ANTHROPOMETRIC STUDY OF PROXIMAL FEMUR GEOMETRY USING COMPUTED TOMOGRAPHY (CT) SCAN IN PATIENTS UNDERGOING HIP SURGERY-A ONE YEAR HOSPITAL BASED PROSPECTIVE STUDY

BY

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ABSTRACT

Background:

The purpose of the studyis to examine the morphology of the proximal end of the femur in relation to different diameters and angles in the Indian population to provide a database for surgeons and implant manufacturers in order to develop a quantitative understanding of the proximal end of the femur on the normal side in patients undergoing hip surgeriesinaxial and three-dimensional (3D) cuts onCT scan.

Methods:

A hospital based Prospective Study was conducted among 74 Patients undergoing hipsurgeries in Department of Orthopaedics at the KLE's Dr. PrabhakarKore Hospital and Medical Research Centre and Charitable Hospital, Belagavi for a period of One year [1st January 2021 to 31st December 2021]. An observational study of 74 normal hips(n=74)of fractured patients was conducted with Computed Tomography scanning.The age of the participants were spaced from 20- 95 years age groups. The CT scans (128 slice GE Evo Revolution) were collected with slice thickness of 1.25 millimeter and 512x512 pixels per image. The normal hips of fractured individuals was CT scanned in supine position with 15degrees of internal rotation. Proximal femur segmentation was acquired and each image was obtained in Digital Imaging and Communications in Medicine (DICOM) format. The CT scan data were then imported into self-development imaging software to outline cortical contour by using thresholding technique. Cortical bone and Cancellous bone were segmented based on Hounsfield units(-37 to +1027 HU) described by Lamvohi et al. which are the appropriate threshold value. They were segmented for each CT slice, and a 3D model will be

reconstructed using

Advantage software.

Radiant DICOM viewer (Osirix) was utilized to reconstruct the three-dimensional bony model via the cortical contours and subsequent geometric measurements werenoted. Surface smoothing of the 3D model was achieved and the files wereconverted to Initial Graphic Exchange Specifications (IGES) files.Institutional Ethical clearance & Informed consent was obtained prior to the start of the study

Statistical Methods: Chi-square test was used as test of significance for qualitative data. Continuous data was represented as mean and standard deviation. Independent t test or Mann Whitney U test were used as test of significance to identify the mean difference between two quantitative variables and qualitative variables respectively. p value <0.05 was considered as statistically significant.

Results:

Values of mean, range, standard deviation of CT scan images of hip joints of Femoral head diameter (FHD), Femoral neck diameter (FND), Neck shaft angle (NSA), Horizontal offset (HO), Vertical offset (VO), Canal width at 20mm above L.T (lesser trochanter), Canal width at midpoint of L.T, Canal width at 20mm below L.T, Canal width at 50mm below L.T of Indian population and their comparison with Western and Caucasian population were obtained.

In the current study, the average femoral head diameter was 43.36± 8.08mm, the average neck diameter was 29.47 ±3.45mm, the average neck shaft angle was 123.40 ±2.45mm, the average horizontal offset was 43.43 ±8.08mm, and the average vertical offset was 49.24 ±8.97mm. The average canal width at mid-point of L.T was 22.12 ±4.00mm, the average canal width 20 mm above L.T was 37.94±4.55mm , canal width 20mm below L.T was 16.22±3.40mm and canal width 50mm below L.T was 15.58±2.43mm.

Conclusion:

In our study the comparison of average measurements in male andfemale femur was obtained. The male femur had larger dimensions in all theanthropometricparameters.

Significantanthropometricdifferencesexistintheanthropometryofproximal femurbetweenvarious ethnicpopulations.

TheAsianandIndianfemurboneisofmuchsmallersizesincomparison toEuropeanfemurs.

Insummaryallcurrentimplantshavetoberevisedonpopulationbasistofitthechanginganthropometryofourproximalfemur.

This study may offer a data base for surgeons and implant manufacturers who deal with proximal femoral bone surgeries.

Keywords: Anthropometry,Arthroplasty,CT, DICOM,Implant manufacturers

LIST OF ABBREVIATIONS

CT	:	Computed Tomography
THR	:	Total Hip Replacement
CI	:	Confidence Intervals
HRA	:	Hip Resurfacing Arthroplasty
ROM	:	Range Of Motion
NSA	:	Neck Shaft Angle
VO/OSV	:	Vertical Offset
HO/OSH	:	Horizontal offset
FHD	:	Femoral Head Diameter
LT	:	Lesser Trochanter
DICOM	:	Digital Imaging & Communications in Medicine
GT	:	Greater Trochanter
IGES	:	Initial Graphic Exchange Specifications

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INTRODUCTION

Hip geometry's significance has been clearly established in earlier research. The anatomy of femoral prostheses varies, making it challenging to establish a precise fit for the bone implant. Asians' proximal femurs are smaller than those of those in the west. Currently available western orthopaedic implants do not match the size of the proximal femur of the Indian population because the majority of artificial femoral prostheses are standardised and produced in the European and North American region .The use of these oversized and inappropriate implants has an impact on how the procedure turns out by causing issues with stress shielding, micro-motion, and aseptic loosening[39,40]. Since they are not based on the anthropometry of the respective people, the typical hip implant is not useful for the Indian population .In the last ten years, proximal hip surgeries, including trauma and hip arthroplasty procedures, have significantly increased globally[39].Surgery is typically necessary for proximal femoral fractures. Computerized tomography or radiographs can be employed for preoperative planning for a successful proximal femoral surgery in order to match the preplanned internal fixation devices (DHS and PFN) and prosthesis with that of the proximal femoral geometry and restore the natural hip biomechanics[41].The majority of implants that manufacturers typically provide are available in standard sizes. Inadequate load distribution will cause a lot of patient discomfort if the utilised prosthesis or fixation implants do not match the proximal femoral geometry.This feature has led to a general agreement among surgeons that it is essential to closely fit the prosthesis and internal fixation implants to the geometry of the proximal femoral bone in order to obtain the best primary stability and subsequent biologic fixation. The proximal femoral geometry has been the subject of numerous research utilising computerised tomography and radiography on dry bone. These investigations revealed significant variances in these parameters amongst populations from various geographical areas[41].In order to get a close fit, Noble et al. showed that there is endosteal and periosteal variance and that numerous stem designs are required[43].

Nelson and Megyesi highlighted the need for gender-specific implants by researching sex and ethnic differences in bone construction. Women could require smaller femoral designs[44].

Femoral configurations vary among various ethnic groups. The two genders also differ significantly from one another. Orthopaedic femoral implant designs must be customised for different ethnic groups and genders[44].

Cementless stems' fit and fill in the femoral canal can be improved to reduce the risk of proximal bone resorption brought on by stress shielding.

For the cementless prosthesis to fit as well as possible, precise measurements are necessary[45]. However, because of differences in age, gender, and ethnicity, precise measurements are challenging to ascertain. Preoperative measurements of the proximal femur dimensions and implant size are frequently performed using radiography. Resolution, image distortion, and precise alignment are only a few of the drawbacks of this. These restrictions are removed by computed tomography (CT), which offers three-dimensional views[22].

NEED FOR THE STUDY:

In order to provide a database for surgeons and implant manufacturers, the aim of this study is to examine the morphology of the proximal end of the femur in relation to different diameters and angles in the Indian population. In order to develop a quantitative understanding of the proximal end of the femur on the normal side in patients undergoing hip surgeries, we used axial and three-dimensional (3D) cuts on computational modelling (CT) scan.

AIM AND OBJECTIVE

AIM:

To evaluate the anthropometry of proximal femur geometry using three dimensional computed tomography on unaffected side in patients undergoing Hip surgeries.

OBJECTIVES:

1. To measure the geometrical parameters of proximal femur on axial cuts and three dimensional CT scan on normal side in patients undergoing hip surgeries.
2. To provide database for surgeons and implant manufacturers.
3. To provide basis for anatomical design of proximal femoral implants of Indian population.

REVIEW OF LITERATURE

ANATOMY OF THE PROXIMAL FEMUR:-

THE PROXIMAL FEMUR:-The longest and sturdiest bone in the human body is the femur. Its strength is correlated with its weight and muscular forces, whereas its length is correlated with a striding gait .It is a significant weight-bearing bone that helps transfer weight from the pelvis and axial bones to the tibia.The greater and lesser trochanters, the head, the neck, and the shaft make up the proximal femur (proximal). The femur's head varies in shape from spherical to circular. The articular cartilage covers two thirds of the sphere, with the fovea, a central depression/pit located medially on the skull. The ligamentum teres, which attaches to the femur's head, enters the fovea.The head is connected to a trapezoidal neck with a wide base that runs parallel to the femur's shaft.With the neck and head, which have an oblique angulation that is greatest at birth and gradually diminishes, the proximal shaft forms a joint. The greater trochanter, which is laterally positioned over the proximal shaft's apex, acts as a point of attachment for the abductor muscles.Normally, this neck shaft angle is 126 degrees, which causes the abductor mechanism to lateralize away from the centre of rotation (the femoral head). The proximal femur also exhibits a small anterior bow that later changes to a posterior bow up to the level of the lesser trochanter.Additionally, as we descend down the shaft, the femur gradually develops a medial bow. This is one of the anthropometrically significant parameters that implant manufacturers frequently overlook or don't prioritise.The posterior condyles of the femur are used to reference the coronal plane of the bone distally. The proximal femur's head and neck are turned anteriorly when viewed in relation to the condyles. Anteversion describes this anterior rotation of the head and neck.The proximal femur's typical anteversion ranges from 10 to 15 degrees on average, with 10 degrees in males and 15 degrees in females[10,31].The intertrochanteric line, a thin line that separates the two trochanters, is present. This line acts as a reference point for attaching the capsule. The femur's shaft is expansile proximally and distally, but tubular and thin proximally. Because of the lateralization of the abductor mechanism, the axis of the femoral shaft forms an angulation of 5-7 degrees with the axis of the tibia[37].

THE INTERNAL ARCHITECTURE OF THE PROXIMAL FEMUR:-

The frail yet robust lattice work of "struts and trusses" generated by the trabecular framework of the bones makes up the proximal end of the femur. Galileo understood the significance of the hollow cylinders formed by this network of trabecular bones[42].

THECALCAR FEMORALE:-

A small, vertical bone plate known as the calcar femorale. This plate rises into the trabeculation of the neck of the femur from the linea aspera and connects the posterior wall of the neck of the femur medially.The real neck of the femur, as Bigelowet et al. put it. Laterally, it extends into the neck of the femur's trabeculations before progressively separating into the fine trabeculations[10]. This calcar is significant because it is a thick plate of bone. Any hip joint prosthesis will rest its shoulder over the calcar femorale, which aids in transferring the stress of weight bearing to the calcar femorale.

