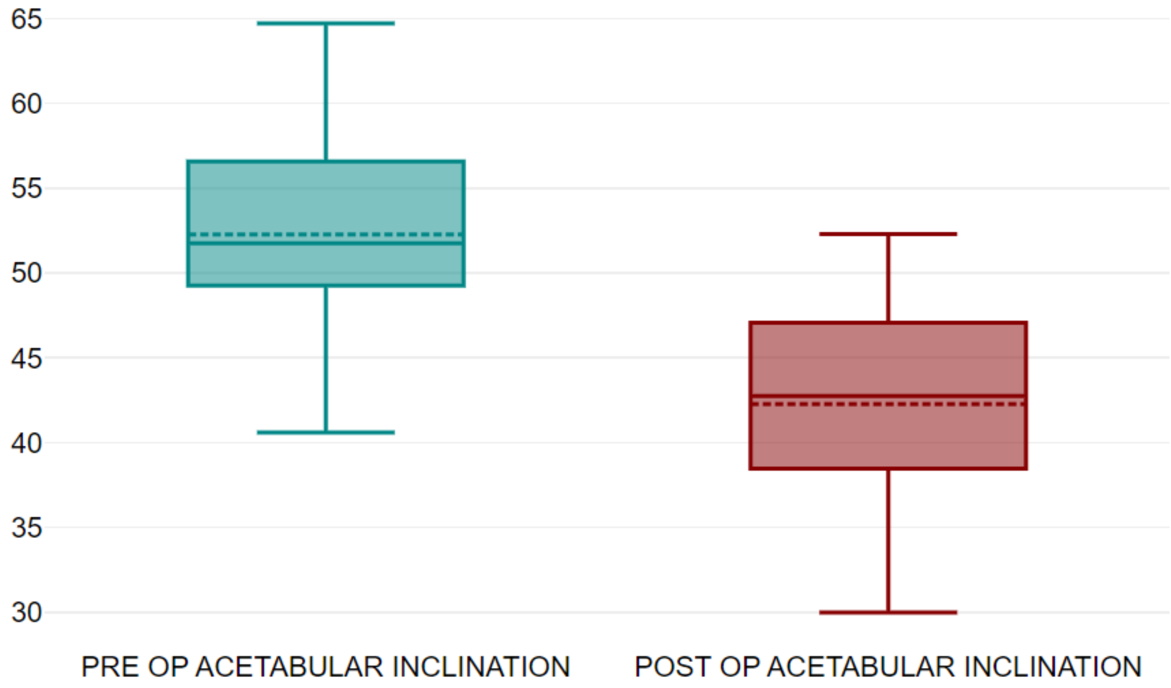


95% Confidence Interval of the Difference:

PRE OP Pelvic tilt - POST OP Pelvic tilt	Mean	Standard deviation	Standard error mean	Lower limit	Upper limit
	0.44	4.86	0.89	-1.38	2.25

t-Test for paired samples:

PRE OP Pelvic tilt - POST OP Pelvic tilt	T	Df	P	Cohen’s d
	0.49	29	0.626	0.09



95% Confidence Interval of the Difference:

PRE OP inclination - POST OP inclination	Mean	Standard deviation	Standard error mean	Lower limit	Upper limit
	9.94	7.53	1.38	7.18	12.8

t-Test for paired samples:

PRE OP inclination - POST OP inclination	T	Df	P	Cohen’s d
	7.27	29	<0.001	1.33

DISCUSSION:

Total hip replacement is a highly effective and safe surgery that offers major benefits to patients at a relatively low cost. Despite this, there has been a notable surge in the global number of these procedures, particularly among younger individuals. This demographic, often eager to resume athletic activities, places a high emphasis on achieving optimal functional results.

Negm AM et al., states that the survival rates for primary total hip arthroplasties (THAs) generally reflect their effectiveness and durability over time[83].

Kurtz SM et al.,noted that the most common complications that lead to readmission within 30 days after hip arthroplasty are dislocation and infection[84]. In our study, one patient was readmitted within 30 days due to infection and was treated with dressing and IV antibiotics.

Lee S et al., found that the overall incidence of VTE, DVT, and PE within 90 days was 3.9% after total hip arthroplasty[85]. In our study no patient developed thrombo-embolism related complications, all patients post operatively treated with low molecular weight heparin for 7 days.

These causes of pain can be mitigated by adhering to the safe zone for acetabular cup placement as defined by Lewinnek et al., which is 15 ± 10 degrees of anteversion and 40 ± 10 degrees of abduction.

The historical incidence of dislocation following total hip arthroplasty (THA) is around 3%. Various anatomical, surgical, and epidemiological factors can elevate this risk. Gillinov SM et al., revealed 52% of first-time dislocations occurred within the first three months[90]. So far, in our study, no patient has presented with a dislocation complication.

Esposito CI et al., study revealed that Lewinnek's safe zone concept reduces impingement and pain, but acetabular component position alone is not effective in preventing dislocation rates[86].

Widmer KH et al., states that selecting the optimal combined orientation of both the acetabular cup and femoral stem(Combined Anteversion), whether through manual or computer-assisted implantation, will maximize the range of motion (ROM) and minimize the risk of dislocation[87].

Fagotti L et al., study introduces two classifications (subjective and objective) for assessing postoperative hematomas following total hip replacement (THR). he states that 0.41% of post THR patients require re-operation due to hematomas[88]. In our study no patients developed significant hematoma after immediate postoperative period.

Goetz MB et al. found the risk of nerve palsy after primary total hip arthroplasty (THA) to be 0.5% for arthritis, 2.3% for hip dysplasia, and 3.5% for revision surgery[89]. In our study 1 patient developed sciatic nerve palsy, post operatively he was given with foot drop splint & advised walking with full weight bearing walking.

In our study, one patient sustained a greater trochanter avulsion fracture and protrusio acetabuli intraoperatively. The patient was treated with stainless steel wire fixation for the greater trochanter and bone grafting was performed for the acetabulum. The patient was advised to remain non-weight bearing for 1.5 months. Probst A et al., noted iatrogenic avulsion of the greater trochanter occurring during hip prosthesis implantation[93].

Tezuka T et al. emphasize the importance of examining the interconnected movement of the pelvis and femur in relation to the spine. As the patient moves, the acetabulum shifts with the pelvis in the sagittal plane, causing the acetabular cup to adjust dynamically rather than remaining static. This dynamic adjustment in cup position is referred to as the **"functional cup position"**[91]. Weber M et al., study also supports this concept of pelvic tilt impacts functional cup position in total hip arthroplasty (THA)[92]

In our study, the mean values in postoperative patients were an acetabular cup inclination of 42.27°, a cup anteversion of 20.53°, and a pelvic tilt of 9.57°.

To evaluate the effectiveness of our study, functional outcome measurements are crucial in clinical research. These measures, which reflect the patient's perspective, are essential for enhancing the quality of our research. In our study, we utilized the Harris Hip Score[93] to assess the impact of acetabular cup inclination and anteversion and pelvic tilt in total hip arthroplasty.

In our study **two** patients have reported anterior groin and lateral groin pain, which is not solely associated with the positions of the cup. The literature describes several causes of lateral hip pain, including increased femoral offset and limb length discrepancy. Additionally, other potential reasons for anterior groin and lateral thigh pain include iliopsoas impingement, infection, osteolysis, and soft tissue damage.

In our study, patients achieved good Harris Hip Scores when cup inclination, anteversion, and pelvic tilt were within the normal range, correlating with high patient satisfaction and favourable functional outcomes.

However, this study evaluated patient-reported satisfaction and outcomes in 30 hips after primary THA, focusing solely on the impact of cup anteversion, inclination, and pelvic tilt, as measured by the Harris Hip Score.

CONCLUSION

Preoperative templating, which involves measuring acetabular cup inclination, pelvic tilt, and acetabular anteversion using X-ray and CT scan, plays a crucial role in optimizing intra-operative cup positioning. This approach helps reduce surgery times and infection rates.

Achieving precise intraoperative positioning of the acetabular components within safe zones is crucial for hip stability and optimal patient outcomes. Defining and adhering to these zones can significantly impact the success of the procedure.

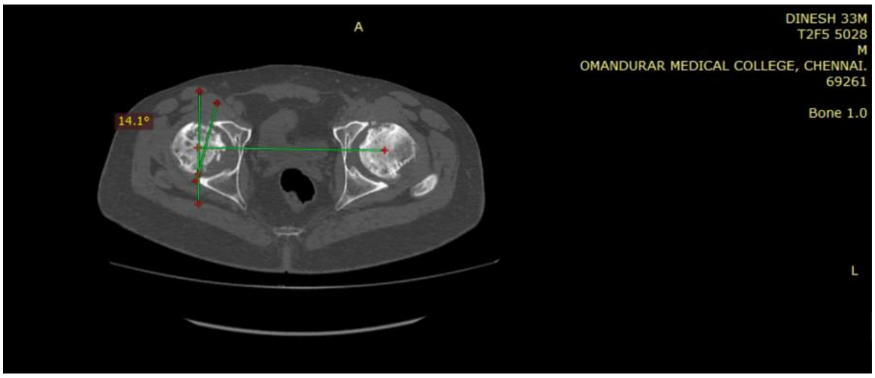
In addition to adhering to safe zones, meticulous closure of the soft tissues is crucial for hip stability in the immediate postoperative period. Postoperative physiotherapy and muscle strengthening exercises also play a significant role in improving patient outcomes.

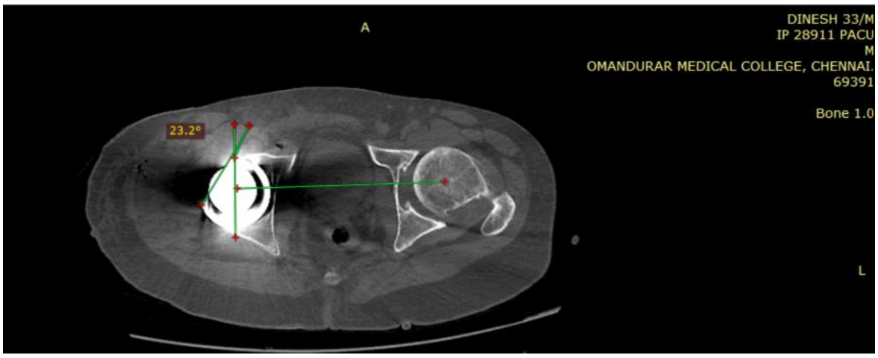
Understanding the interplay between the spine, pelvis, and hip, including their normal and abnormal movements and compensatory mechanisms, has significantly enhanced our knowledge of achieving precision and longevity in THA. It is essential to pay close attention to spinopelvic motion by carefully evaluating patients' symptoms through physical examination and appropriate imaging techniques.