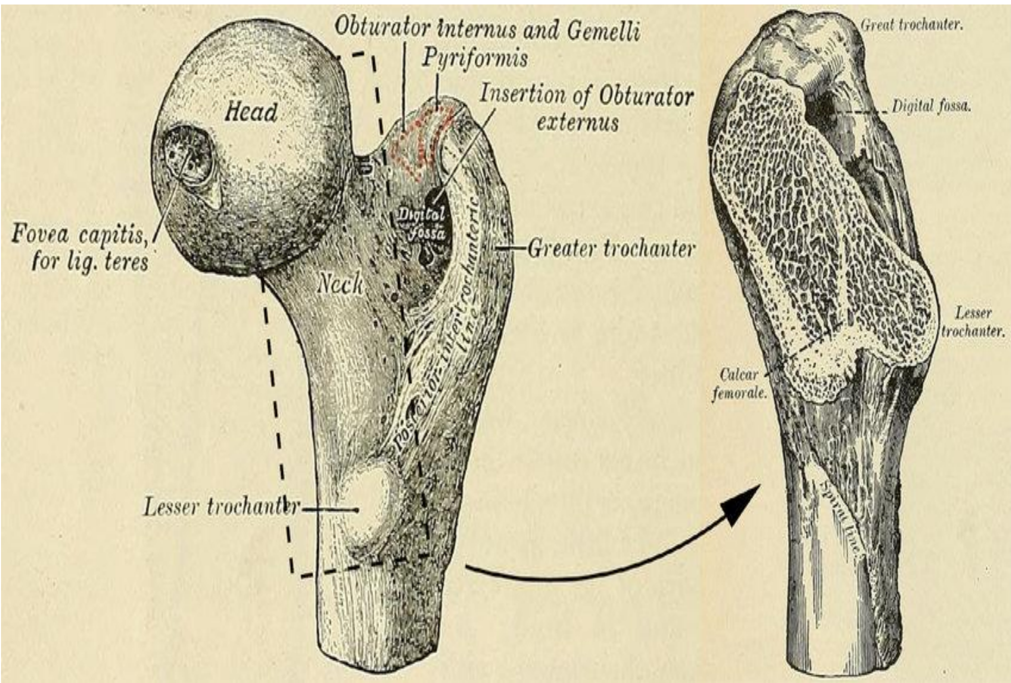


Fig 1 :- Anatomy of proximal femur

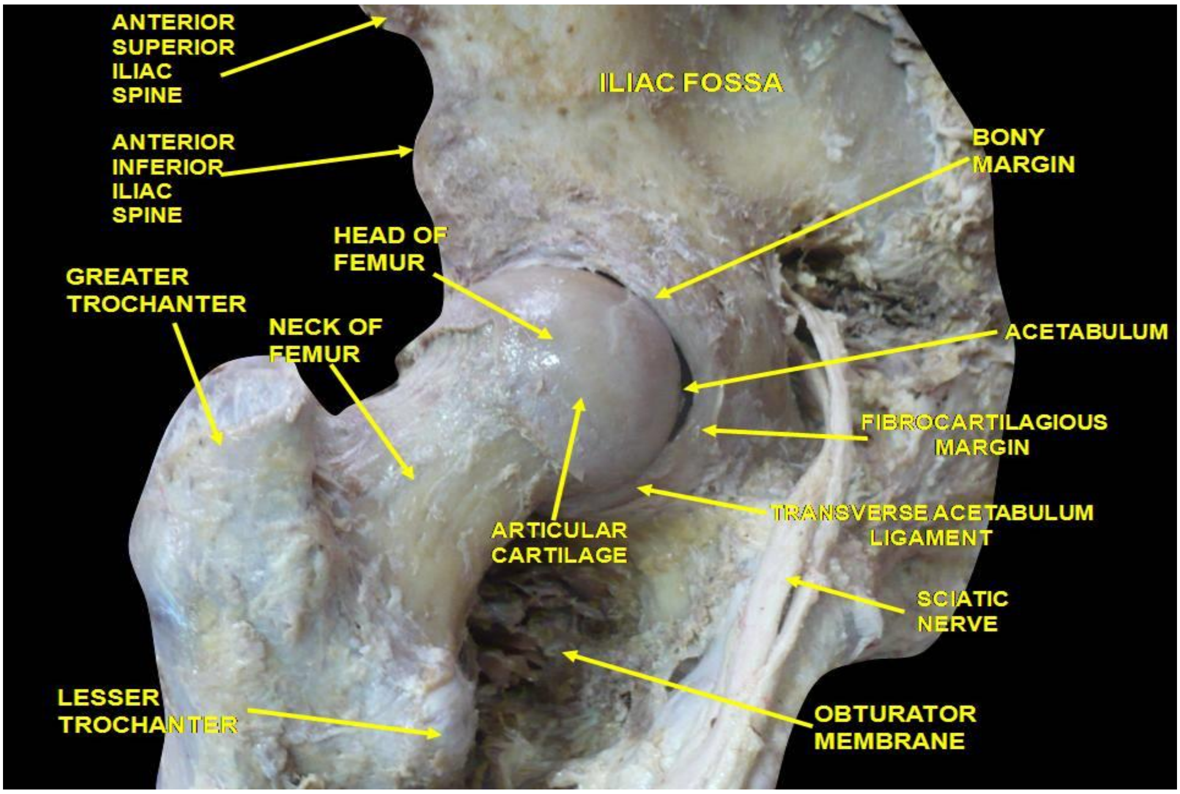


Fig 2 :-Anatomy of hip joint

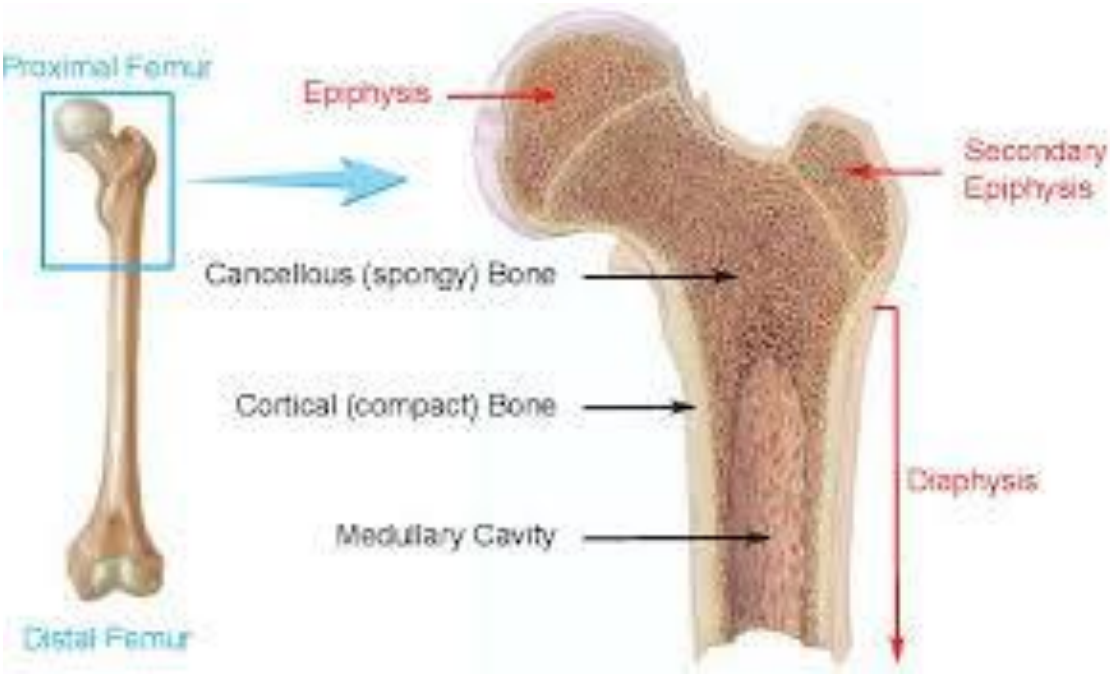


Fig 3 :- Internal anatomy of proximal femur

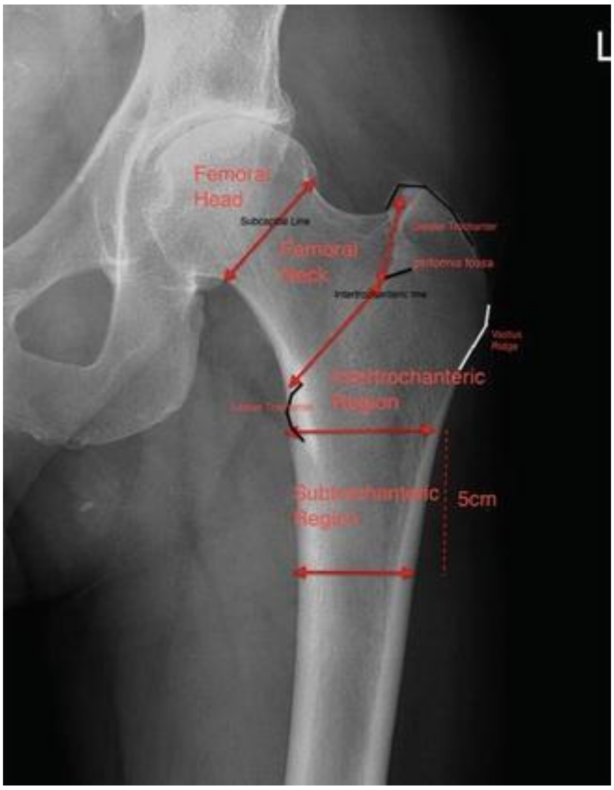


Fig 4 :- Radiographic anatomy of Proximal femur

CT SCAN:-

The word "computed" in CT (computed tomography) refers to calculations or reconstructions, while the word "tomography" is a compound word made up of the Greek words "tomo," which means to "cut" or "section," and "graphy," which means "to describe."

X-rays provide the foundation for CT scanner operations. 100 kV to 150 kV is the average energy range for general CT.

The mathematical underpinnings of the Radon transformation (Radon theorem), which was developed by Austrian mathematician Johann Radon and published in 1917, are the basis for the algorithms used for CT image reconstruction[3-6].

According to the Radon theorem, an infinite set of an image distribution function's projections that were obtained through rotational scanning could be used to rebuild an image. A South African-born American physicist named Allan M. Cormack published the mathematical computation method in the early 1960s[46,47]. It was based on this method that cross-sectional images of internal distributions could be calculated from projection of attenuation data resulting from X-rays that penetrated the body at various angles.

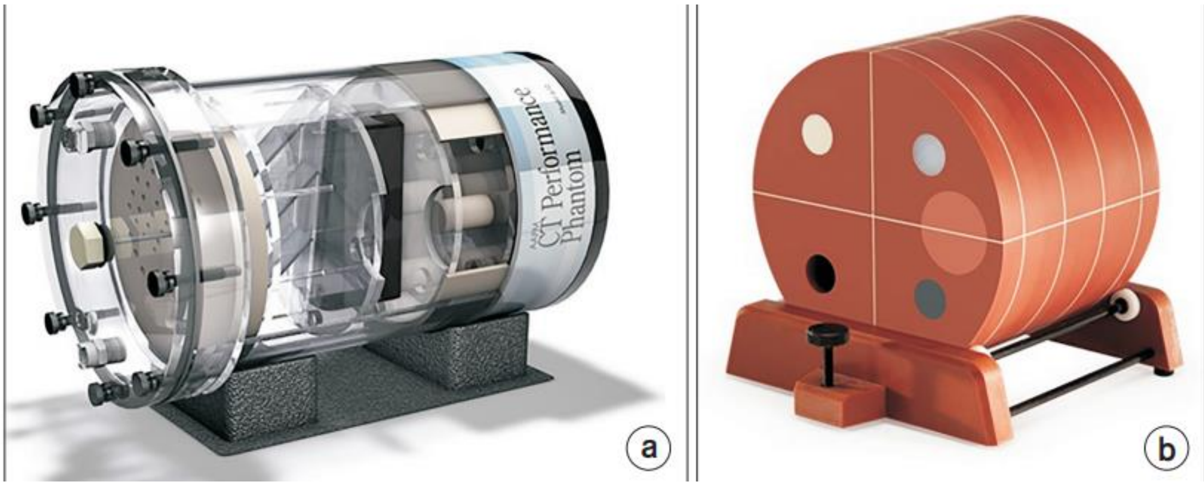


Fig 5 : - (a)Model 76-410 of the American Association of Physicists in Medicine's CT performance phantom. (b) The CT 464 phantom from the American College of Radiology, which can test a variety of image quality factors.

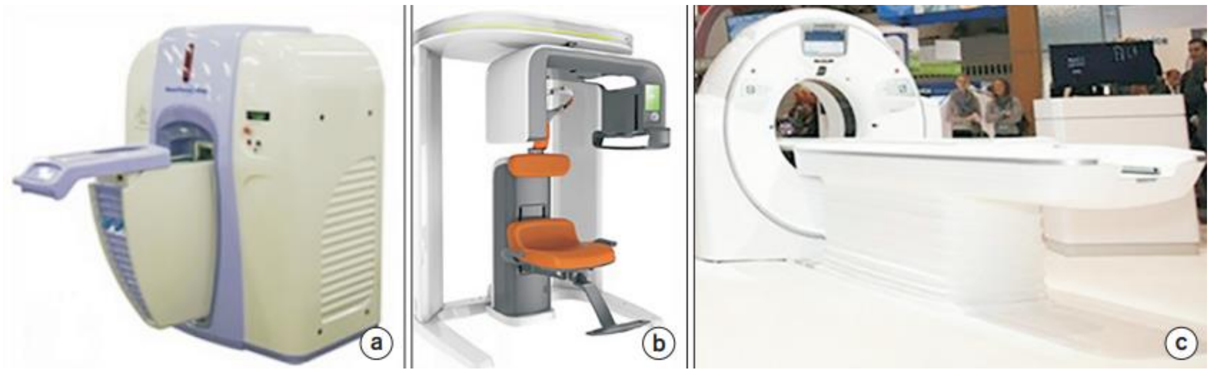


Fig6 :- Computed tomography (CT) scanners for domestic commercial use. (a)Gantry of the rotatable microct system built by Nano Focus Ray (Nano Focus Ray Co., Ltd., Seoul, Korea; 2008). (b) Vatech's PaX-13D Green Premium conical beam dental CT (Vatech Co., Ltd., Seoul, Korea; 2012). (c) NEXCT 7 Diagnostic CT Scanner (Samsung Electronics Co. Ltd., Suwon, Korea; 2015).

Modern CT scanners include a basic structure made up of a gantry, an X-ray tube, a high-voltage generator, filters, collimators, detector arrays, a DAS, a couch (patient table), an operator console, and an image reconstruction computer. A focusing spot as small as 1.310 mm must be driven by 60–80 kW for up to 20 seconds in a contemporary CT X-ray tube. High voltages (often between 120 and 140 kV) are generated by a very reliable, three-phase generator and sent to the X-ray tube. The range exposure parameters, such as the X-ray characteristics of kV and mA, are determined by the power capacity of the generator indicated in kW. Low energy X-rays that don't help form images but increase patient dose are taken out by the filter positioned between the X-ray tube and the patient. Between the filter and the patient is the collimator. Its function lowers the radiation exposure and limits the scattering of X-rays from the connected slice's outside regions. Gas-filled detectors, scintillation detectors (solid-state detectors), and various types of CT detectors have all been developed. A gas-filled detector is divided into different subdetectors and has a single vessel that is filled with high-pressure gases (about 25 atm) of high atomic number elements (Krypton, Xenon, or Krypton and Xenon) Initially, sodium iodide scintillation crystals (NaI) and a photomultiplier tube were employed in CT scanners. The X-rays are transformed into visible light photons by the majority of solid-state detectors, which are then transformed into electrical impulses by photodiodes. Due to the use of crystals that fluoresce when X-ray photons interact with them, solid-state detectors are also referred to as scintillation detectors. Scintillation lights are converted to electrical impulses by a photodiode. Carbon fibres are used to make the patient couch (table) as a result of their low photon absorption characteristics. In order to ascertain the scanning position and to regulate the patients' movements following position settling during examination, patients are moved through the gantry aperture while lying on a sofa. To hold weights of up to 204 kg, a CT sofa needs to be sturdy and rigid. While diagnostic CT utilises a circular table top for patient comfort, radiation therapy uses a flat table shape to rebuild the patient image in the same condition as a treatment machine. For circumstances where the overall diameter of the imaging chamber is large due to immobilisation devices, a larger gantry bore is used in simulations of radiation therapy. Additionally, for effective treatments, specific patient postures are frequently required (85 cm for radiation treatment vs. 70 cm for diagnostic purposes). The CT scan's command centre is the operating console. To operate the scanner, receive data from the DAS, and reconstruct the CT image, it is made up of a keyboard, multiple monitors, and computers[46,47].

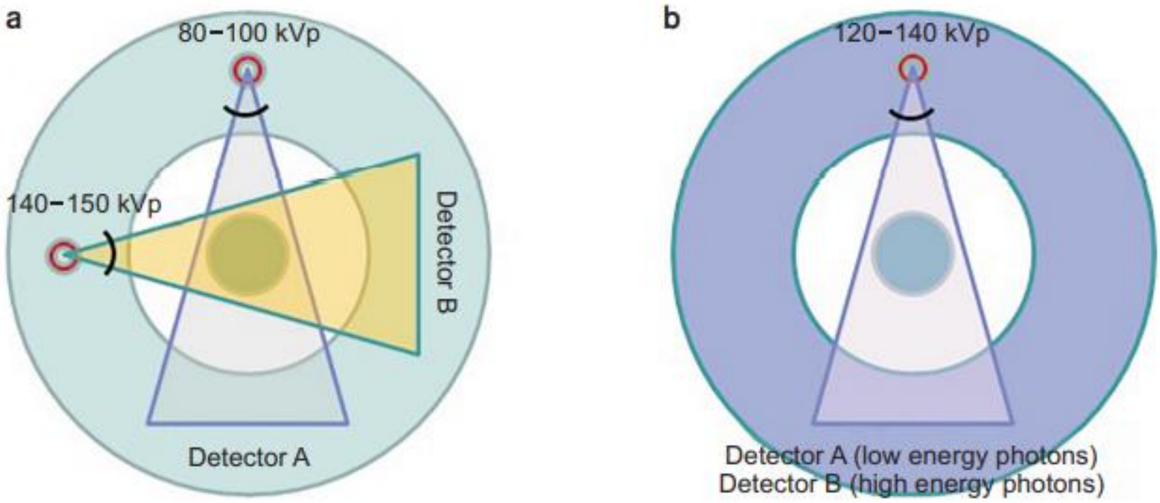


Fig 7 :-Two X-ray tubes and matching detector arrays make up the structure of the (a) dual-energy computed tomography (CT) system, and (b) the detector-based spectrum CT system (single X-ray tube and two layers within detector arrays).

LITERATURE REVIEW : -

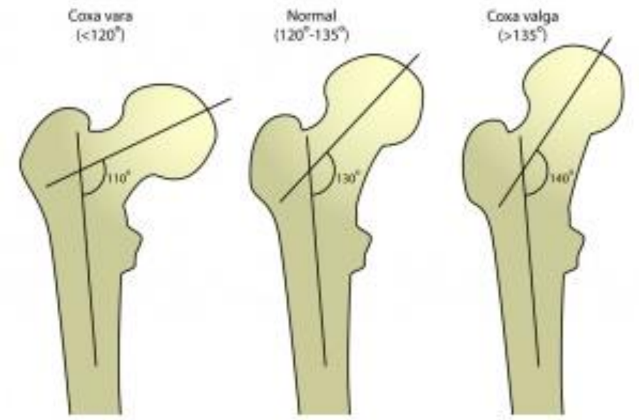


Fig 8 :-Neck shaft angle

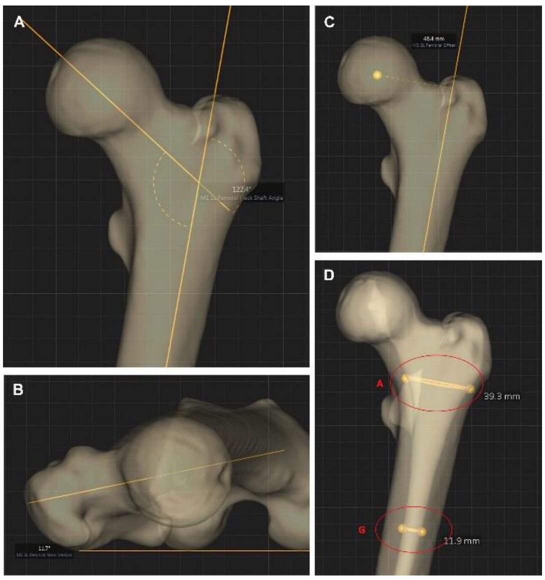


Fig 9:- Neck shaft angle measurement on CT scan

One of the topics in orthopaedics that has received the greatest research over the past three centuries is the treatment of arthritic diseases in different joints.Arthritis is well-known for its disabling effects, pain, and functional restrictions. Because of its complexity and significance as a primary weight-bearing joint, hip arthritis results in serious limitations.Therefore, efforts to find ways to promote the recovery of function and decrease pain continued. Over the past three centuries, total hip replacement has improved dramatically to become the gold standard for treating hip arthritis. Even now, extensive research is being done on this procedure.

As suggested by diverse causes, numerous surgical operations are carried out on and near the proximal femur. “When necessary, two typical joint procedures—total hip replacement and hemiarthroplasty”—are carried out to restore the hip joint's painless functioning. Implant-based fracture fixations are typically carried out in the wake of traumatic, pathologic, or fragility fractures. In order to ensure that the hip joint and the leg work as well as possible, the proximal femur's anatomy is restored.Corrective osteotomies continue to be important surgical operations in the arsenal of orthopaedic surgeons because they are utilised to treat abnormalities, remodel the bone, and effectively reroute load paths[12]. These aforementioned methods involve the use of hip joint prosthesis and surgical implants, including plates, different kinds of screws, and proximal intramedullary nails. However, the prostheses and surgical implants that are currently accessible and in use in our setting were made using bone measurements from other groups. It is known that skeletal measurements vary between racial groups and between different geographic regions[12-14].

The prevalence of hip osteoarthritis, neck of femur fractures, and other hip joint pathologies are rising daily. Arthroplasties are the only proven treatment for these patients. The femur, which bears the body's weight, supports leg motion, and serves as an attachment point for muscles, forms the skeleton of the thigh[1].

The shape of bones is influenced by lifestyle choices and environmental variables.

Early osteoarthritis has been shown to be affected by abnormal morphology, such as joint deformity (in situations of excessive neck-shaft angle [NSA])[17].

The geometric indices of bone strength in the proximal femur are affected by lifestyle factors, according to a population-based study by Nurzenskiet al.[3].

Commercially available hip prosthesis are created using European data[5]. These functions may be impacted by the THA's (Total Hip Arthroplasty) undersized and oversized hip prostheses. Removing disease and returning anatomy to normal with stable fracture fixation, which aids with bone reunion and permits early mobilisation, are the fundamental goals of surgical intervention.

In several populations and communities, the proximal femur was anthropometrically studied[8]. The information from these research showed that there were socioeconomic and regional variations in femoral geometry.

In particular for cementless implantation, the osteological characteristics of the proximal femur are crucial for the design of appropriately sized prostheses for total hip replacement (THR)[1].

Orthopaedic surgeons constantly emphasise the importance of a suitable implant-patient match in hip joint replacements in order to prevent post-operative mismatch complications that could impair the procedure's outcome[8]. For Caucasians and Chinese, the definition of normal has been standardised[10-16], however data for Indians are unavailable.

It is probable that the anthropometric measurements at the proximal end of the femur that are considered typical for Westerners may differ significantly from those observed because of the substantial differences in build, physique, habits, and genetic make-up amongst different ethnic groupsamongst Indians.

Preoperative planning for THR by orthopaedic surgeons must take into account the biomechanical behaviour and physiological operation of the hip joint[17].

By choosing the right type, size, and model of whole hip stem and head, orthopaedic surgeons can adjust the neck shaft angle, the vertical offset (OSV), and the horizontal offset (OSH). In contrast, the surgeon must cope with the preexisting femur morphology and has less control over the important parameters in hip resurfacing arthroplasty (HRA), which replaces only the cartilage surface with a metal cap.

More thorough understanding of femoral morphology is essential to deal with contemporary medical difficulties including impingement after THR and HRA, the aetiology of hip fracture, and proper implant design for orthopaedic implants, as a result of the scant amount of published data. Postoperative problems include thigh pain, aseptic loosening, and impingement are typically caused by a bone-implant mismatch[17,18].

Large implants and screws can cause intraoperative splintering and avascular necrosis, respectively. Additionally, the thread may not entirely cross the fracture site without providing sufficient compression for optimal healing[17-19].Additionally, in regard to femoroacetabular impingement, femoral offset and head-neck ratio affect the joint's range of motion (ROM) and the integrity of the artificial hip[17,18].

The neck-shaft angle influences THR results (NSA).

Improved NSA research may make it possible to predict the likelihood of femur fractures, particularly in cases when the patient is osteoporotic[17-19]. The frequency of total hip replacements (THR) has significantly grown recently in emerging nations like India.

A market study reveals that joint replacement procedures in India are increasing annually[20].

It is crucial to match the dimensions of the implant with those of the femur, thus radiography or computed tomography images of the morphological characteristics of the proximal femur are employed in preoperative planning before total hip arthroplasty. The effectiveness of a hip implant's basic stability has a significant impact on its secondary biologic fixation. A mismatch in size between the femur bone and prosthesis causes the implanted stem to move somewhat in the first few days following surgery, which prevents formation of trabecular bone. In order to prevent stress shielding, it is crucial to design a prosthesis through which sufficient loads may be delivered to the bone[16].

For the construction of the prosthesis, the three criteria femoral head diameter, horizontal offset, and neck shaft angle are primarily taken into account. Numerous studies examining proximal femoral geometry using computed tomography, radiography, or dry bone revealed significant variability in these parameters among persons from various geographical areas[8].

Nelson and Megyesi identified the need for creating gender-specific implants after researching sex and ethnic variances in bone architecture[8].

According to Chaubber and Singh's study, more persons utilise the left lower limb for more weight bearing on the left than the right, regardless of whether they are right- or left-handed[9].

Reddy et al. claim that a direct link has been drawn between the occurrence of thigh pain and the implant's poor fit and fixation[7].

It has been shown that the clinical result score has improved, and that improvement was closely correlated with the degree of implant bone fit[16]. Therefore, the implants should be created by taking into account the characteristics of the local population in order to minimise post-operative difficulties[8]. Implant design has a significant impact on how well hip anatomy is rebuilt. in chronological order

The proximal femoral morphology has been the subject of numerous studies in the recent years in an effort to choose an implant that matches the native hip.

Studies have revealed notable variations in the structure of the proximal femur between individuals of the same race, ethnicity, gender, and geographic region[13].

Because of this, these research demonstrated the necessity for creating ethnic- and gender-specific implants[16].The prosthetic parts now on the market, particularly in the smaller sizes, are believed by Indian and Asia-Pacific arthroplasty surgeons to not meet the needs of these anthropometrically smaller ethnic groups.The trend is to undersize the implant for safety because if it is too large, the femur may fracture as it is pushed down into the bone. However, if the implant is significantly too small, the bone may not adhere to it. Consequently, choosing the right implant size is crucial[16].The majority of orthopaedic implants made for femoral head prostheses and trochanteric fracture fixation are based on the Caucasian population. The majority of Asian patients are not properly matched in terms of size and shape. Even while Caucasian designs can be used in smaller sizes, mismatching issues still exist, though they are less severe[3]. When proximal femoral nails are used on Asian patients, mismatching issues have been noted. Mismatching could result in serious issues like the proximal femur bursting when the nail is inserted.

If the implants are correctly constructed based on the morphometric data of the proximal femur from a specific population for which the implant will be used, this issue may not arise[3].

Total hip arthroplasty (THA) is frequently praised in the orthopaedic literature as one of the most effective and affordable medical procedures[14]. We are currently in a time where achieving excellent post-operative functional results is our main focus because THA has now been ingrained in mainstream orthopaedic surgery.

The increased number of young people having hip replacements has given this issue more significance[14,15].

The development of non-cemented arthroplasty as an alternative to fixation with cement has regained attention. Aseptic loosening was a problem that led to the invention of uncemented prosthetics. The patient age groups below 65 years required better bone stock to be left behind for revision arthroplasty, which was the second factor[14]. The cemented prosthesis has received unsatisfactory reports from younger patients (under 50 years old).

According to an analysis by Dorr et al of 81 cemented complete hip arthroplasties performed on patients between the ages of 14 and 45, 78% of patients experienced satisfactory results between two and five years following the treatment, although this number fell to 72% after five years.

The group with the worst outcomes was under 30 years old[14,15]. According to one method of non-cemented stem design, a stem shape that closely follows the anatomy of the femur, especially in the proximal area, can achieve close contact and stability and roughly approximate the stress and strain pattern of a normal femur[15].

Due to the wide range of anatomy and age-related changes in geometry, some anatomic investigations claim that an exact total fit of a non-cemented prosthesis to the cortical envelope is an impossibility[14-17]. However, the fit attained with an anatomic design, emphasising the maximum fit in priority areas of contact, should result in the greatest load transfer to cortical bone and resist both the significant torsional stresses as well as the axial and bending loads[14-18]. The condition of the trabecular and cortical envelope into which the prosthesis is administered must be a crucial element for success[15,16].

Age and gender have been proven to affect the proximal femur morphology in cadaveric studies. Cementless femoral prostheses of one standard shape have been found to be unable to offer a close fit to the endosteal contours, particularly in young and elderly women[16,17].

When Mahaisavariya et al. used a three-dimensional reverse engineering technique to examine cadaveric femora from a Thai population, they found differences from a Caucasian population in the femoral head diameter, neck anteversion angle, and femoral canal[3].

Siwach et al. anthropometric investigation found that the proximal femur shape varied noticeably among different ethnic groups to the point where some standard prostheses would not be suitable for implantation in specific subgroups of the Indian femora[2].

The gamma nail, which is used to anchor a femoral neck, was modified by Leung et al.[15,16] to accommodate Asian people.

Predictions of degenerative illnesses like osteoarthritis can be made by analysing irregularities in femoral shape and orientation[17,18].

Thus, for the design of nails, plates, and orthopaedic prosthesis as well as for preoperative planning, precise descriptions of angles and bone measurements are essential[18,19].

Therefore, throughout the past ten years, therapies for the hip joint, such as hip resurfacing arthroplasty, have focused on creating a thorough assessment of femoral morphological features[18]. Numerous investigations into femoral geometrical parameters have been conducted. Few, nevertheless, offer an entire set of criteria, including their correlation and surgical applicability. In order to create a database for the femur that will aid in the design of future implants, we examined 09 crucial morphological parameters of the proximal human femur in the Indian population as part of the current study's analysis of proximal femoral morphology on computed tomography.We go into great detail on the clinical significance of these factors.

Orthopedic surgeons and engineers require a thorough knowledge for preoperative planning and to optimise prosthetic design due to the variation observed in femur morphology. The information offered in this study is applicable to numerous medical and biological research fields.

MATERIALS AND METHODS

Study settings: Patients undergoing hip surgeries and following up in Orthopaedics OPD with CT scan at the KLE's Dr. Prabhakar Kore Hospital and Medical Research Centre and Charitable Hospital, Belagavi.

Study Population: Patient undergoing hip surgeries were advised for CT scan and the normal side hip was measured.

Inclusion Criteria:

1. Skeletally mature patients (age group 20-95yrs) undergoing hip surgery for intertrochanteric fracture , neck of femur fracture , hip dislocation , acetabulum fracture.
2. Patients with osteoarthritis of hip.
3. Patients with osteonecrosis of femoral head.
4. Patients who gave informed consent to participate in the study

Exclusion Criteria:

1. Patients with hip deformity (DDH , Perthes disease , Functional coxa vara).
2. Patients with previous history of hip surgery & hip fracture.
3. Patient with present history of any hip infection.
4. Patient with neurological disorders of lower limb (post polio).

STUDY DESIGN: A hospital based Prospective Study.

STUDY PERIOD: One year [1st January 2021 to 31st December 2021]

SAMPLE SIZE: Sample size (Relative precision approach)

Based on Canal width 20mm below lesser trochanter parameter)

Standard Deviation = 1.99

Mean= 11.97

Relative Precision (%)= 5

Desired confidence level(%)= 99

Sample size (n)= 74

Formula

$$n = \frac{Z^2 S^2}{d^2}$$

Where, Z= Standard normal variate value (Z= 2.58 at 1% alpha error)

S= Sample standard deviation

d= Clinically acceptable error

Statistics

Descriptive statistics including min, max, range, mean and SD

METHODS:

In this study we are assessing the anthropometry of proximal femur geometry on CT scan of normal side in patients undergoing hip surgery- A one-year hospital based observational study.