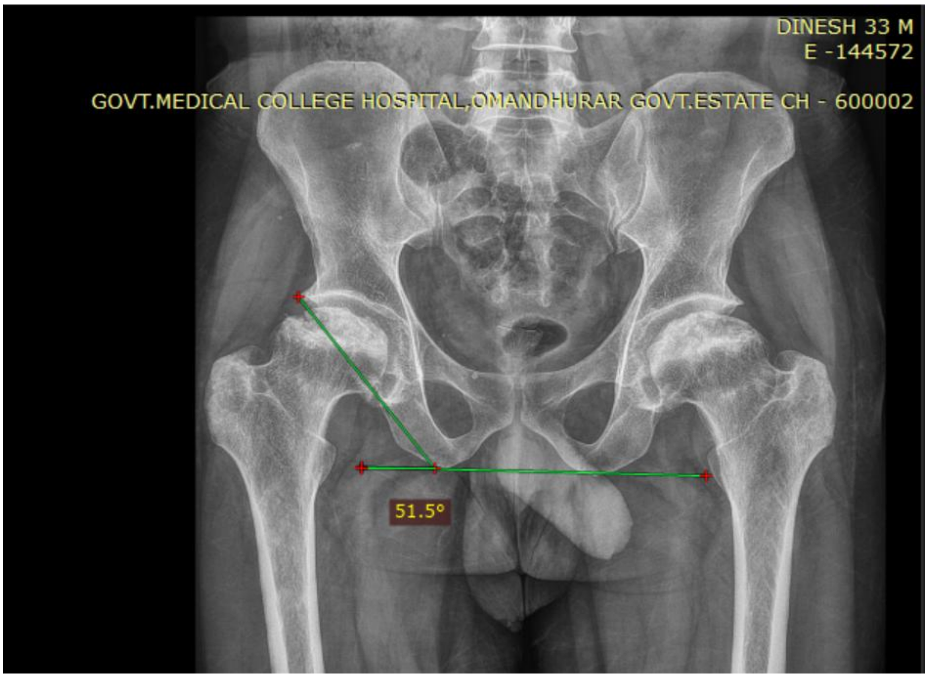
The future of total hip arthroplasty lies in patient-specific implants, which promise to enhance precision and personalize treatment for improved outcomes.

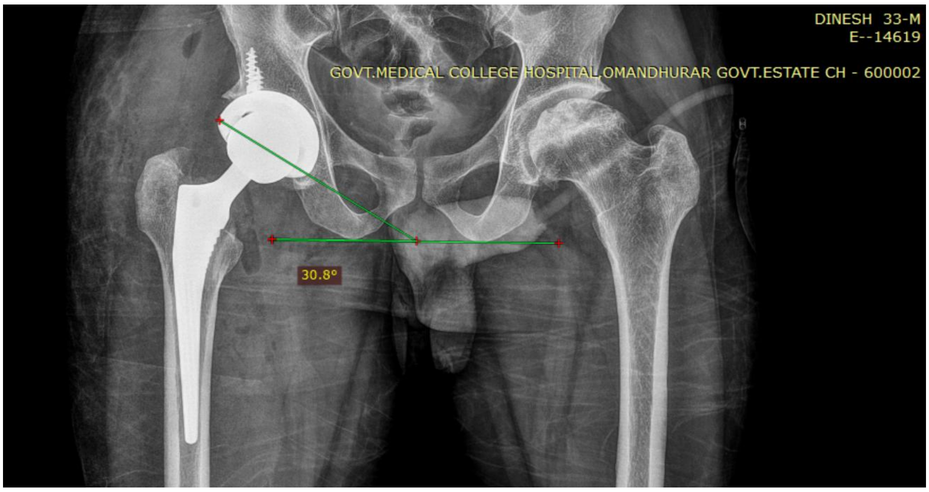
CASE DETAILS

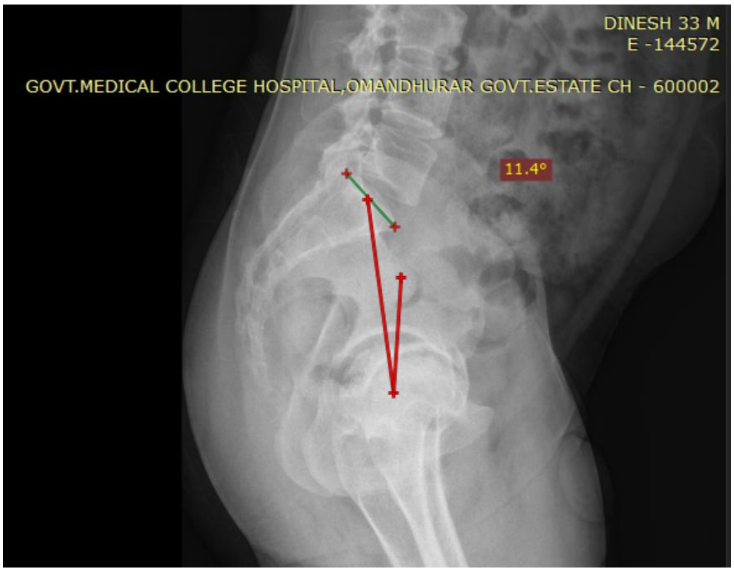
CASE 12: Dinesh 33/M Diagnosis: Osteoarthritis right hip joint

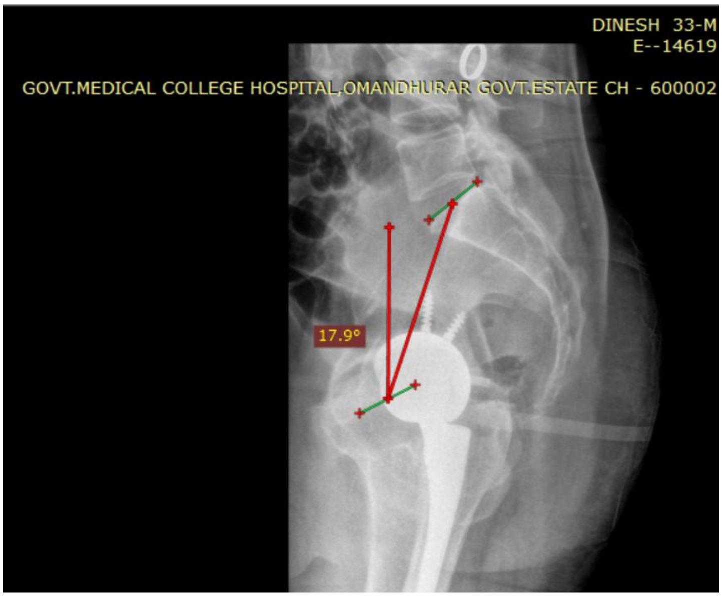




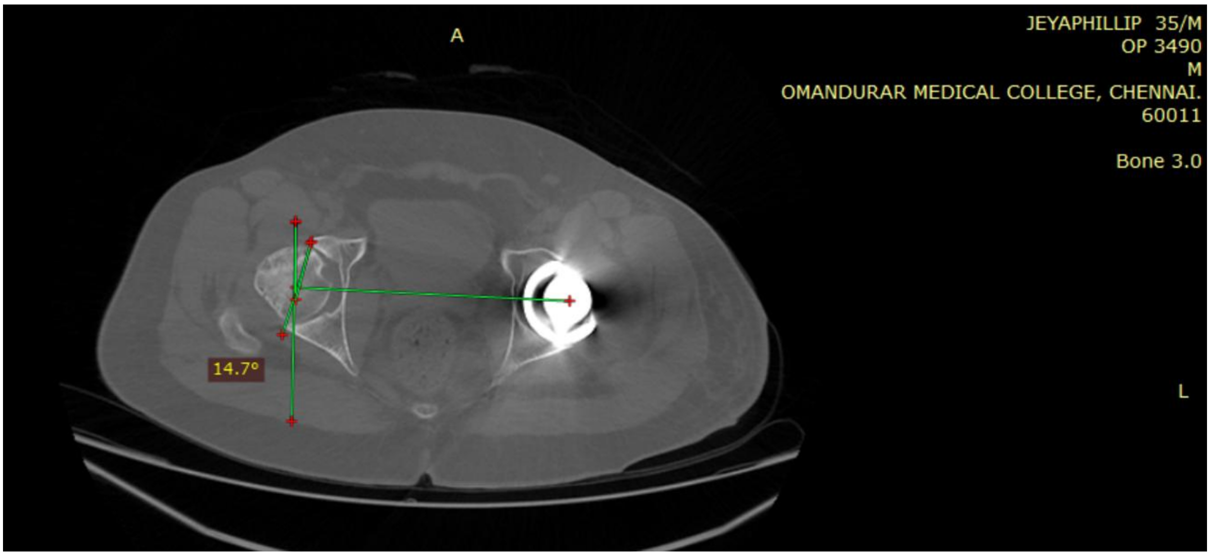


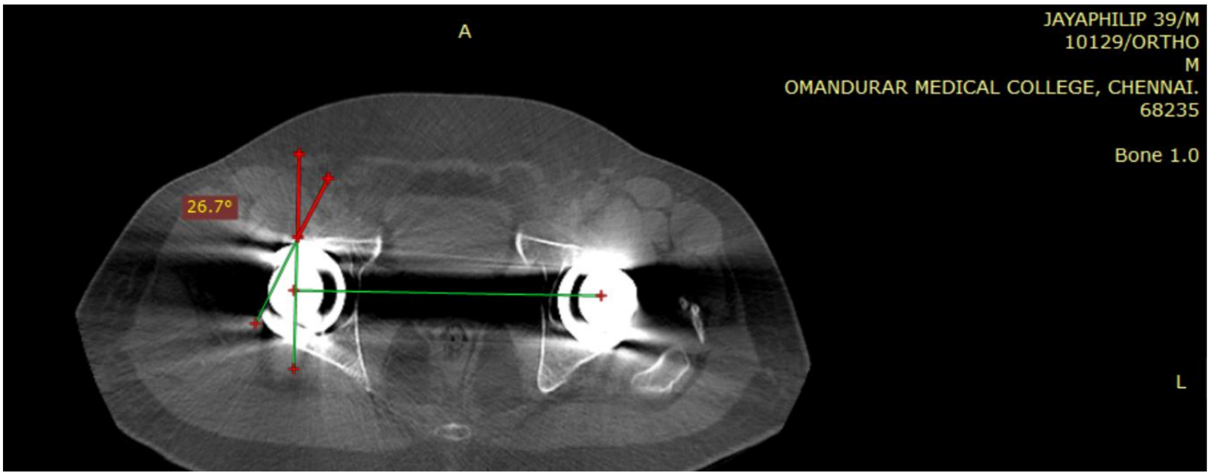

DINESH 33-M
E--14619
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
30.8°

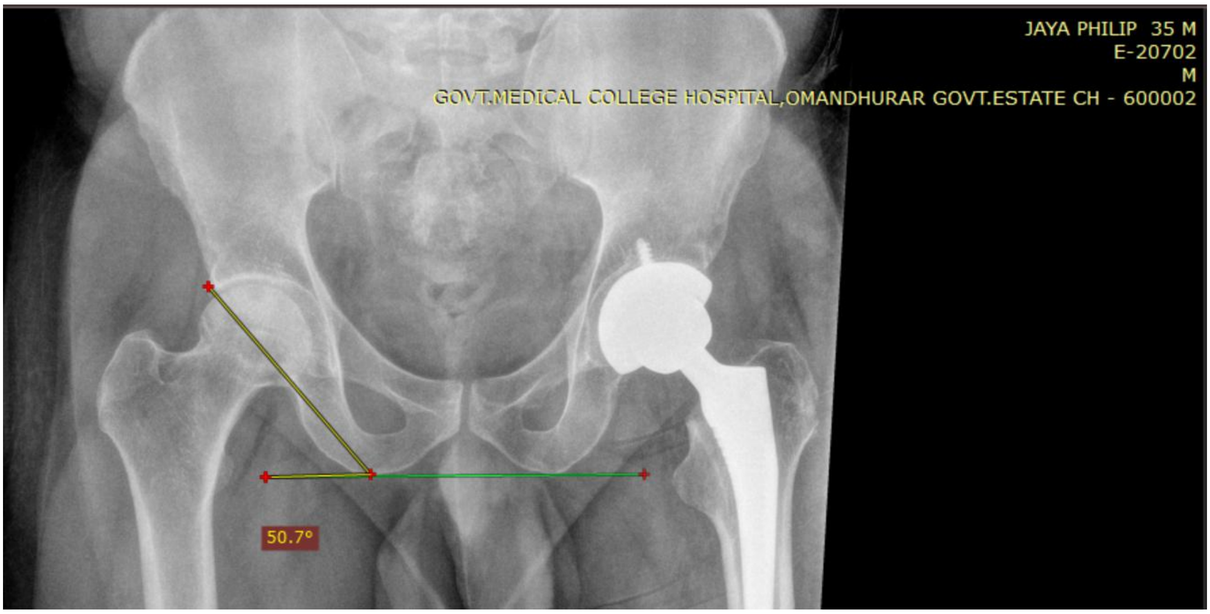

DINESH 33 M
E -144572
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
11.4°