PROCEDURE:

An observational study of 74 normal hips of fractured patients will be conducted with Computed Tomography scanning. The CT scans (128 slice GE Evo Revolution) will be collected with slice thickness of 1.25 millimeter and 512x512 pixels per image. The normal hips of fractured individuals to be CT scanned in supine position with 15degrees of internal rotation. Proximal femur segmentation to be acquired and each image to be obtained in Digital Imaging and Communications in Medicine (DICOM) format. The CT scan data will be then imported into self-development imaging software to outline cortical contour by using thresholding technique. Cortical bone and Cancellous bone will be segmented based on Hounsfield units(-37 to +1027 HU) described by Lamvohi et al.[27] which are the appropriate threshold value. They will be segmented for each CT slice, and a 3D model will be reconstructed using Advantage software Radiant DICOM viewer (Osirix) will be utilized to reconstruct the three-dimensional bony model via the cortical contours and subsequent geometric measurements will be noted. Surface smoothing of the 3D model will be achieved and the files were converted to Initial Graphic Exchange Specifications (IGES) files.

PARAMETERS TEMPLATED ON CT SCAN :-

Femoral head diameter

Femoral neck diameter

Horizontal offset

Vertical offset

Neck shaft angle

Canal width at a level 20mm above Lesser trochanter

Canal width at the midpoint of the Lesser trochanter

Canal width at a level 20mm below the Lesser trochanter

Canal width at a level 50mm below the Lesser trochanter

FEMORAL HEAD DIAMETER :-

The femoral head diameter is taken as the largest vertical diameter (superior-inferior) of head perpendicular to the axis of the neck of femur. The neck axis is drawn by drawing neck widths at 2 regions on the neck of femur, preferably in the trans-cervical and sub-capital region. The midpoints of these two lines are joined and extended further to form the axis of the neck. The Femoral head diameter is measured perpendicular to this line taking the largest superior-inferior diameter of the femoral head.

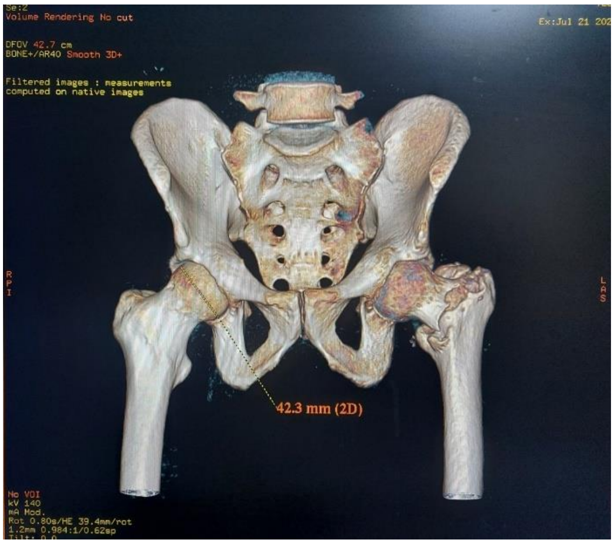


Fig 10 :- Femoral head diameter on 3D CT Scan.

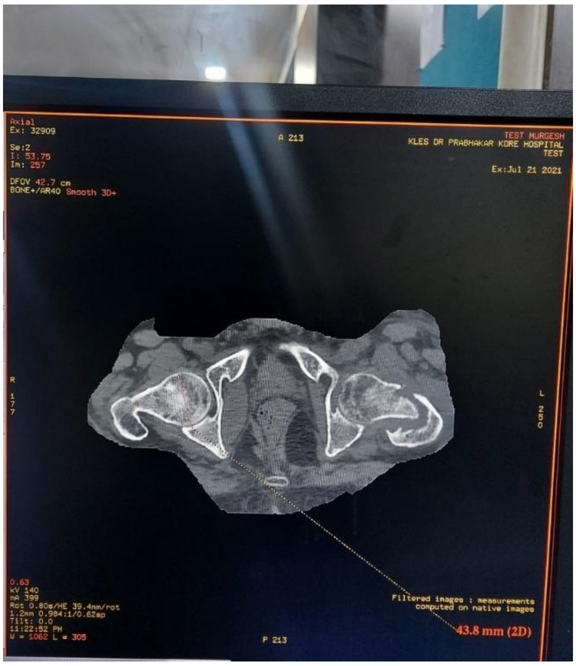


Fig 11 :-Femoral head diameter on axial cuts of CT scan.

FEMORAL NECK DIAMETER :-

FND was the distance in a straight line from upper end to the lower end of the anatomical neck of femur in cranio-caudal direction. The width of the narrowest part of the neck was measured.

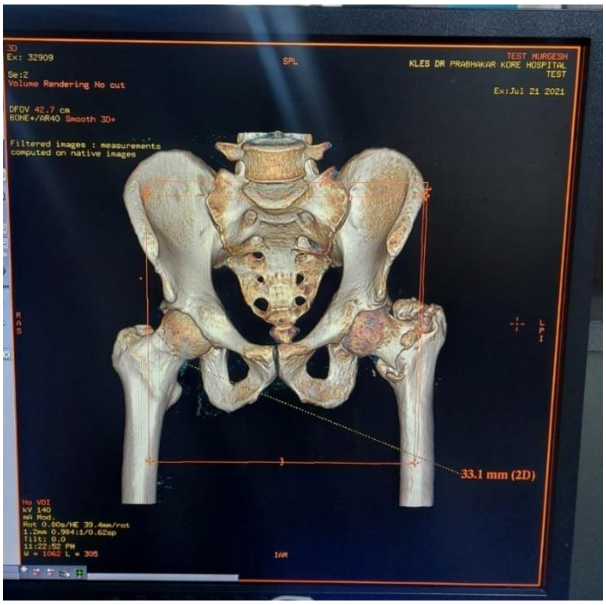


Fig 12 :-Femoral neck diameter on 3D CT scan

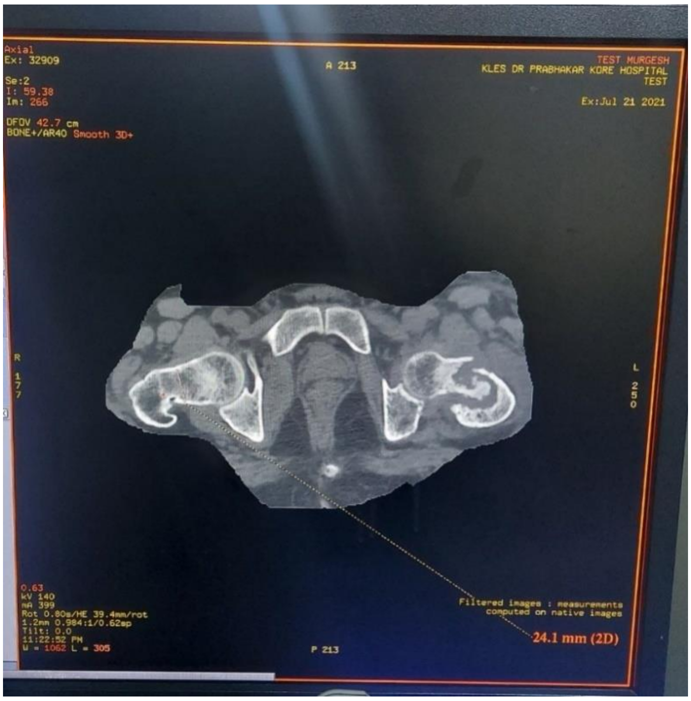


Fig 13: Femoral neck diameter on axial cuts CT Scan.

NECK SHAFT ANGLE :-

The center of head of femur was obtained using Image J Software by drawing a circle around the femoral head, its center was plotted. Then mid point of the neck was marked by measuring the width of the narrowest portion of the neck and dividing by two. The line from center of the head of femur through the center of the neck was drawn. A line through the centre of the diaphysis of the femur was drawn. These two lines intersected each other. The angle between the two was measured.

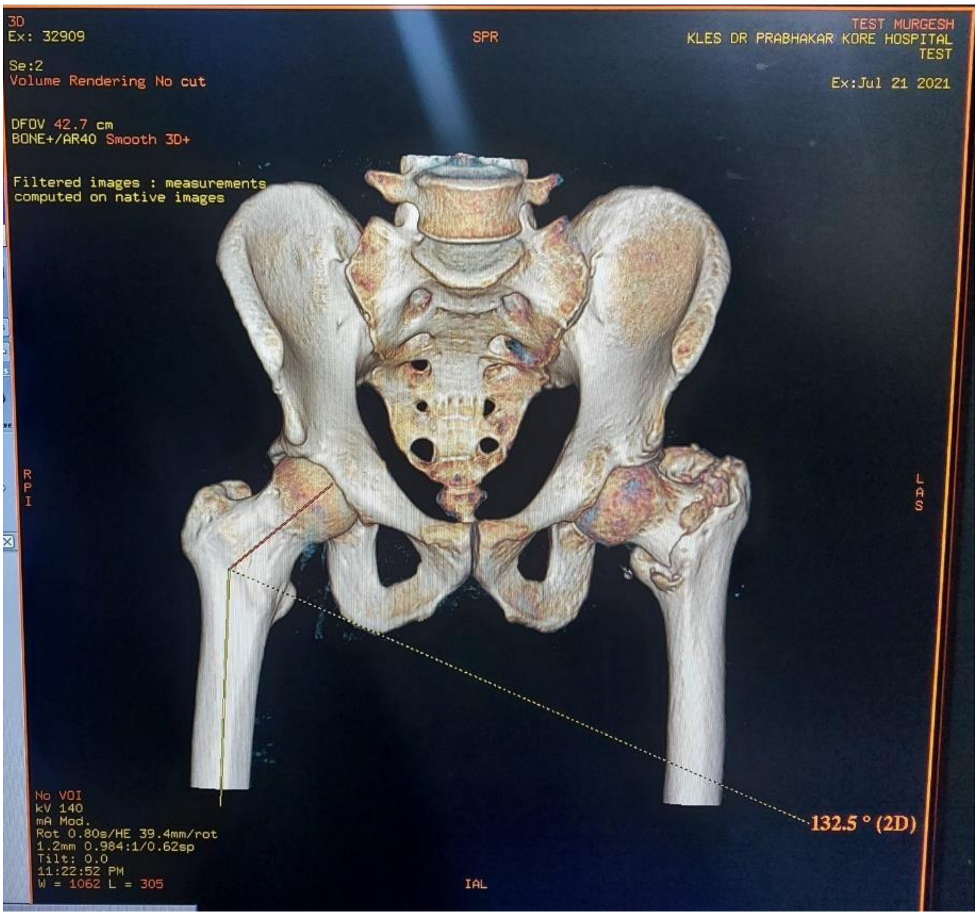


Fig 14: - Neck shaft angle on 3D CT scan.

HORIZONTAL OFFSET :-

Three anatomical points were marked. The center of the femoral head, the lesser trochanter and the tip of greater trochanter. The center of head of femur was obtained using Image J Software. Linear measurements, the FHO was the horizontal distance among the center of femoral head to the axis of femoral shaft.

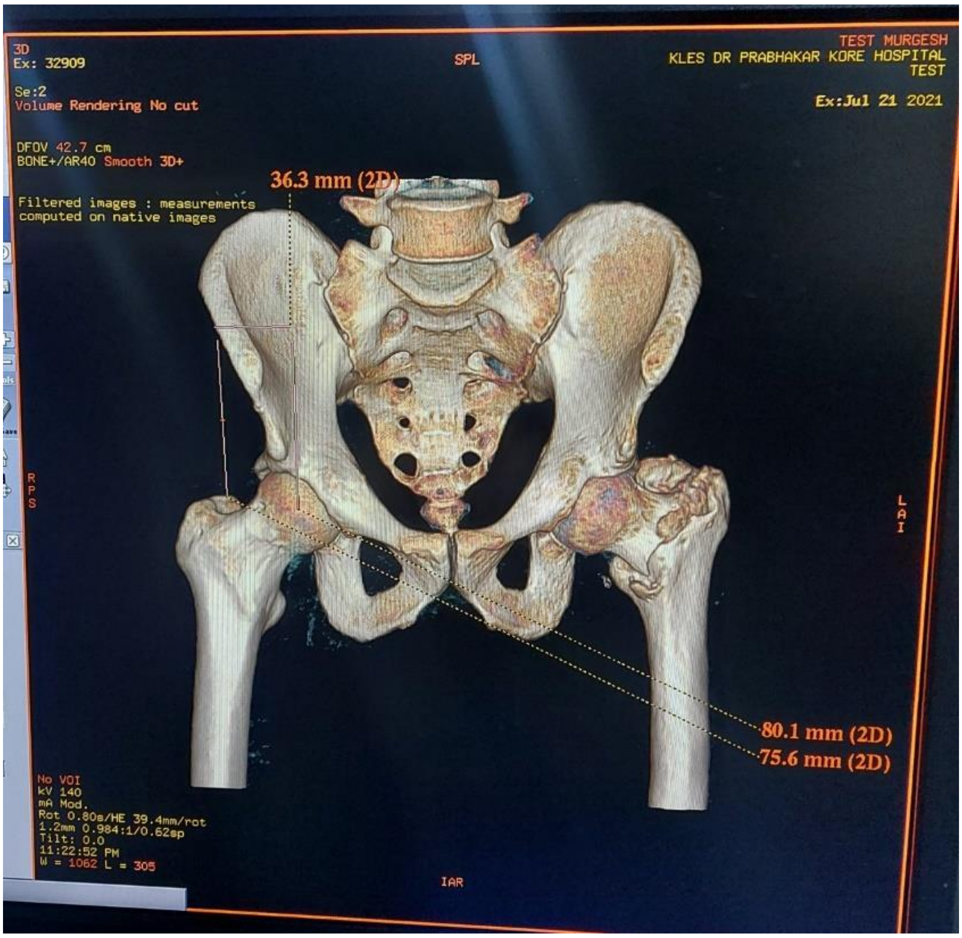


Fig 15:- Horizontal offset on 3D CT Scan

VERTICAL OFFSET:-

The vertical distance between proximal extent of lesser trochanter to the center of femoral head.