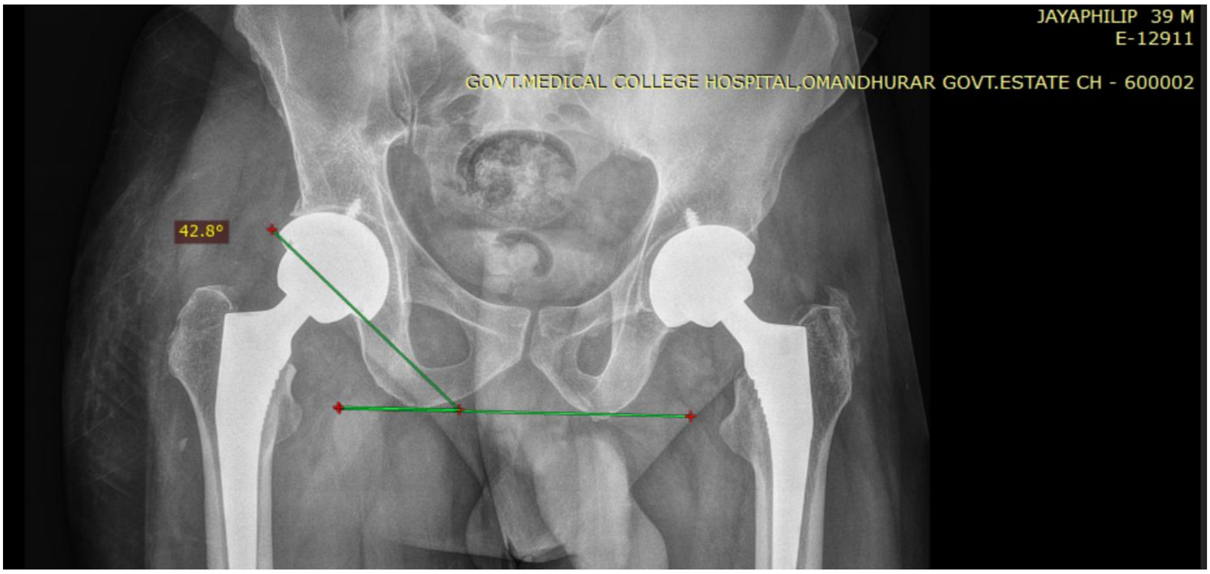

DINESH 33-M
E--14619
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
17.9°

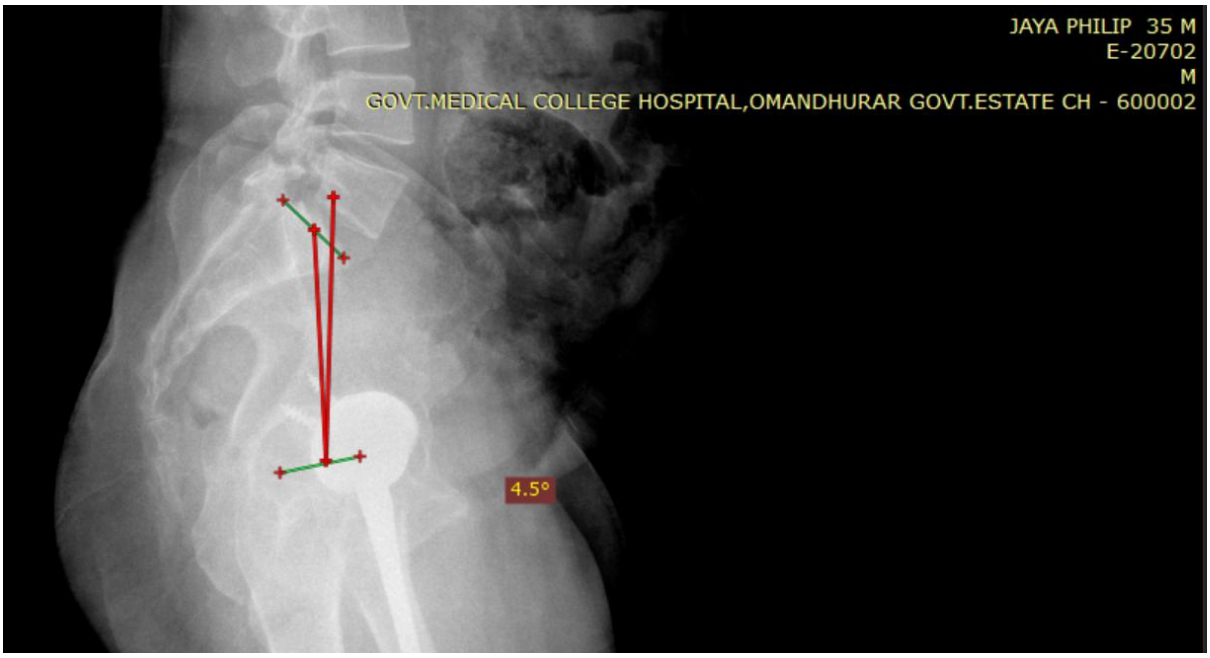
CASE 28: Jayaphilip 35/M Diagnosis: Avascular necrosis of femoral head right side

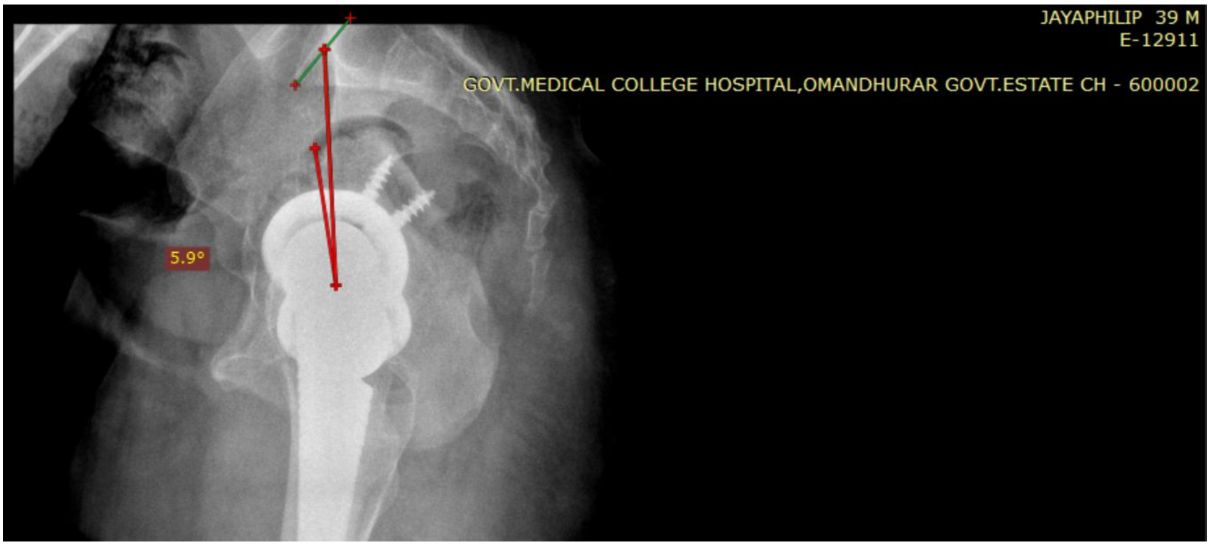




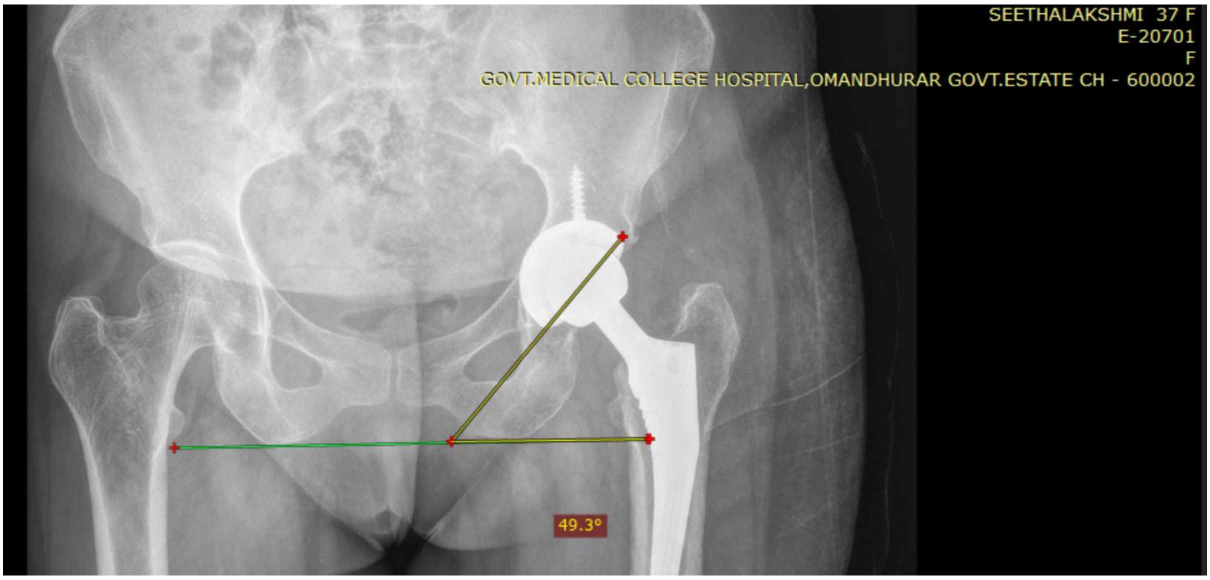


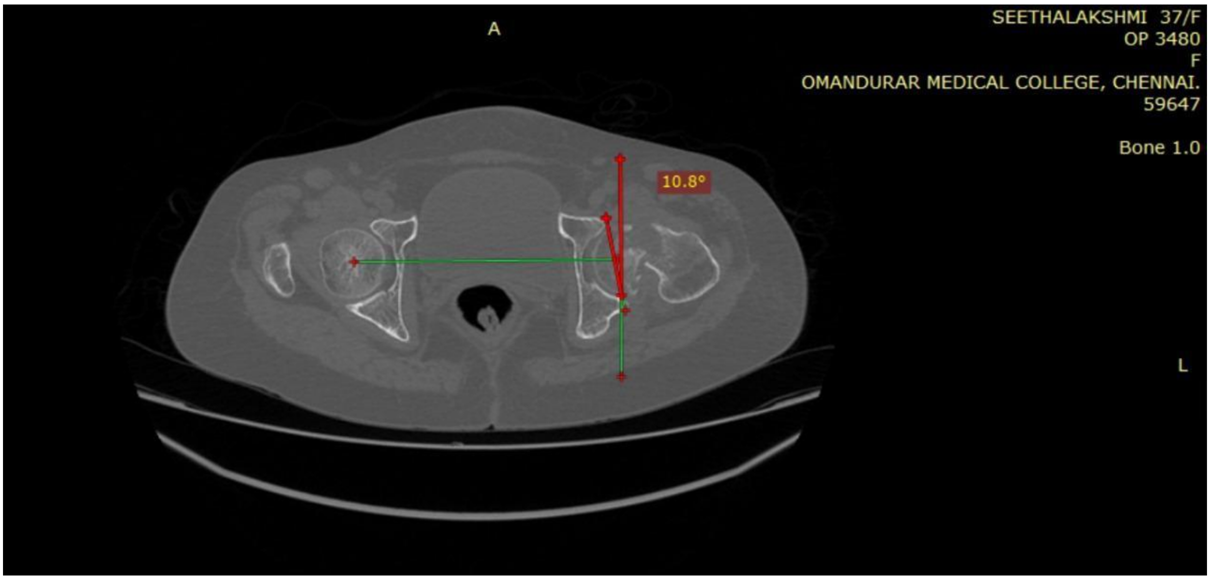

JAYAPHILIP 39 M
E-12911
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
42.8°

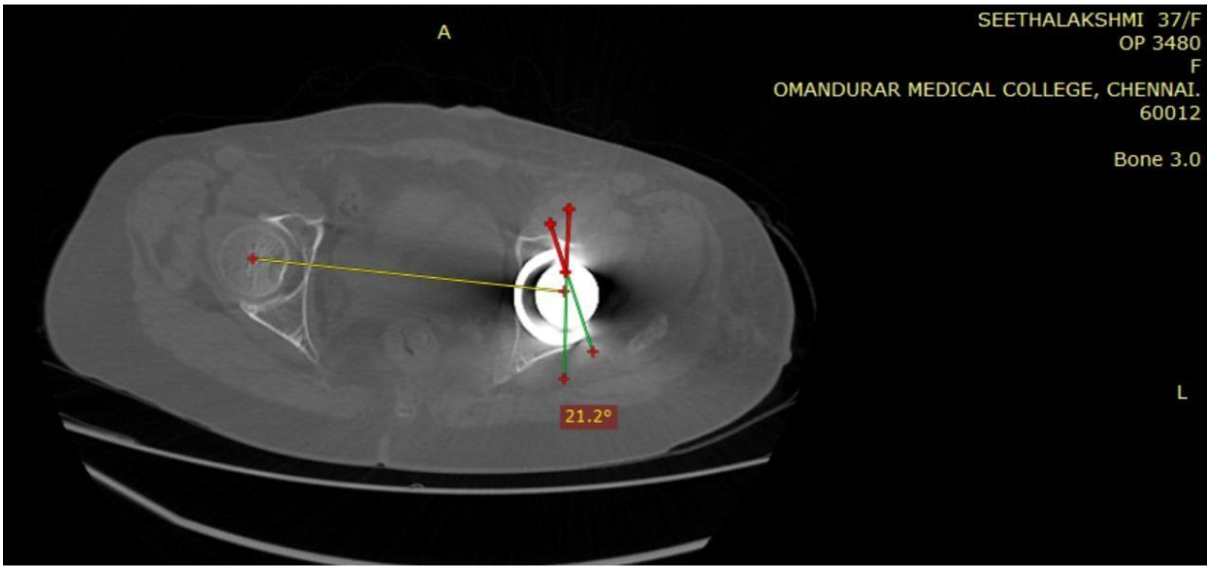

JAYA PHILIP 35 M
E-20702
M
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
4.5°

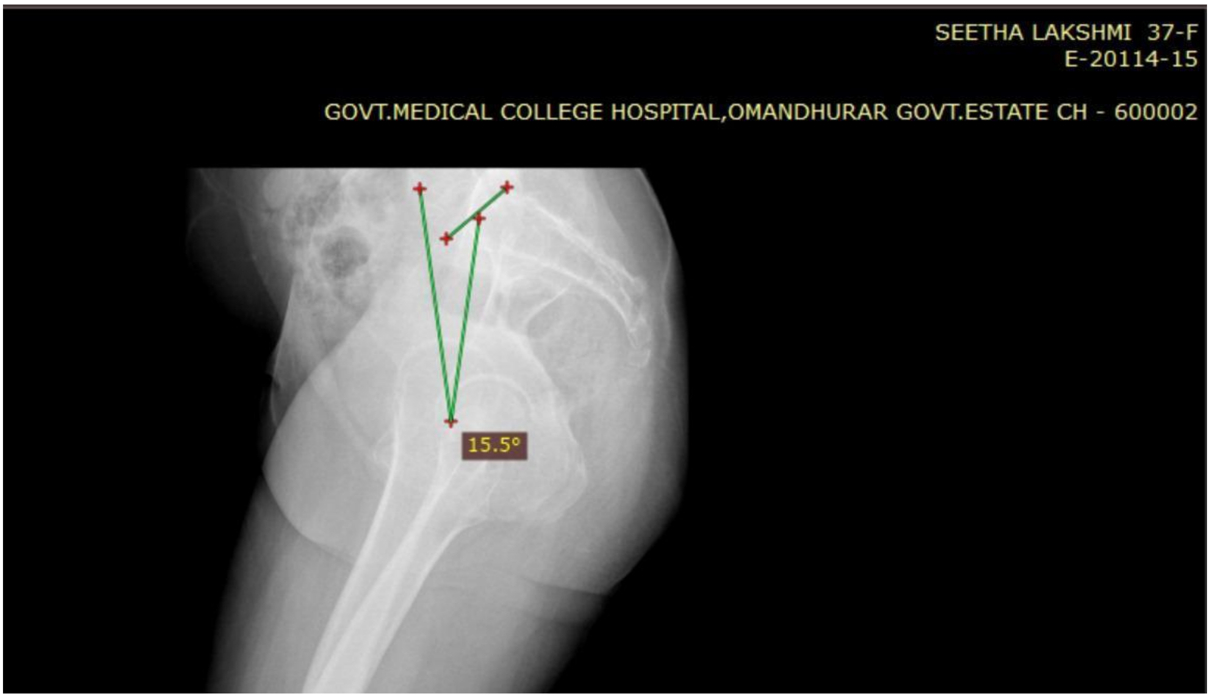

JAYAPHILIP 39 M
E-12911
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
5.9°

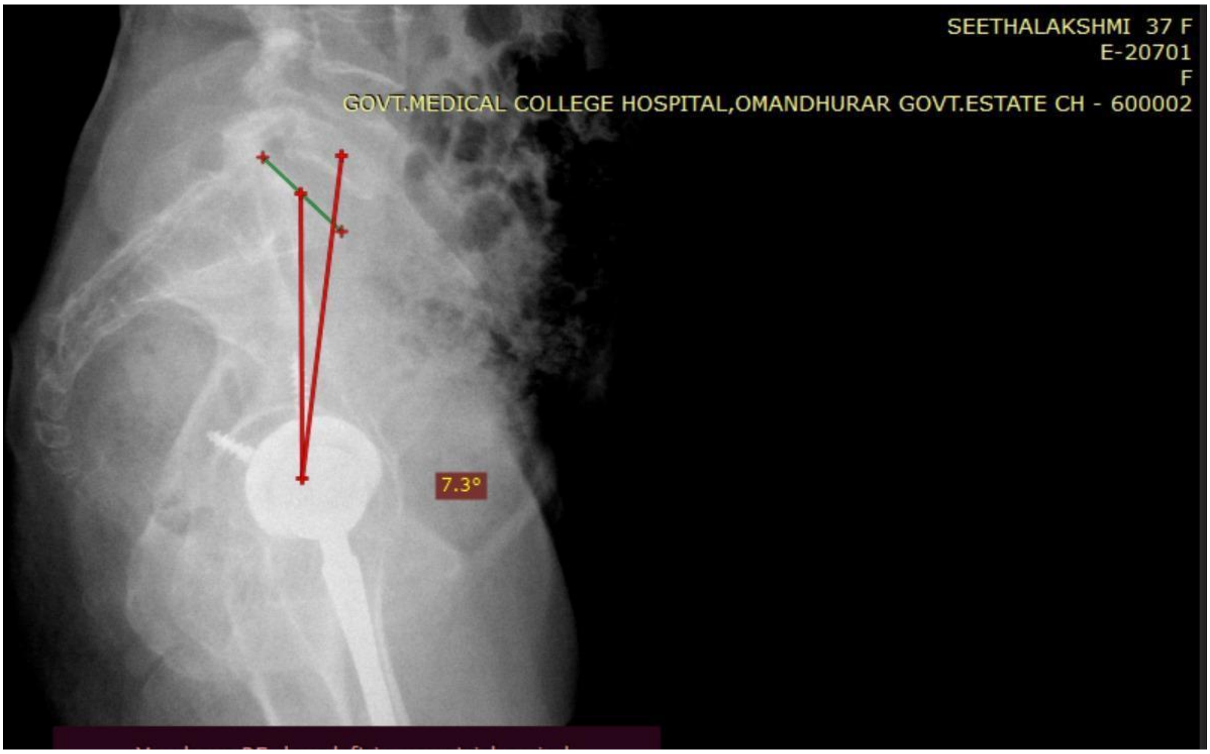
CASE 20: Seethalakshmi 37/F Diagnosis: Neck of femur fracture left side