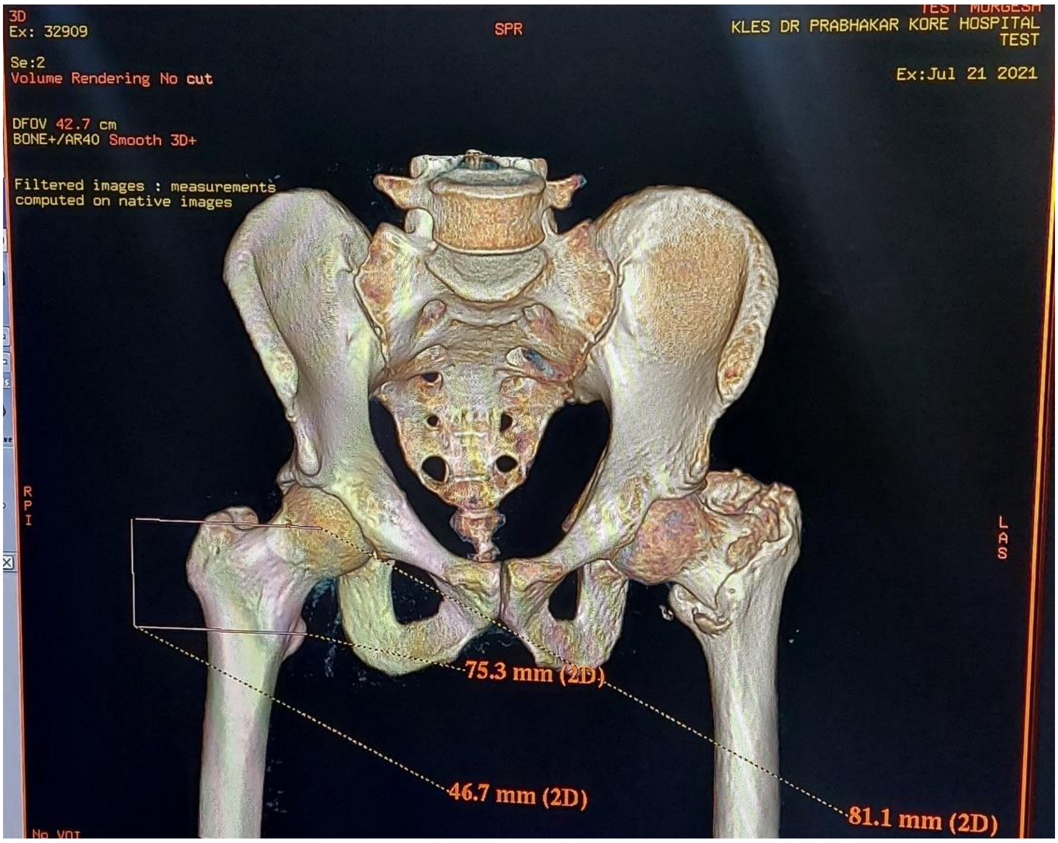


Fig 16 : - Vertical offset on 3D CT Scan

CANAL WIDTH 20MM ABOVE LESSER TROCHANTER:-

The measurement was done on axial cuts of CT scan. Two points were marked 20 mm above the lesser trochanter at maximum intracortical area and the distance between them was measured.

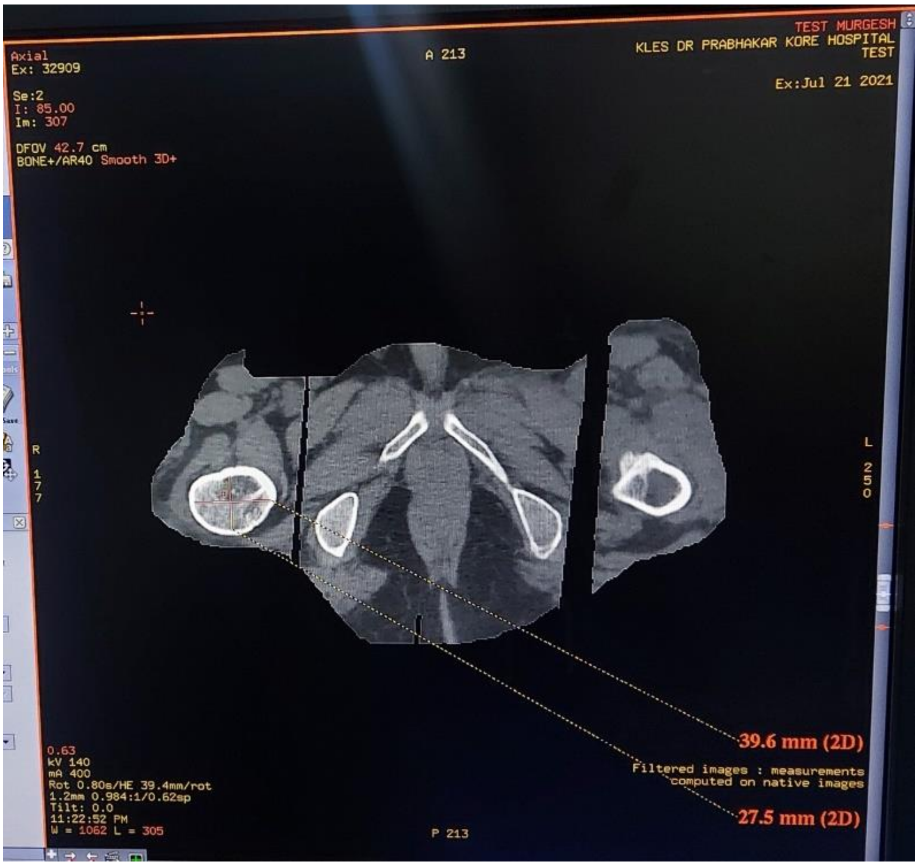


Fig 17 : - Canal width 20mm above L.T on axial cuts CT scan

CANAL WIDTH AT MID POINT OF LESSER TROCHANTER:-

Two points were marked at the level of lesser trochanter at maximum intracortical area and the distance between them was measured.

Fig 18 :- Canal width at mid point of L.T on axial cuts CT scan

CANAL WIDTH 20MM BELOW LESSER TROCHANTER:-

Two points were marked 20 mm below the lesser trochanter at maximum intracortical area and the distance between them was measured.

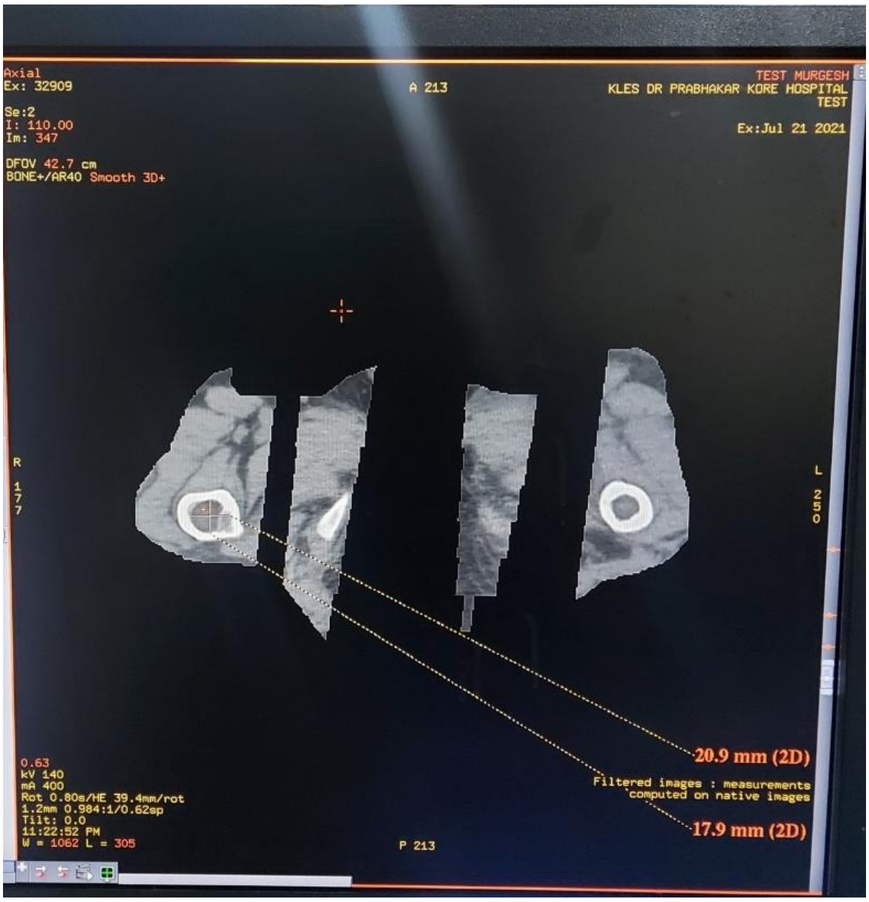


Fig 19 :- Canal width 20mm below L.T of axial cuts CT scan.

CANAL WIDTH 50MM BELOW LESSER TROCHANTER:-

Two points were marked 50 mm below the lesser trochanter at maximum intracortical area and the distance between them was measured.

Fig 20 :- Canal width 50mm below L.T on axial cuts CT scan.

Investigations:

All the patients underwent

1. C.T scan of hip joint with 3D reconstruction

Statistical Analysis:

SPSS 22 was used to analyse the data after it was loaded into a Microsoft Excel spreadsheet. Data in a categorical format was represented using frequencies and proportions. The Chi-square test will be used as a test of significance for qualitative data.

The continuous data were described using the mean and standard deviation. The independent t test or Mann Whitney U test were employed as statistical tests of significance to ascertain the mean difference between two quantitative variables and qualitative variables.

A p value (probability that the result is true) of 0.05 was determined to be statistically significant after applying all statistical principles.

Ethical consideration:

1. Institutional Ethical clearance was obtained prior to the start of the study
2. Informed consent was obtained from all the patients recruited prior to the start of the study
3. Standard of Care was provided to all the patients during the study period.

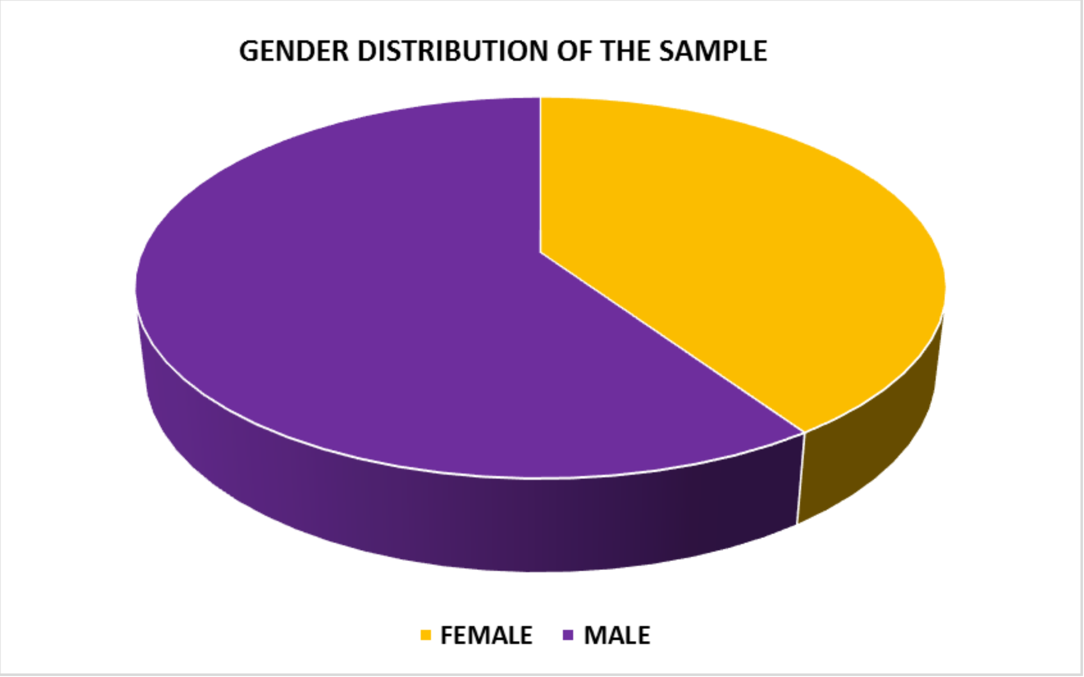
RESULTS

The aim of our study is to evaluate the anthropometry of proximal femur of Indian population in comparison with Western and Caucasian population. The total population that was CT scanned was 74 (n=74). There were 44 males and 30 females. The age of the participants were spaced from 20- 95 years age groups.

Values of mean, range, standard deviation of CT scan images of hip joints of Femoral head diameter (FHD), Femoral neck diameter (FND), Neck shaft angle (NSA), Horizontal offset (HO), Vertical offset (VO), Canal width at 20mm above L.T (lesser trochanter), Canal width at midpoint of L.T, Canal width at 20mm below L.T, Canal width at 50mm below L.T of Indian population and their comparison with Western and Caucasian population are shown in table.

GENDER	NUMBER	%
FEMALE	30	40.54
MALE	44	59.46
TOTAL	74	100.00

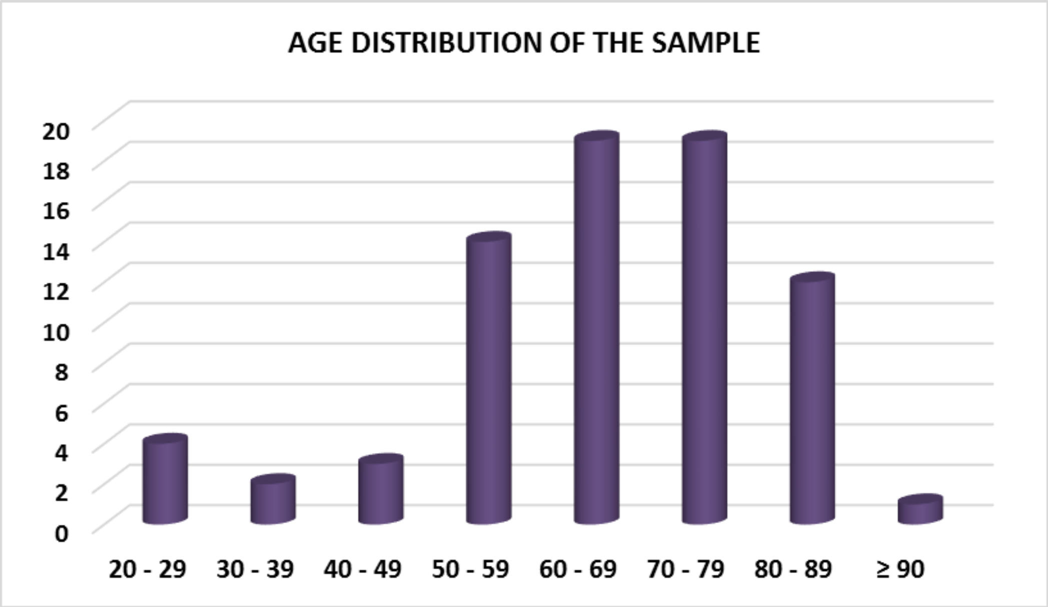
Table 1 – Gender distribution of the sample



Graph 1 :- Pie chart showing gender distribution of sample

AGE (YRS)	NUMBER	%
20 - 29	4	5.41
30 - 39	2	2.70
40 - 49	3	4.05
50 - 59	14	18.92
60 - 69	19	25.68
70 - 79	19	25.68
80 - 89	12	16.22
≥ 90	1	1.35
TOTAL	74	100.00

Table 2 :- Age distribution of the sample



Graph 2 : - Bar graph showing age distribution of the sample.