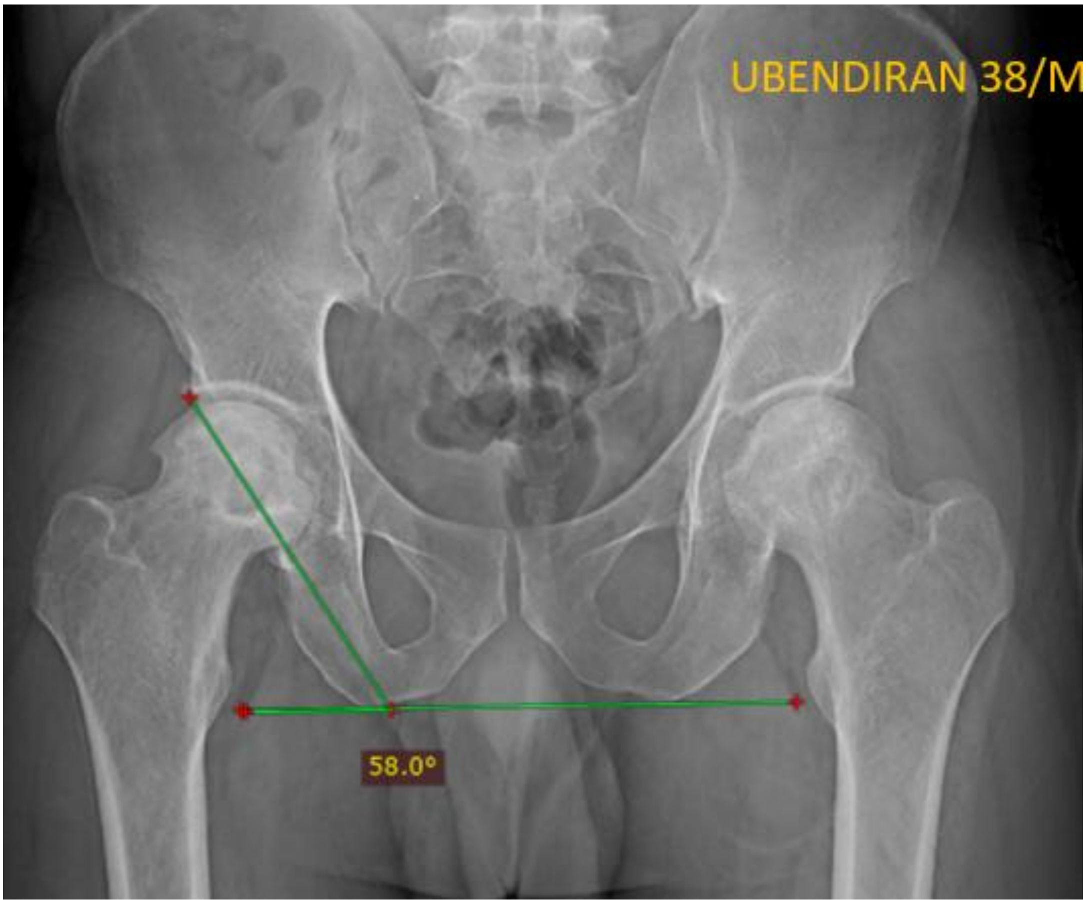

A
SEETHALAKSHMI 37/F
OP 3480
F
OMANDURAR MEDICAL COLLEGE, CHENNAI.
59647
Bone 1.0
10.8°
L

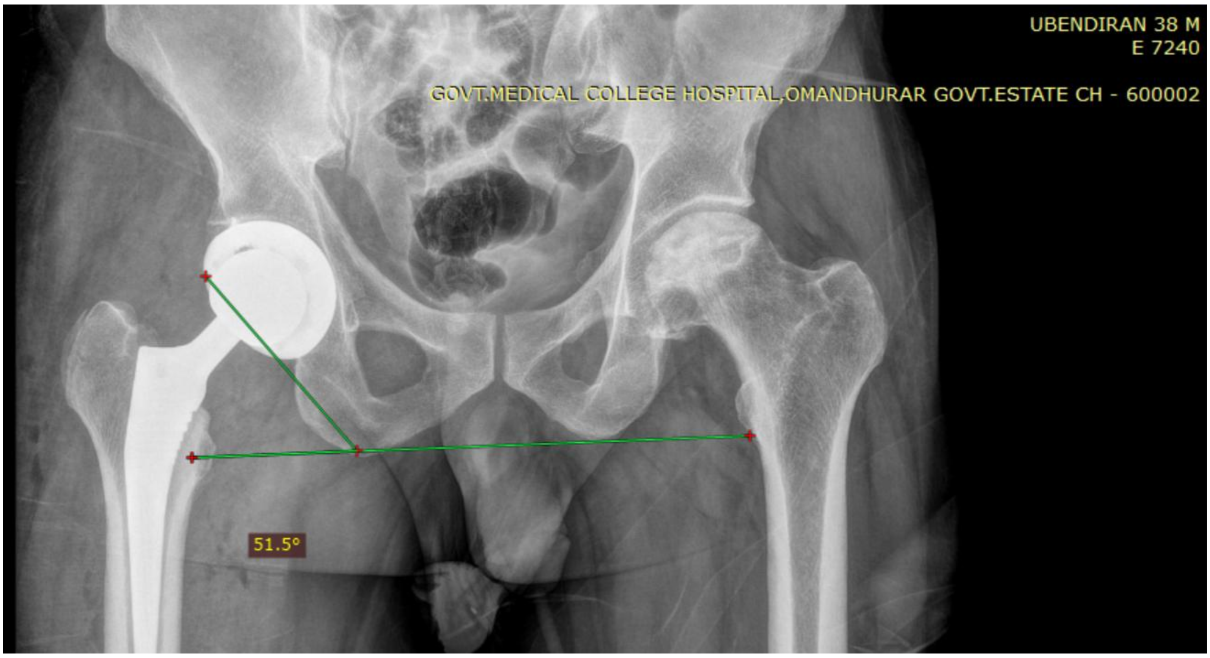

A
SEETHALAKSHMI 37/F
OP 3480
F
OMANDURAR MEDICAL COLLEGE, CHENNAI.
60012
Bone 3.0
21.2°
L

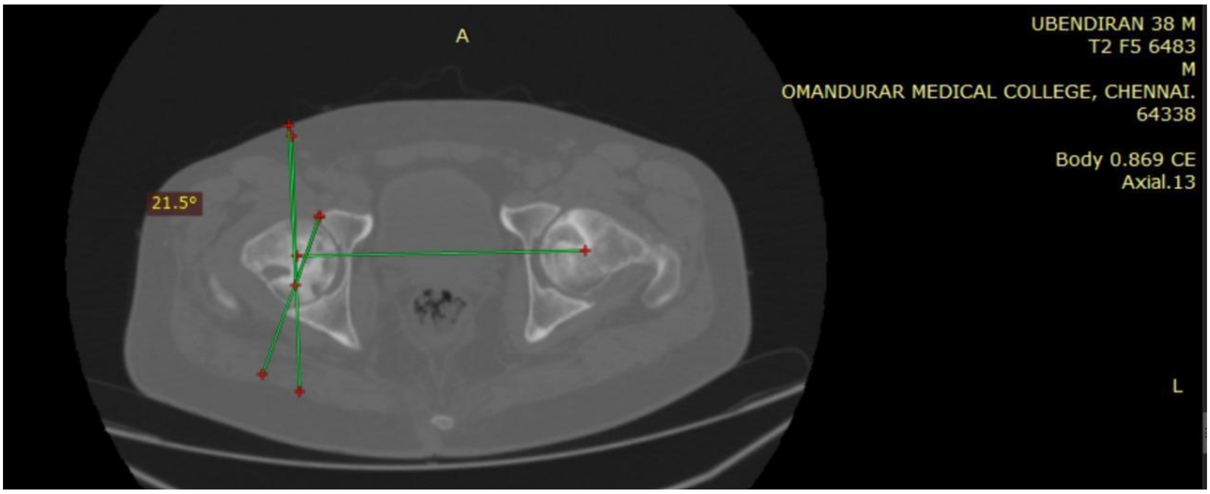

SEETHA LAKSHMI 37-F
E-20114-15
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
15.5°

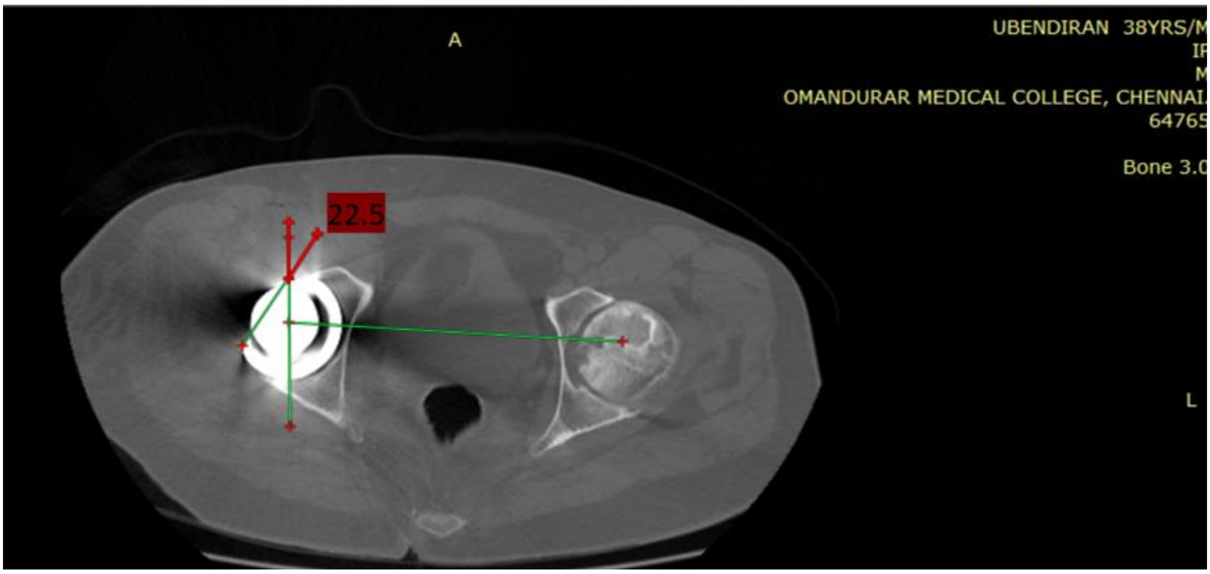

SEETHALAKSHMI 37 F
E-20701
F
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
7.3°

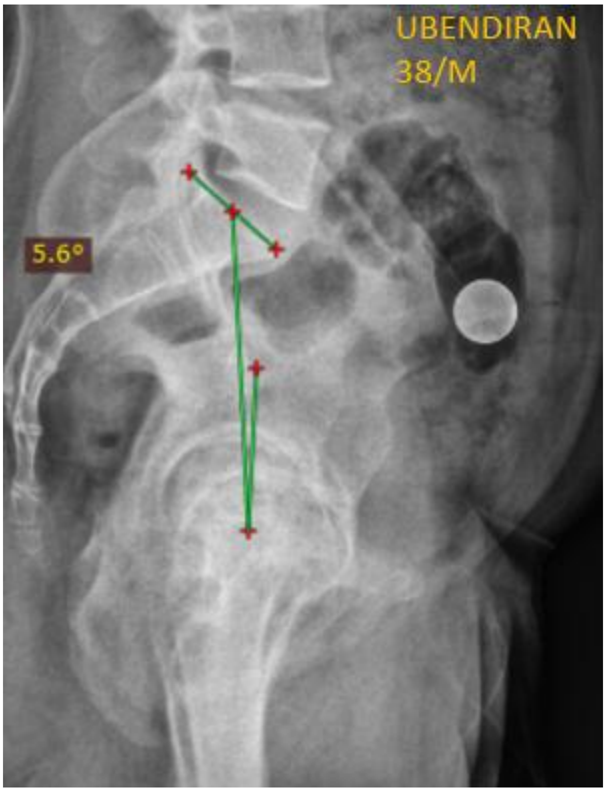
CASE 26: Ubendiran 38/M Diagnosis: Avascular necrosis of femoral head Left side