	MEAN	S.D.	MIN	MAX
HORIZONTAL OFFSET	43.43	8.08	29.5	59.1
VERTICAL OFFSET	49.24	8.97	34.7	72.5
FEMORAL HEAD DIAMETER	43.36	3.90	32.6	50.6
NECK DIAMETER	29.47	3.45	18.7	36.7
NECK SHAFT ANGLE	123.40	2.45	119.3	135

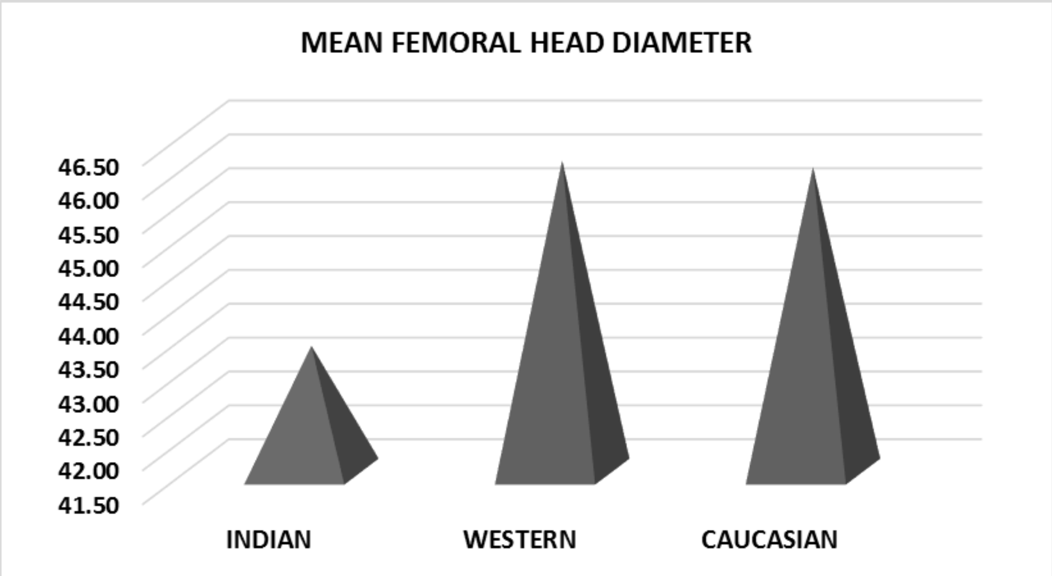
Table 3 :-Mean and standard deviation of Horizontal offset , Vertical offset , Femoral head diameter , Neck diameter , Neck shaft angle .

	INDIAN	WESTERN	CAUCASIAN
Femoral head diameter	43.36	46.1	46
Neck diameter	29.47	-	33
Neck shaft angle	123.40°	124.7°	136°

Table 4 :-Comparision of Femoral head diameter , Neck diameter and Neck shaft angle between Indian , Western and Caucasian Population.

INDIAN	WESTERN	CAUCASIAN
43.36	46.1	46

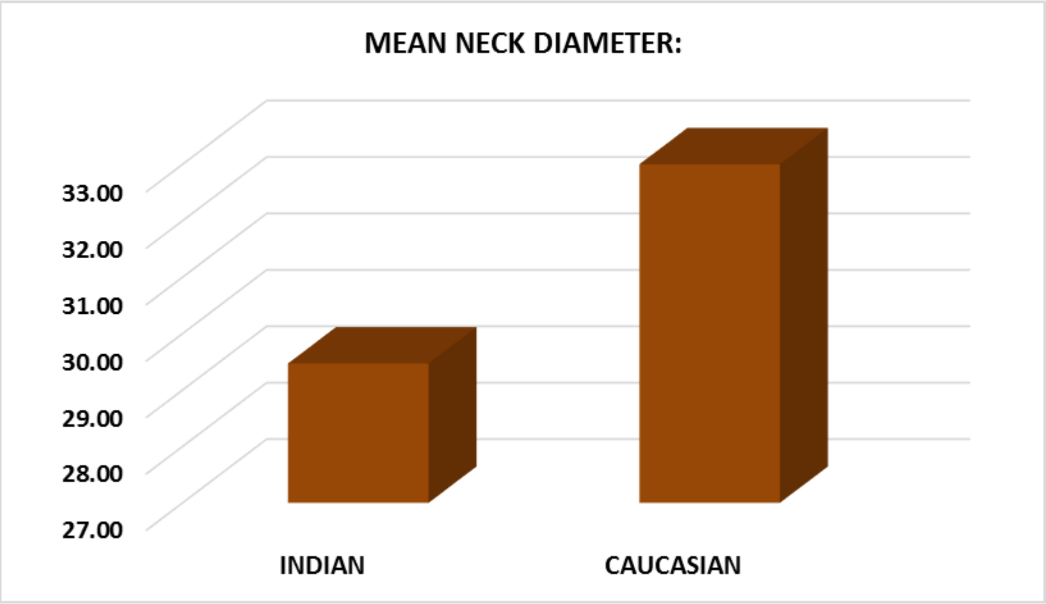
Table 5 : - Femoral head diameter of Indian Population and comparison with Western and Caucasian Population.



Graph 3 :- Bar graph showing comparison of Mean Femoral Head Diameter of Indian Population with Western and Caucasian Population.

INDIAN	WESTERN	CAUCASIAN
29.47	--	33

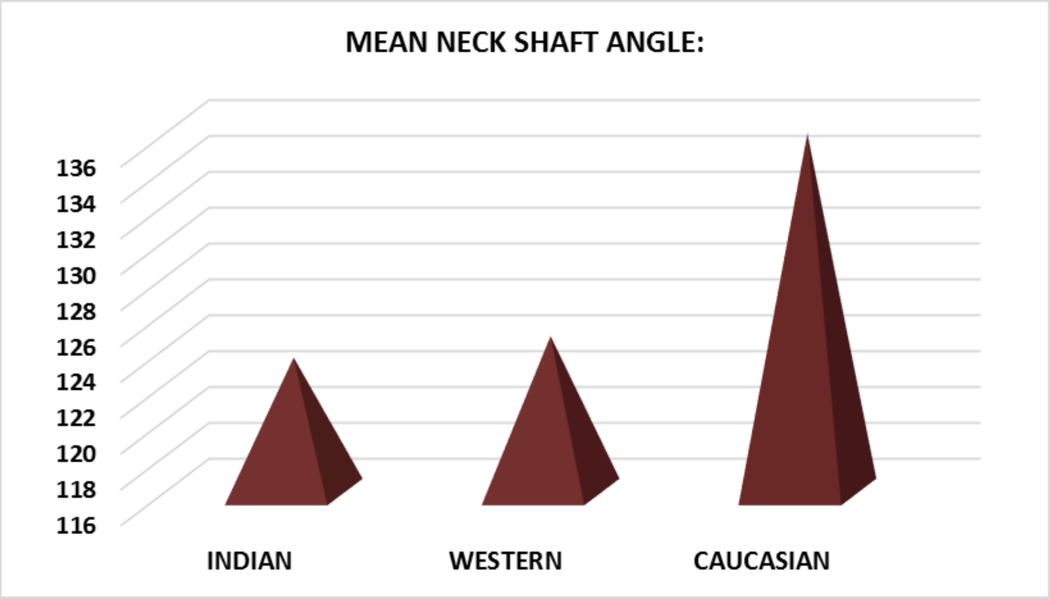
Table 6 :- Femoral Neck Diameter of Indian Population and its comparison with Western and Caucasian Population



Graph 4 :- Bar graph showing comparison of Mean Femoral neck diameter between Indian population and Caucasian population.

INDIAN	WESTERN	CAUCASIAN
123.5	124.7	136

Table 7 :- Mean neck shaft angle of Indian Population and comparison with Western and Caucasian Population.



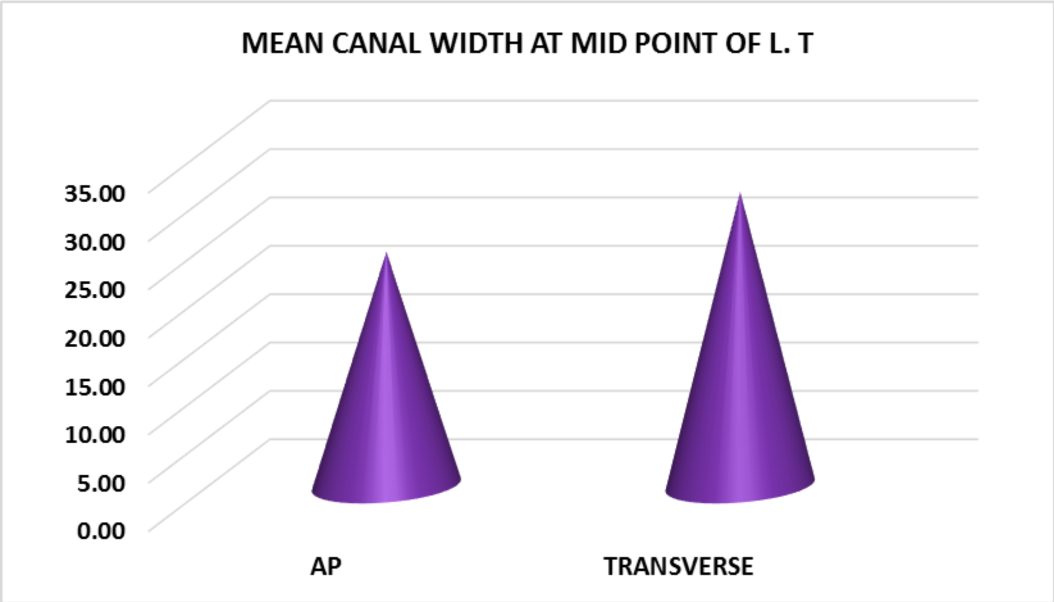
Graph 5:- Bar graph showing Mean neck shaft angle of Indian Population and comparison with Western and Caucasian Population.

IN THE FOLLOWING TABLES p VALUE IS CALCULATED USING STUDENT'S UNPAIRED t TEST

ABBREVIATIONS: NS -NOT SIGNIFICANT S - SIGNIFICANT VS - VERY SIGNIFICANT HS - HIGHLY SIGNIFICANT

AT MID POINT OF L.T									
AP				TRANSVERSE					
MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
22.12	4.00	12.8	32.5	24.33	6.94	11.3	39.6	0.0192	S

Table 8 :- Mean and standard deviation of AP and transverse canal width at mid point of L.T. Canal width at mid point of L.T of Indian femur as compared to Western is statistically significant (p value is <0.05).

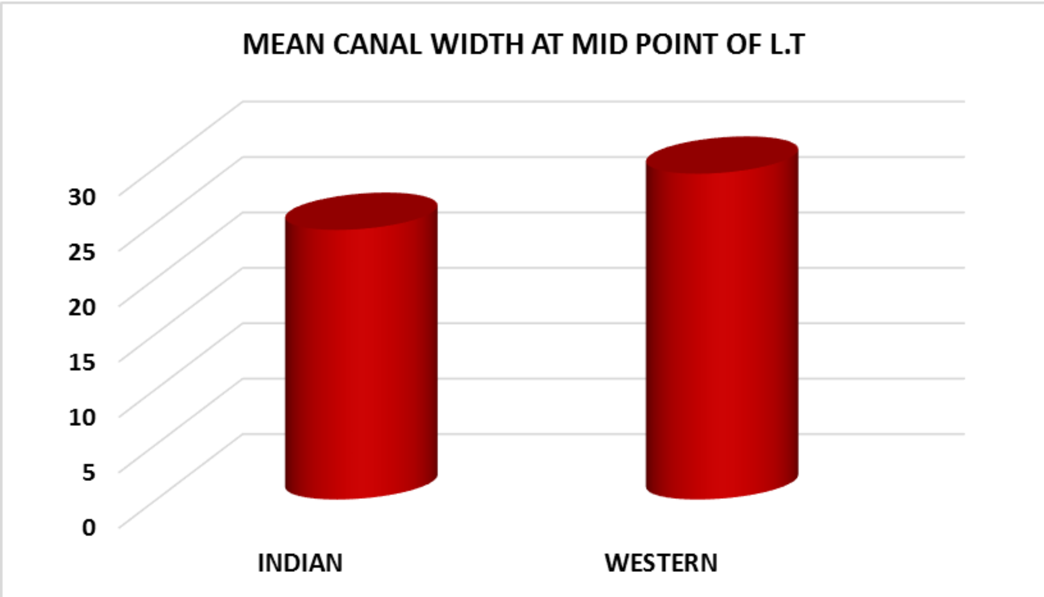


Graph 6 :- Bar graph showing Mean canal width (both AP and Transverse) at midpoint of L.T

COMPARISON BETWEEN INDIAN AND WESTERN POPULATIONS:

INDIAN	WESTERN
24.33	29.4

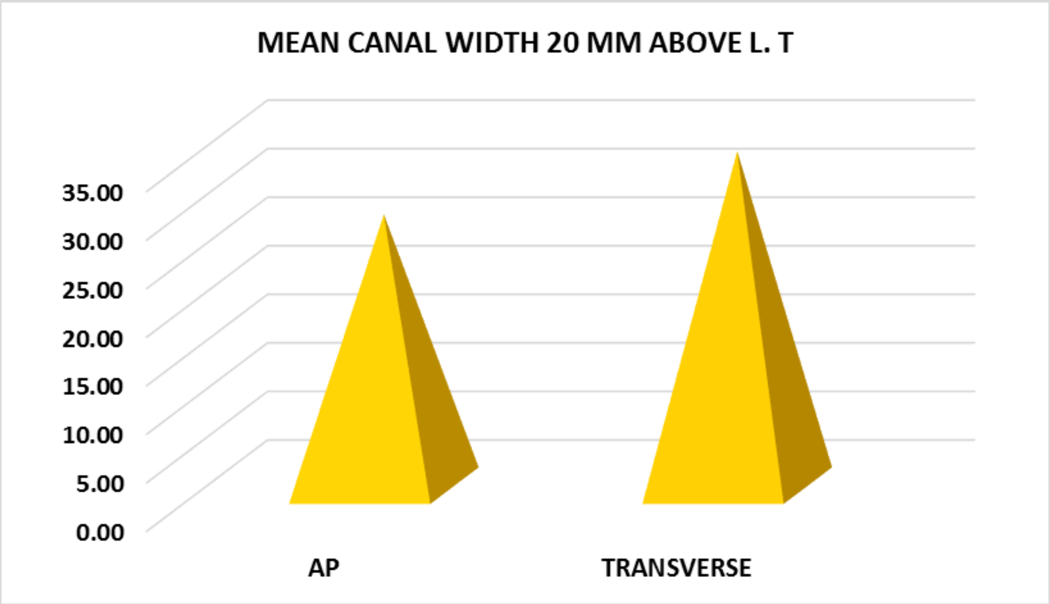
Table 9 :- Mean canal width (Transverse) at midpoint of L.T comparison between Indian and Western Population



Graph 7:-Bar graph showing Mean Canal Width(Transverse) at mid point of L.T of Indian Population and comparison with Western Population.