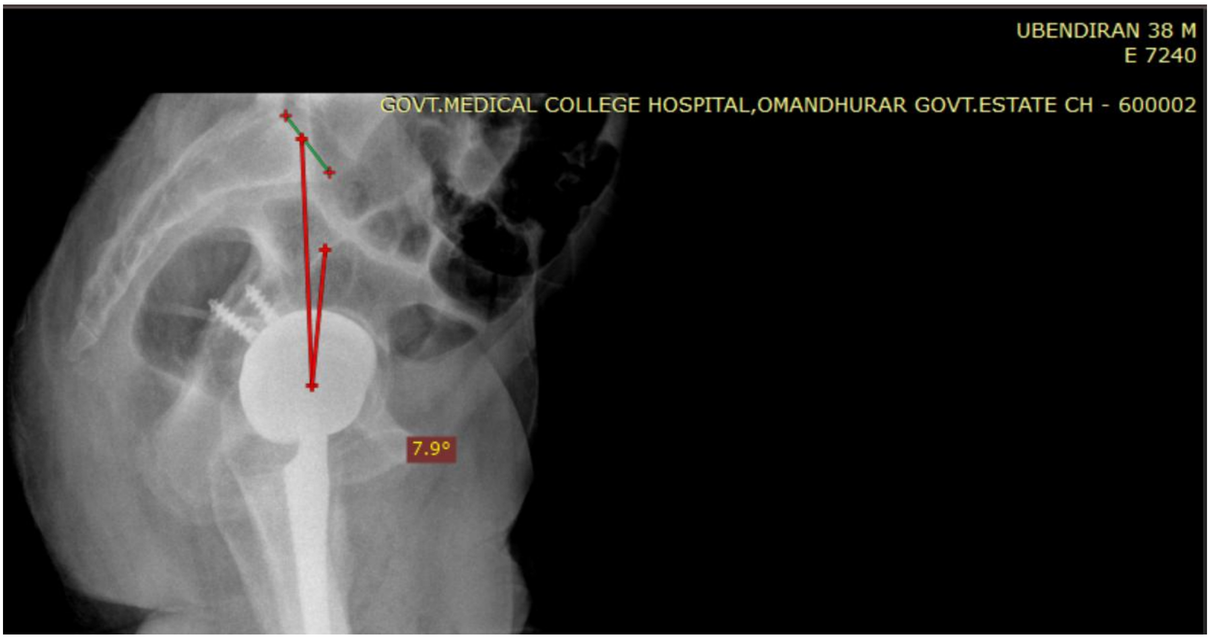




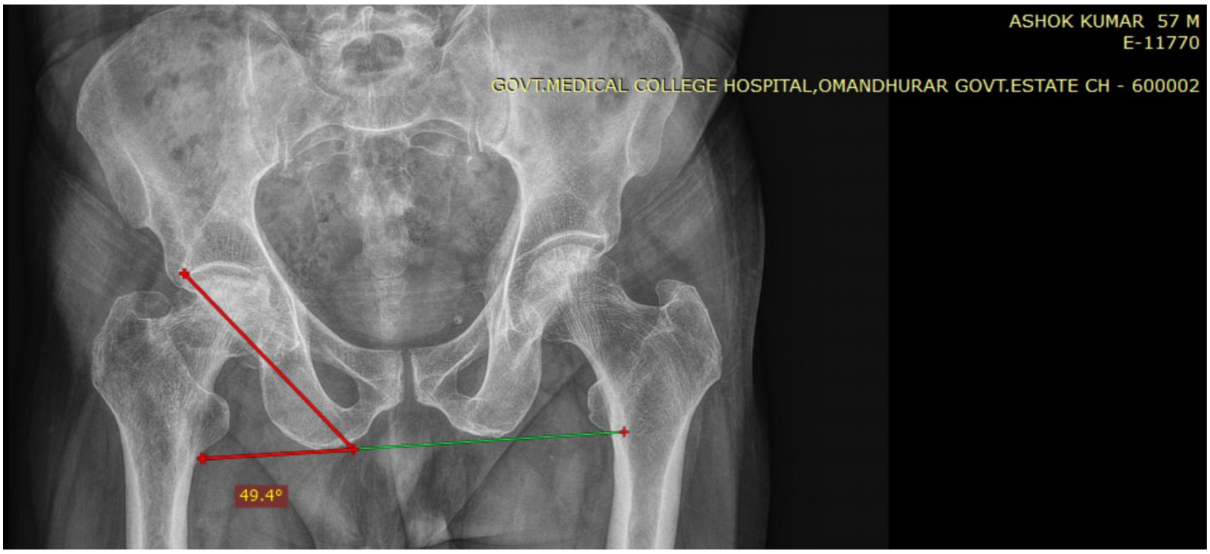

A
UBENDIRAN 38 M
T2 F5 6483
M
OMANDURAR MEDICAL COLLEGE, CHENNAI.
64338
Body 0.869 CE
Axial.13
21.5°
L

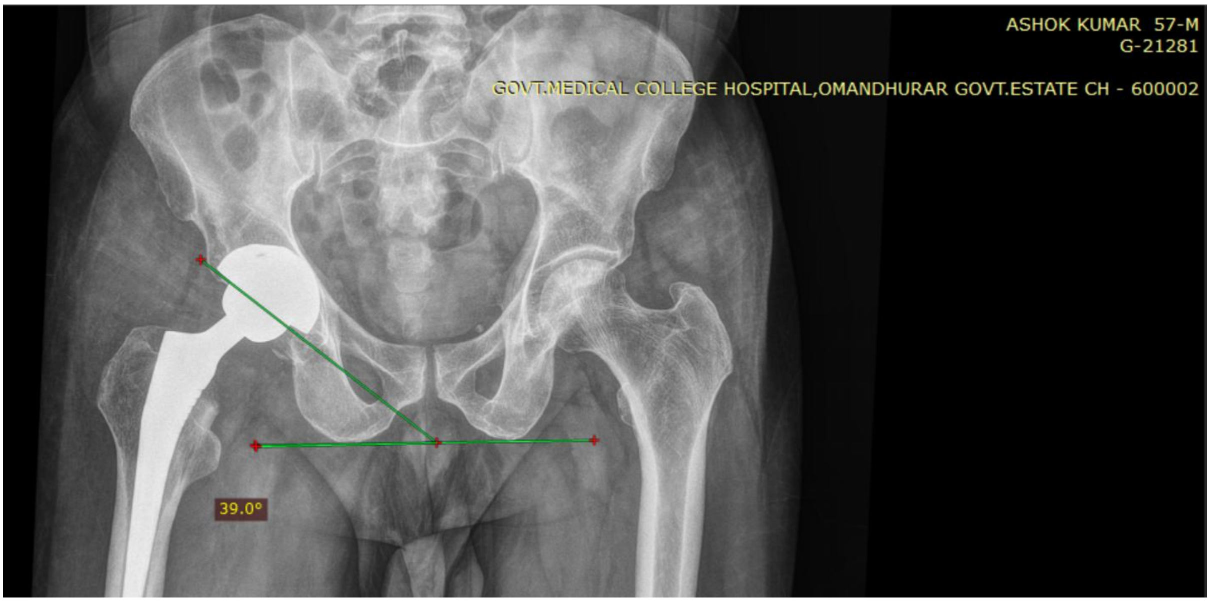

A
UBENDIRAN 38YRS/M
M
OMANDURAR MEDICAL COLLEGE, CHENNAI.
64765
22.5
L

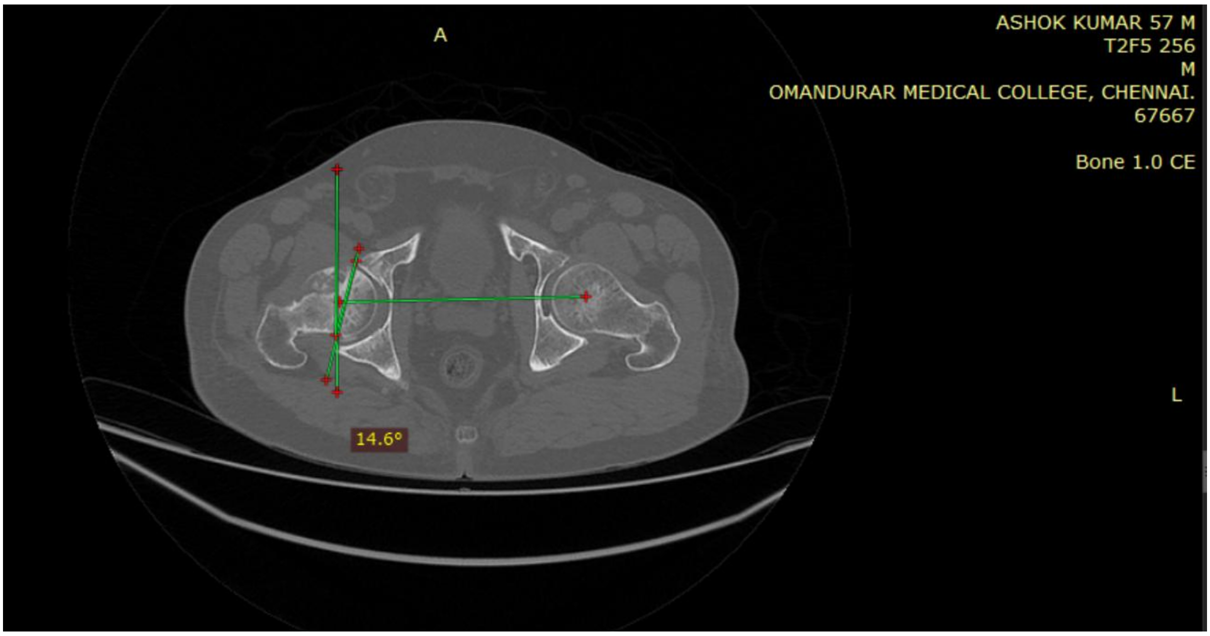

UBENDIRAN
38/M
5.6°

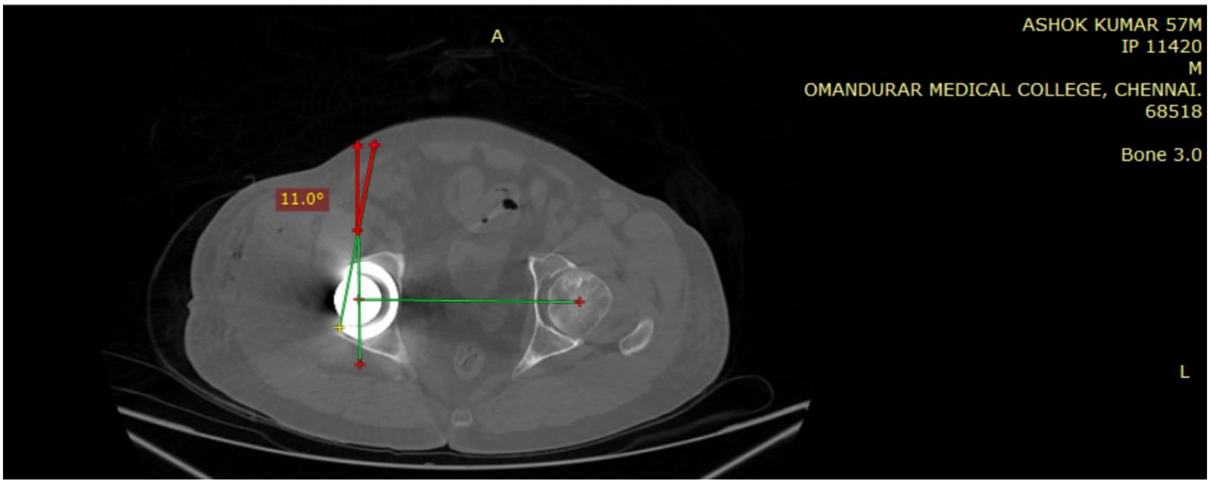

UBENDIRAN 38 M
E 7240
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
7.9°

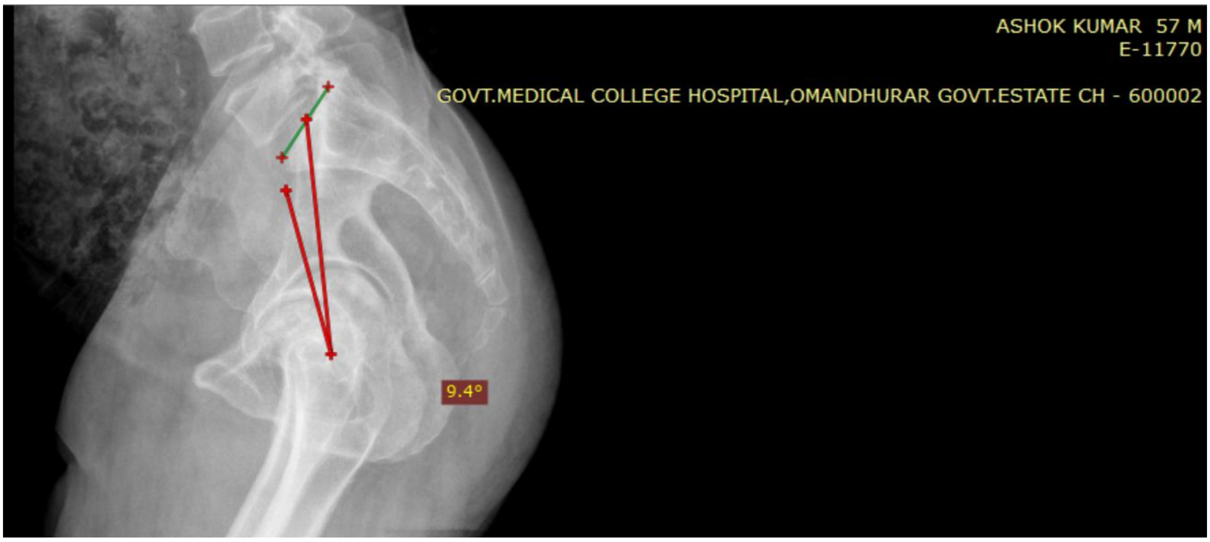
CASE 29: Ashok kumar 57/M **Diagnosis:** Avascular necrosis of femoral head Right side