	AT 20 MM ABOVE L.T								
AP				TRANSVERSE					
MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
37.94	4.55	27.6	51.1	44.45	5.05	32.3	56.1	<0.0001	HS

Table 10 : - Mean and standard deviation of AP and transverse canal width at 20mm above L.T. Canal width at 20mm above L.T of Indian femur as compared to Western is statistically highly significant (p value is <0.05).

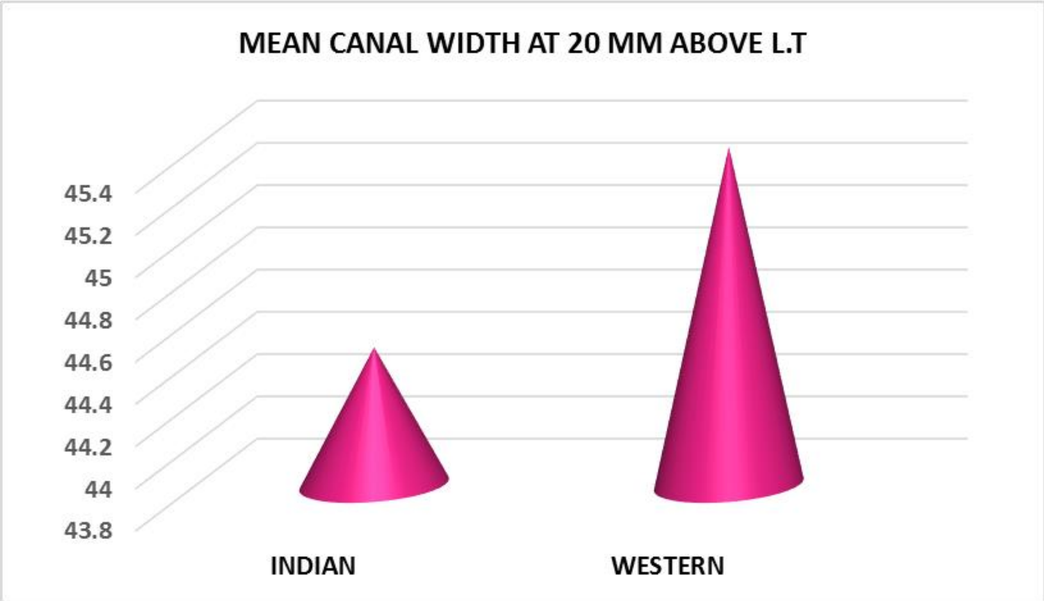


Graph 8: - Bar graph showing Mean Canal Width(Transverse) at 20mm above L.T of Indian Population and comparison with Western Population.

COMPARISON BETWEEN INDIAN AND WESTERN POPULATIONS:

INDIAN	WESTERN
44.45	45.4

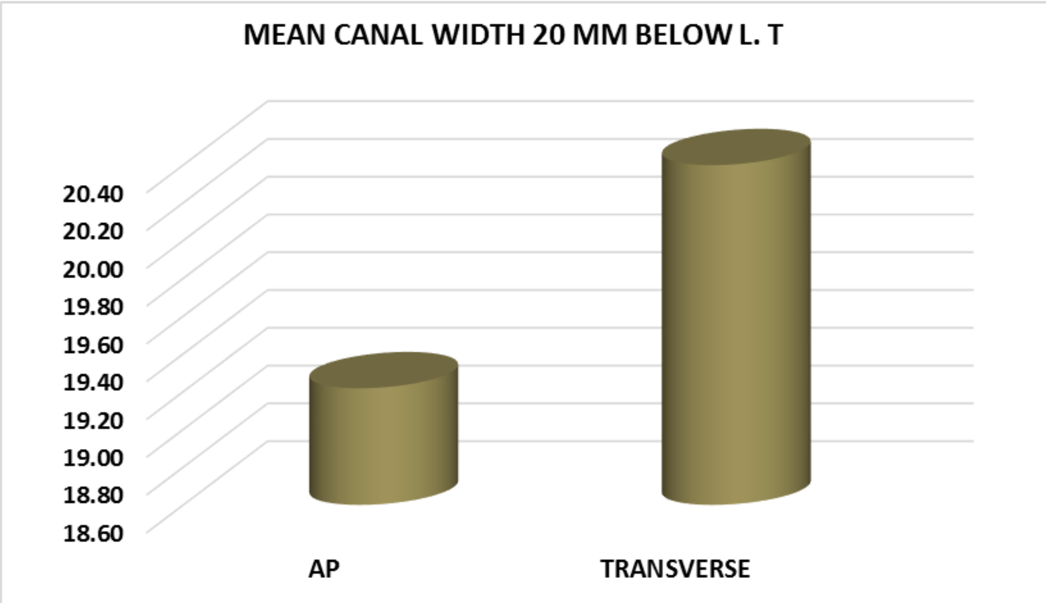
Table 11 :- Mean canal width (Transverse) comparison between Indian and Western Population



Graph 9 :- Bar graph showing Mean Canal Width(Transverse) at 20mm above L.T of Indian Population and comparison with Western Population.

	AT 20 MM BELOW L.T								
	AP			TRANSVERSE					
MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
16.22	3.40	8.4	25.7	17.40	4.86	9.3	28.3	0.0888	NS

Table 12 : - Mean and standard deviation of AP and transverse canal width at 20mm below L.T. Canal width at 20mm below L.T of Indian femur as compared to Western is statistically not significant (p value is >0.05).

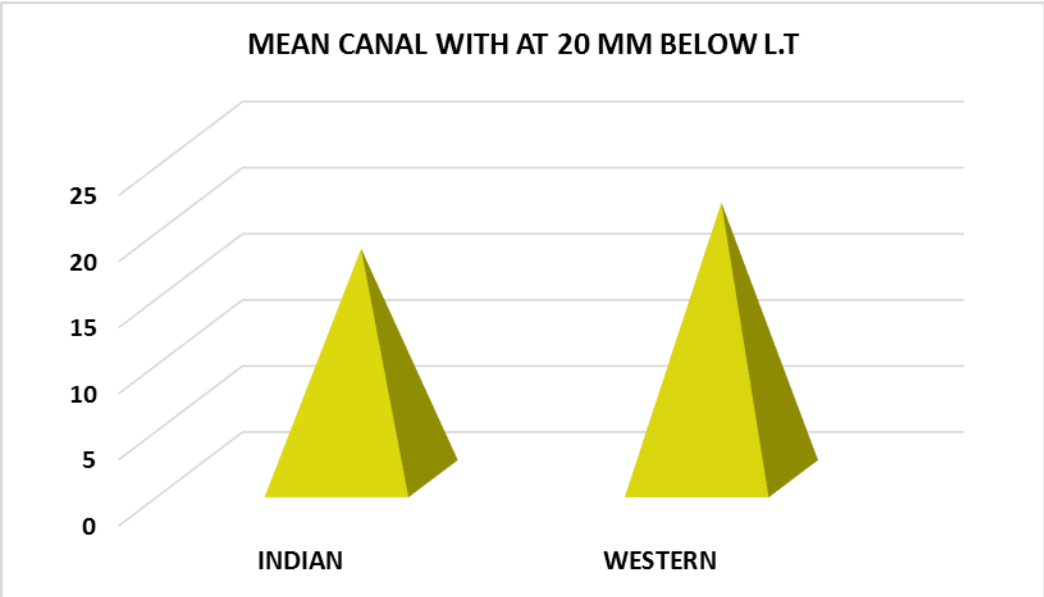


Graph 10 :- Bar graph showing Mean Canal Width(Transverse) at 20mm below L.T of Indian Population and comparison with Western Population.

COMPARISON BETWEEN INDIAN AND WESTERN POPULATIONS:

INDIAN	WESTERN
17.4	20.9

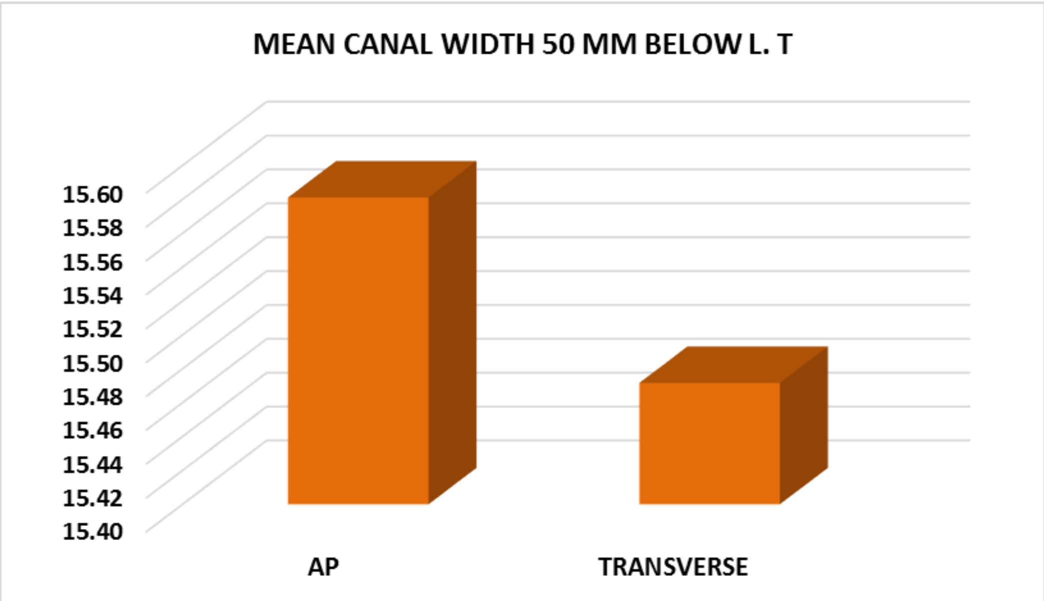
Table 13 : - Mean canal width (Transverse) 20mm below L.T. comparison between Indian and Western Population.



Graph 11 :- Bar graph showing Mean Canal Width(Transverse) at 20mm below L.T of Indian Population and comparison with Western Population.

AT 50 MM BELOW L.T									
AP				TRANSVERSE					
MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
15.58	2.43	11.2	24.6	15.47	2.87	11.2	22.6	0.8026	NS

Table 14 :- Mean and standard deviation of AP and transverse canal width at 50mm below L.T. Canal width at 50mm below L.T of Indian femur as compared to Western is statistically not significant (p value is >0.05).



Graph 12: - Bar graph showing comparison of both AP and Transverse Canal width at 50mm below L.T .

DISCUSSION

Annually, more than 80,000 artificial hip joints are replaced[12]. Human stature varies by place, hence it is important to tailor prostheses to the needs of the local population. Reddy et al. pointed out that a mismatch between the femoral bone and stem may unquestionably cause micromotion, which can cause osteolysis, aseptic loosening, and thigh pain[13]. The femur can fracture if the implant is too large, therefore undersizing is typically done for safety, although an extremely small implant may not bind with bone[14].

For the purpose of obtaining and analysing the three-dimensional inner and outer geometry of the proximal cadaveric femur, Mahaisavariya B et al. combined CT imaging with the reverse engineering technique[7]. Deshmukh TR et al. used a mathematical approach to study the geometry of the femur in the Vidarbha (central) region of India[15].

A strong correlation was found between the values determined by mathematical models and the anthropometric measurements. Indian cadaveric femur characteristics were compared to those of the western, Chinese, and Hong Kong populations by Siwach RC and Dahiya S[16].

Ho Jung Cho et al. also noted that Korean participants' femurs differed anatomically from those of Americans and Japanese subjects[17]. He suggested creating a unique hip replacement system specifically for Asian people. With the help of the Auto CAD 200 software, De Sousa E et al. also assessed the proximal femur characteristics in the Brazilian population and contrasted their findings with those of other research conducted in other areas[11].

Numerous investigations on the proximal femur's characteristics have been done in Asian nations, including ones on the Malay and Chinese populations[19,20].

El-Kaissai et al. hypothesised in a retrospective analysis that Caucasian postmenopausal women with hip fractures have a longer femoral neck than women without fractures. Every millimetre that the femoral neck's thickness increased, the chance of a hip fracture rose by 24%[23]. Similar findings were made in Turkish women by Calis et al., who found that patients with hip fractures had considerably wider femoral necks and angles[24]. Age-related increases in male neck thickness can contribute to osteoarthritis development in men by worsening cam impingement[25].

By comparing the results of our current study with results from measurements made in different ethnic communities in the past, we were able to determine how ethnic variances in the proximal femur's anthropometry were existent. We used the proximal femoral anthropometry values from the Noble P.C. et al.[19] (n-200) study on the Caucasian population for the comparison. This study was significant because it provided the dimensions needed to develop the different somatotypes for the cemented and un-cemented replacement armamentarium. The study has given us the means to replace the implant while also allowing the implant to fit into the mass of the femora.

In the current study, the average femoral head diameter was 43.36± 8.08mm, the average neck diameter was 29.47 ±3.45mm, the average neck shaft angle was 123.40 ±2.45mm, the average horizontal offset was 43.43 ±8.08mm, and the average vertical offset was 49.24 ±8.97. The average canal width at mid-point of L.T was 22.12 ±4.00mm, the average canal width 20 mm above L.T was 37.94±4.55mm , canal width 20mm below L.T was 16.22±3.40mm and canal width 50mm below L.T was 15.58±2.43.