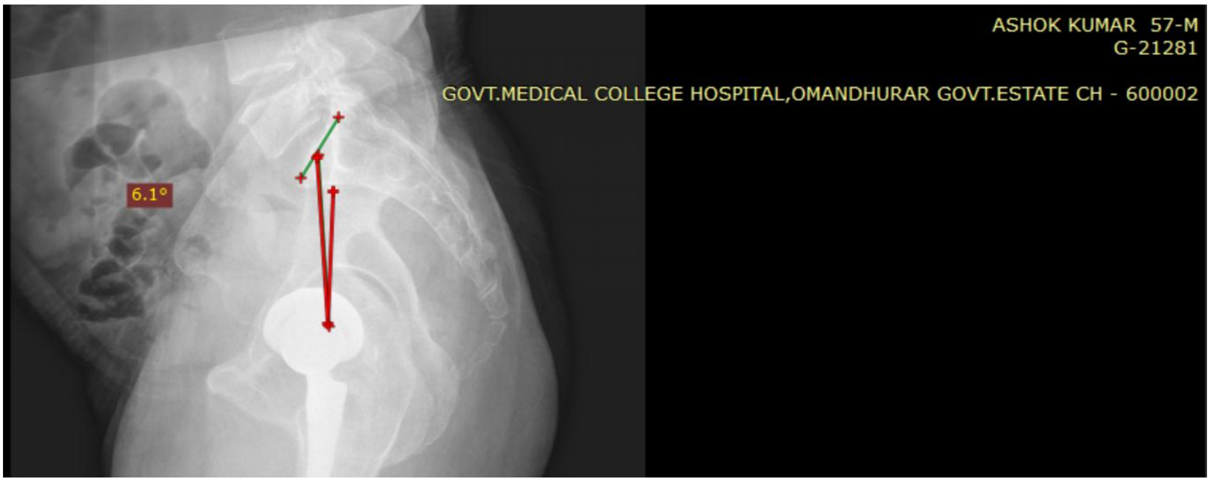




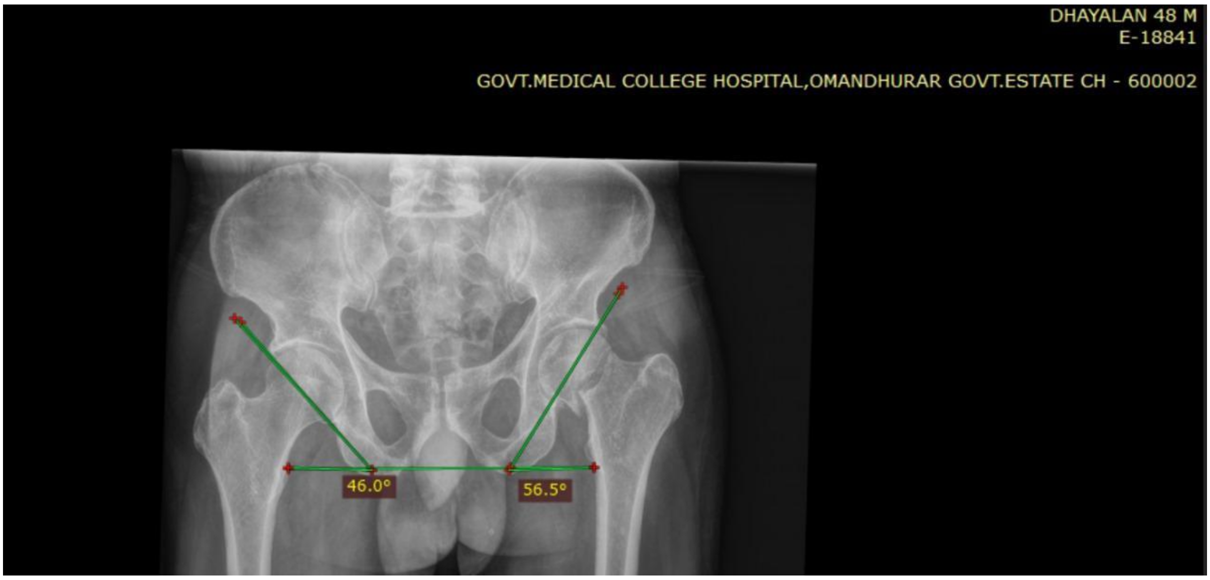

A
ASHOK KUMAR 57 M
T2F5 256
M
OMANDURAR MEDICAL COLLEGE, CHENNAI.
67667
Bone 1.0 CE
L
14.6°

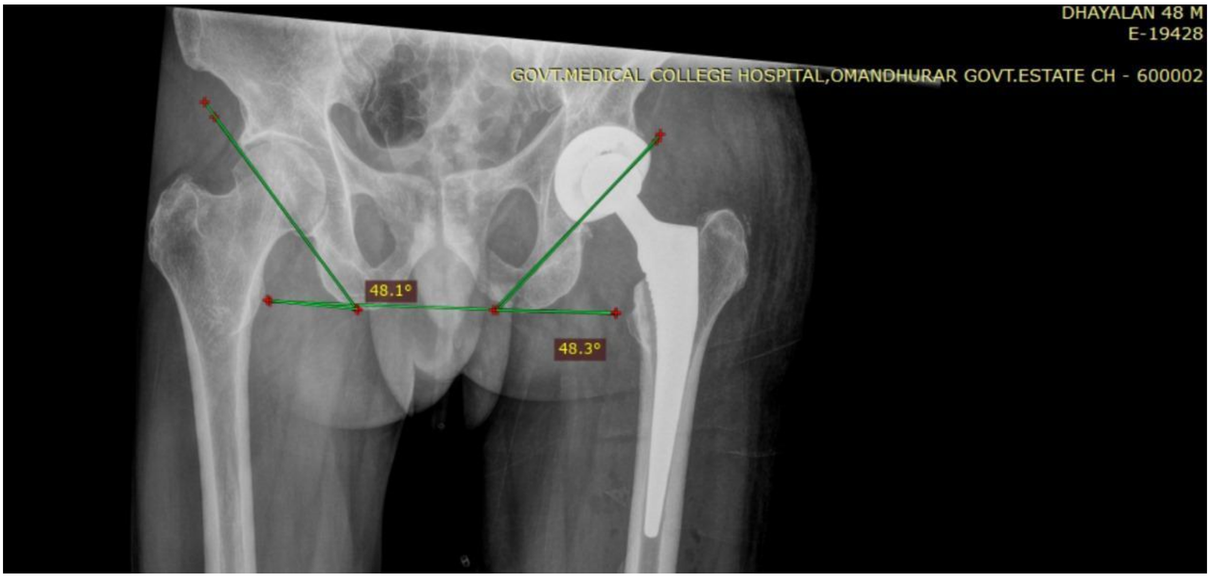

A
ASHOK KUMAR 57M
IP 11420
M
OMANDURAR MEDICAL COLLEGE, CHENNAI.
68518
Bone 3.0
L
11.0°

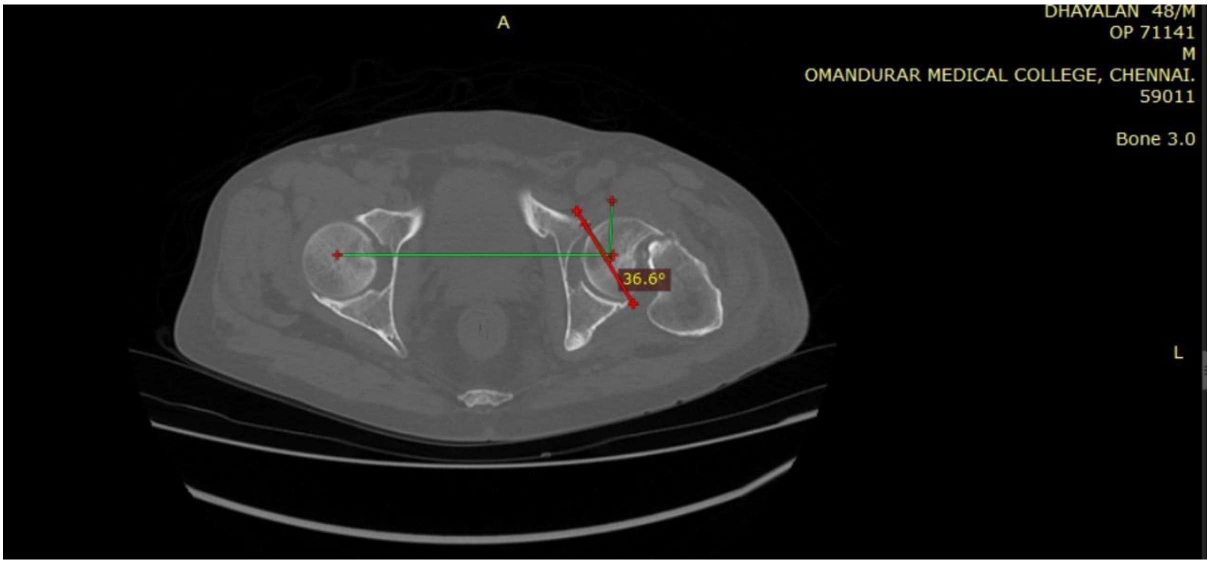

ASHOK KUMAR 57 M
E-11770
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
9.4°