FEMORAL HEAD DIAMETERS:-

We measured the variation in femoral head sizes among diverse ethnic groups. According to the current study, the average femoral head diameter in the Indian population is 43.36±4.5mm. When compared to the Malay population, the mean femoral head diameter for Indians was 40.81± 3.43 mm. Baharuddinet al.[20]. Femoral head diameters were discovered to be the shortest in the Malay population. When compared to the Thai population, the current study's mean femoral head diameter was 43.98±3.47mm. Mahasavariyaet al.[49]. When compared to the Swiss population, the current study's mean femoral head diameter was 43.40± 2.26 mm. Rubinet al.[21].The French population had bigger mean femoral head sizes 45.60± 4.20 mm than the Indian population when the mean femoral head diameters of the two populations were compared. Massinet al.[48].

NECK SHAFT ANGLE:-

In this study of Indians, the mean Neck shaft angle was determined to be 123.4 degrees.The verge neck shaft angle of the Indian and Japanese populations was examined. Compared to the Indian population, the Japanese population had a mean neck shaft angle of 137 degrees and an average valgus femoral angulation. Bo et al.[41].The neck shaft angle of the Malay and Indian populations was examined. The Malay population's average neck shaft angle was 130 degrees. When compared to the Indian group in the current study, there was a minor tendency towards valgus mean femoral angulation in the Malay community. Baharuddin et al.[20]

The mean neck shaft angle of Indian population which is 123.4 degrees is less than that of Caucasian population which is 136 degrees respectively.Noble P.C et al.[19].

OFFSET:-

In the Indian population, the average offset was 43.43mm±8.08.

The Malay population's offset values were compared to the Indian population's offset values, which were 31.50± 5mm. Baharuddin et al.[20] discovered that the offset of the Malay population was substantially lower than the Indian population.

Indian population offset data were compared to Japanese population offset values, which were 30.45 ±4.26mm. Bo et al.[41] discovered that the Indian population's offset was much higher than that of the Japanese population.

The French population, which had a mean offset of 41± 6.20mm, was compared with the offset of the Indian population. The French population offset was not statistically different from the Indian population because it was similar. Massinet al.[48].

The Swiss population, whose mean offset was the highest among the studied ethnic groups at 47mm ±7.2, was compared to the offset of the Indian population. The Indian population's mean offset was 4.25mm less than that of the Swiss population. This is most likely related to the larger size of the femur bone in the population of Europe. Rubin et al.

The offset of the Indian and Caucasian populations, 43 +/-6.8 mm, does not significantly differ from one another. Noble PC et al.[19].

CANAL DIAMETERS:-

At four reference levels, the population mean endosteal dimensions were measured and compared across distinct groups.

For the Indian population, the mean femoral canal diameter for the four reference levels was Endosteal diameter is 37.94 +/-4.55mm and is located 20 mm above the lesser trochanter. At the lesser trochanter's level midpoint, the endosteal diameter is 22.12 +/- 4.0 mm.20 mm below the lesser trochanter, the endosteal diameter is 16.22 +/- 3.40 mm. The endosteal diameter is 15.58 +/-2.43 mm, 50 mm below the lesser trochanter Canal width at mid point of L.T of Indian femur as compared to Western is statistically significant (p value is <0.05).

Canal width at 20mm above L.T of Indian femur as compared to Western is statistically highly significant (p value is <0.05).

Canal width at 20mm below L.T of Indian femur as compared to Western is statistically not significant (p value is >0.05).

Canal width at 50mm below L.T of Indian femur as compared to Western is statistically not significant (p value is >0.05).

When Indian femora were matched with the Swiss population, there was no statistically significant difference in the mean canal diameters at the four reference levels, showing a close approximation in endosteal dimensions. Rubin et al.[21].

The endosteal diameters of the Indian population (the subject of the current study) and the French population did not differ statistically significantly. Massinet al.[48].

At all four reference levels, the endosteal widths of Indian femora were 2.0 mm narrower than those of Caucasian femora, a difference that was statistically significant (P 0.05).

CONCLUSION

- In our study the comparison of average measurements in male and female femur. The male femur had larger dimensions in all the anthropometric parameters.
- Significant anthropometric difference exists in the anthropometry of proximal femur between various ethnic populations.
- The Asian and Indian femur bone is of much smaller sizes in comparison to European femurs.
- In summary all current implants have to be revised on population basi to fit the changing anthropometry of our proximal femur.
- This study may offer a data base for surgeons and manufacturers who deal with proximal femoral bone surgery.

SUMMARY

A hospital based Prospective Study was conducted among 74 Patients undergoing hip surgeries in Department of Orthopaedics at the KLE's Dr. Prabhakar Kore Hospital and Medical Research Centre and Charitable Hospital, Belagavi for a period of One year [1st January 2021 to 31st December 2021]. An observational study of 74 normal hips (n=74) of fractured patients was conducted with Computed Tomography scanning. The age of the participants were spaced from 20- 95years age groups.

The Following observations were made in the study:

1. According to the current study, the average femoral head diameter in the Indian population is 43.36 ±4.5mm. When compared to the Malay population, the mean femoral head diameter for Indians was 40.81± 3.43 mm. Baharuddin et al.[20].
2. The mean Neck shaft angle was determined to be 123.4 degrees. The mean neck shaft angle of Indian population which is 123.4 degrees is less than that of Caucasian population which is 136 degrees respectively. Noble P.C et al.[19].
3. In the Indian population, the average offset was 43.43 ±8.08mm.The Malay population's offset values were compared to the Indian population's offset values, which were 31.50± 5mm. Baharuddin et al.[20] discovered that the offset of the Malay population was substantially lower than the Indian population.Indian population offset data were compared to Japanese population offset values, which were 30.45 ±4.26. Bo et al.[41] discovered that the Indian population's offset was much higher than that of the Japanese population.
4. At four reference levels, the population mean endosteal dimensions were measured and compared across distinct groups.
5. For the Indian population, the mean femoral canal diameter for the four reference levels was
6. Endosteal diameter is 37.94 +/-4.55mm and is located 20 mm above the lesser trochanter.
7. At the lesser trochanter's level midpoint, the endosteal diameter is 22.12 +/- 4.0 mm.
8. 20 mm below the lesser trochanter, the endosteal diameter is 16.22 +/- 3.40 mm.
9. The endosteal diameter is 15.58 +/-2.43 mm, 50 mm below the lesser trochanter.
10. Canal width at mid point of L.T of Indian femur as compared to Western is

statistically significant (p value is <0.05).

11. Canal width at 20mm above L.T of Indian femur as compared to Western is statistically highly significant (p value is <0.05).

LIMITATION OF STUDY

The CT scans of the majority of patients from different parts of India who were involved in this study were obtained from the same region (the Belagavi region), it would be wiser to conduct a multicenter study to compare between different regions in India and to yield a more logical standards of the proximal femoral geometry features.

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INFORMED CONSENT

TITLE OF THE STUDY: "ANTHROPOMETRIC STUDY OF PROXIMAL FEMUR GEOMETRY USING COMPUTED TOMOGRAPHY (CT) SCAN IN PATIENTS UNDERGOING HIP SURGERY"

PRINCIPAL INVESTIGATOR**:** Dr. DEVANSHU PATHAK

GUIDE: Dr. SOMANATH .T. SANIKOP

INTRODUCTION AND PURPOSE:

Proximal hip surgeries including trauma and hip arthroplasty procedures have been increased tremendously in the last 10 years all over the world. More than 2,50,000 hip fractures occur annually in the united states and this number will double within the next 30 years. Proximal femoral fractures most of the time require surgery. For a good proximal femoral surgery, Computed Tomography can be used for pre-operative planning to match the pre-planned internal fixation devices (DYNAMIC HIP SCREW AND PROXIMAL FEMORAL NAIL) and prosthesis with that of proximal femoral geometry in order to restore the normal hip biomechanics.

Due to wide variation in anatomy of femoral prosthesis it is difficult to achieve precise bone implant fit. Asians have a smaller distal femur size than that of western population. But maximum artificial femoral prosthesis are standardized and manufactured in European and North-American region and currently available western orthopaedic implants do not match the dimensions of proximal femur of Indian population.

The uses of these over-sized and unsuitable implant affect outcome of the surgery reported with problems such as stress shielding, micro-motion and aseptic loosening. These all will lead to great patient discomfort. As a result of this fact, a consensus has been reached among many surgeons that close adaptation of prosthesis and internal fixation implants to the proximal femoral bone geometry is necessary to achieve an optimal primary stability and secondary biologic fixation.

Different ethnic populations have different femoral configurations. There are also major differences between both genders. Different ethnic populations and different genders all need different types of orthopedic femoral implant designs. The aim of this study is to provide a database for surgeons and manufacturers regarding the proximal femoral geometry for the Indian population by means of Computerized Tomographic evaluation. Many studies have been conducted using Computerized Tomography and Radiography on dry bone on the proximal femoral geometry showed substantial variations in these parameters among populations of different geographical regions.

Noble et al. demonstrated the presence of both endosteal and periosteal variation, and the need for multiple stem designs to achieve close fit. Nelson and Megyesi studies sex and ethnic differences in bone architecture and therefore established the need for developing gender specific implants. Females may need more smaller femoral designs.

The purpose of the study is to evaluate the **Anthropometry of proximal femur geometry using Computed Tomography(CT) scan in patients undergoing hip surgery-** A One Year Hospital Based Prospective Study" in Orthopaedic department of KLE'S Dr.Prabhakar Kore Hospital and Medical Research Centre and Charitable Hospital, Belagavi from 1st January 2021 to 31st December 2021.

VOLUNTARY PARTICIPATION / WITHDRAWAL:

Taking part in this study is voluntary. I may choose not to take part in this study, or if I decide to take part I can later change my mind and withdraw from the study. My decision will not change the present or future health care or other services that I receive. The investigator or the sponsor may stop my participation in this study. I will tell of any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study, I will receive the standard treatment for patients with my condition.

COMPENSATION:

As the subject voluntarily consents to be a part of the study, no compensation will be given.

CONFIDENTIALITY:

All information collected about the subject during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify the subject in this research record. Information from this study may be presented but the subjects identify will be confidential in any publication.

If any enquiries in the future or in case of study related injury or illness, you may contact following person:

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If any enquiries in the future or in case of study related injury or illness, you may contact following person:

DR. HARSHA HEGDE,
Chairperson,
JNMC, IEC & Scientist D,
ICMR, National Institute of Traditional Medicine,
Belagavi.

CONSENT TO PARTICIPATE IN RESEARCH STUDY

"I voluntarily agree to take part in this study by signing below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicated that I have read this entire consent form or it has been read to me, and had all my questions answered. I will be given a copy of this consent form."

Signature of the Participant or legally authorized representative

Participant's Name: …………………

Signature: …………………

Name of legally authorized representative: ………………..

Signature: ……………….

Witness's Name:

Signature: ………………..

Investigators Name and Signature: ……………….

Date and Place: ………………

.

PROFORMA

“ANTHROPOMETRIC STUDY OF PROXIMAL FEMUR GEOMETRY USING COMPUTED TOMOGRAPHY (CT) SCAN IN PATIENTS UNDERGOING HIP SURGERY”

PATIENT.NO IP.NO.

CT SCAN NO. CT SCAN DATE.

NAME:

AGE: SEX:

ADDRESS:

OCCUPATION:

DOA: DOS: DOD:

CT SCAN MEASUREMENTS	RIGHT	LEFT
1. FEMORAL HEAD DIAMETER		
2.FEMORAL NECK DIAMETER		
3. NECK SHAFT ANGLE		
4.HORIZONTAL OFFSET		
5.VERTICAL OFFSET		
6.CANAL WIDTH AT MID POINT OF		

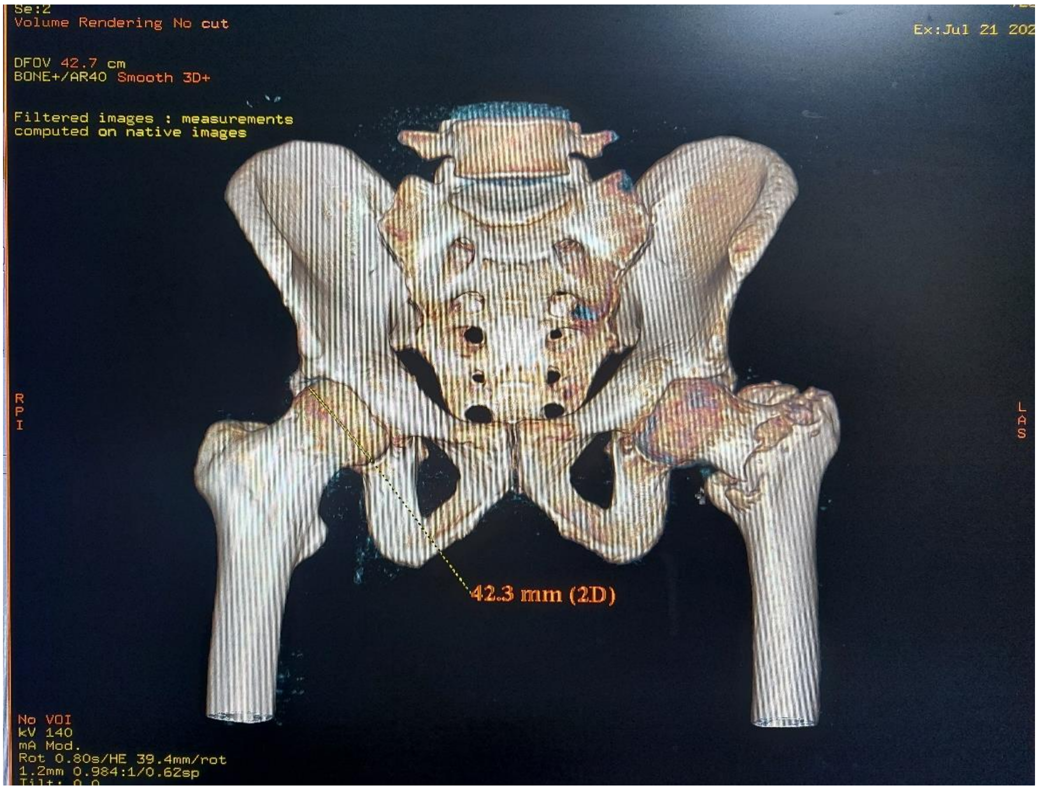
L.T		
7.CANAL WIDTH AT 20MM ABOVE L.T		
7.CANAL WIDTH AT 20MM BELOW L.T		
8.CANAL WIDTH AT 50MM BELOW L.T		

PHOTOGRAPHS