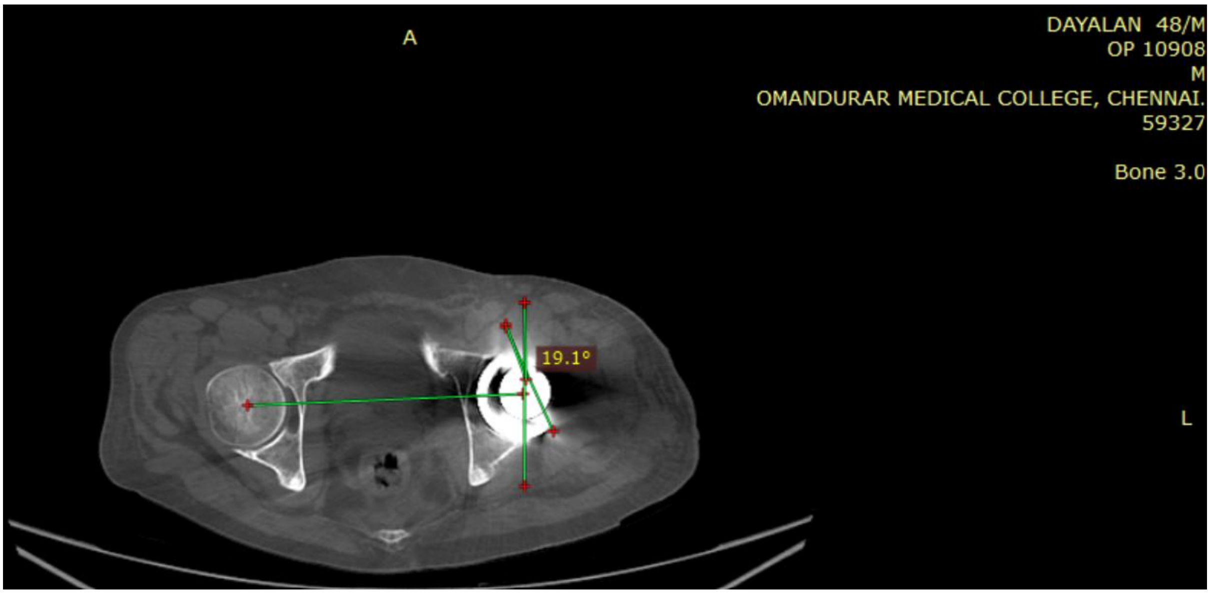

ASHOK KUMAR 57-M
G-21281
GOVT.MEDICAL COLLEGE HOSPITAL,OMANDHURAR GOVT.ESTATE CH - 600002
6.1°

CASE 19: Dhayalan 48/M Diagnosis: neck of femur fracture left side





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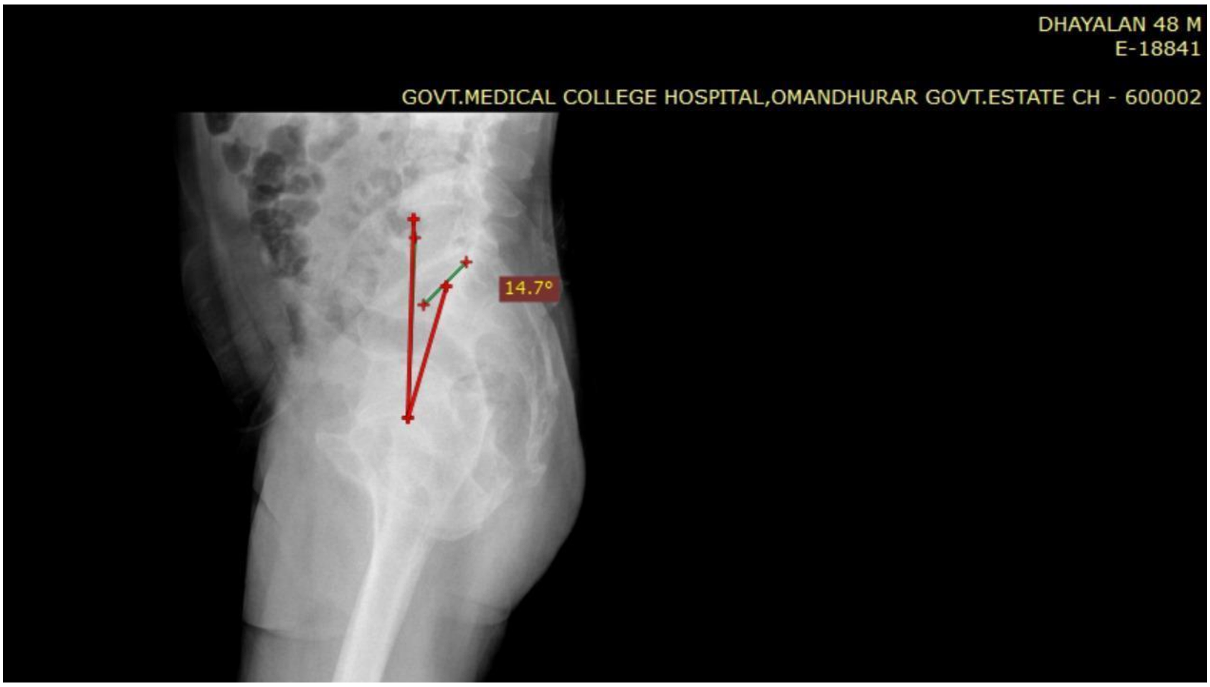
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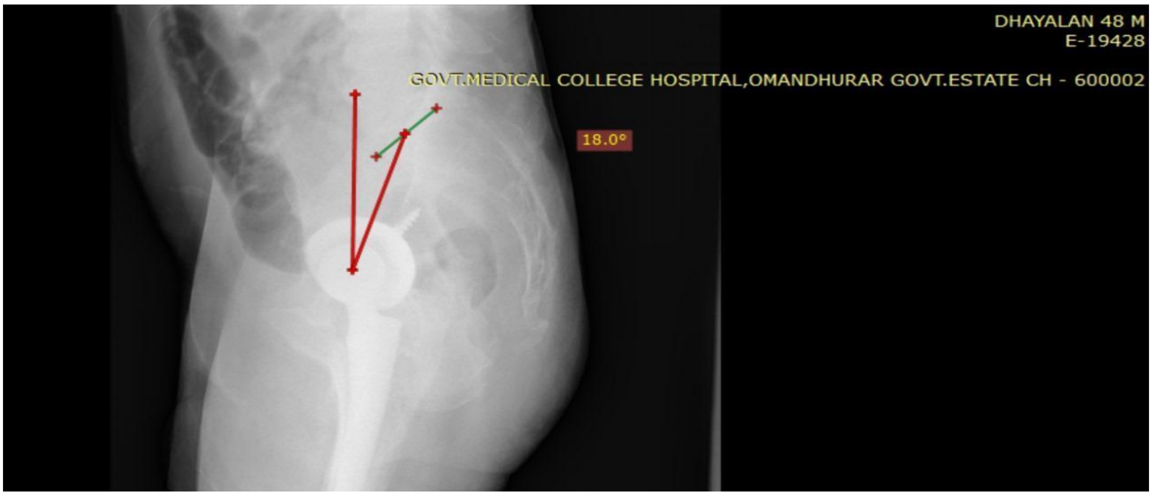
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GOVERNMENT MEDICAL COLLEGE,

OMANDURAR GOVERNMENT ESTATE,
CHENNAI-600002.

INSTITUTIONAL ETHICS COMMITTEE

Registration No: ECR/1492/Inst/TN/2021 Date: 27/02/2023

IEC NO	: **07/IEC/GOMC/2023**
Title of the study	: **"Prospective analysis of Pre and Post operative Anteversion, Inclination of Acetabulum, Pelvic tilt and its relation to functional outcome of Total Hip Arthroplasty"**
Principal Investigator	: **Dr. S. Perumal,** Post Graduate of Orthopaedics, GMC, OGE
Name of the Guide	: **Dr. A. Srinivasan, M.S.,** Professor and HOD of Orthopaedics, GMC, OGE
Name of the Co-Guide	: **Dr. K. R. Kannan, M.S.,** Assistant Professor of Orthopaedics, GMC, OGE **Dr. Vijayalakshmi, DMRD.,** Senior Resident of Orthopaedics, GMC, OGE

The request for an approval from Institutional Ethics Committee (IEC) was considered by the IEC members of Government Medical College, Omandurar Government Estate, Chennai. The members of the committee, the Secretary and the Chairman are pleased to inform you that your proposed project mentioned above is APPROVED.

You should inform the IEC in case of any changes in study procedure, site, investigator, investigation or guide or any other changes.

1. You should not deviate from the area of work for which you applied for ethical clearance
2. You should inform the IEC immediately, in case of any adverse events or serious adverse reactions
3. You should abide by the rules and regulations of the Institution(s)
4. You should finish the work within the specific period and if any extension is required, you should apply for permission again and do the work.
5. You should submit the summary of the work to the Ethics committee on completion of work.

MEMBER SECRETARY
IEC, Government Medical College,
Omandurar Government Estate,
Chennai.

DEAN
Government Medical College,
Omandurar Government Estate
Chennai .

PROFORMA

Patient’s Name:

Age and sex:

Occupation:

Address:

Contact no:

I.P. No:

Date and mode of injury:

Date of admission:

Plain X-ray AP view of hips:

CT scan of both hip and pelvis:

Diagnosis:

Treatment:

Date of surgery:

Other co morbid conditions:

Post operative complications:

Follow up: evaluated with X ray of affected hip and CT scan

Functional assessment: graded as excellent, good, fair and poor.

PATIENT CONSENT FORM

Study Title: PROSPECTIVE ANALYSIS OF PRE AND POST OPERATIVE ANTEVERSION, INCLINATION OF ACETABULUM, PELVIC TILT AND ITS RELATION TO FUNCTIONAL OUTCOME OF TOTAL HIP ARTHROPLASTY

Study Center: Department of Orthopaedics

Government medical college

Omandurar government estate

Chennai-2

Participant Name:

Age/Sex: I.P.No :

I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask the question and all my questions and doubts have been answered to my satisfaction.

I have been explained about the pitfall in the procedure. I have been explained about the safety, advantage and disadvantage of the technique.

I understood that my participation in the study is voluntary and that I am free to withdraw at anytime without giving any reason.

I understand that investigation, regulatory authorities and the ethics committee will not need my permission to look at my health records both in respect to current study and any further research that may be conducted in relation to it, even if I withdraw from the study.

I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law.

I agree not to restrict the use of any data or results that arise from the study.

Date : Place :

Patient Name : **Signature / Thumb impression**

Signature of the investigator:

Name of the investigator: Dr.S.Perumal

ஆராய்ச்சி ஒப்புதல் கடிதம்

ஆராய்ச்சி தலைப்பு

இடுப்பு மூட்டு மாற்று அறுவை சிகிச்சையில் இடுப்பு சாய்வு மற்றும் இடுப்பு எலும்பில் பொருத்தப்படும் உள்வைப்பு கருவிகளின் சாய்வு கோணம் மற்றும் முன்கூட்டிய கோணங்களைப் பொறுத்து செயல்பாட்டு விளைவுகளை பகுத்தறிதல்

பெயர்	தேதி
வயது	உள் நோயாளி எண்
பால்	ஆராயச்சி சேர்க்கை எண்

இந்த ஆராச்சியின் விவரங்களும் அதன் நோக்கங்களும் முழுமையாக எனக்கு தெளிவாக விளக்கப்பட்டது .

எனக்கு விளக்கப்பட்ட விஷயங்களை நான் புரிந்துகொண்டு எனது சம்மதத்தை தெரிவிக்கிறேன்.

இந்த ஆராய்ச்சியில் பிறரின் நிர்பந்தமின்றி என் சொந்த விருப்பத்தின்பேரில் பங்கு பெறுகின்றேன். இந்த ஆராய்ச்சியில் இருந்து நான் எந்நேரமும் பின்வாங்கலாம் என்பதையும் அதனால் எந்த பாதிப்பும் ஏற்படாது என்பதையும் நான் புரிந்துகொண்டேன்.

நான் என்னுடைய சுய நினைவுடனும் மற்றும் முழு சுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் என்னை சேர்த்துக்கொள்ள சம்மதம்.

பங்கேற்பாளரின் பெயர்   பங்கேற்பாளரின் கையொப்பம்

விசாரணையாளரின் பெயர்:

விசாரணையாளரின் கையொப்பம்:

தேதி:

இடம்: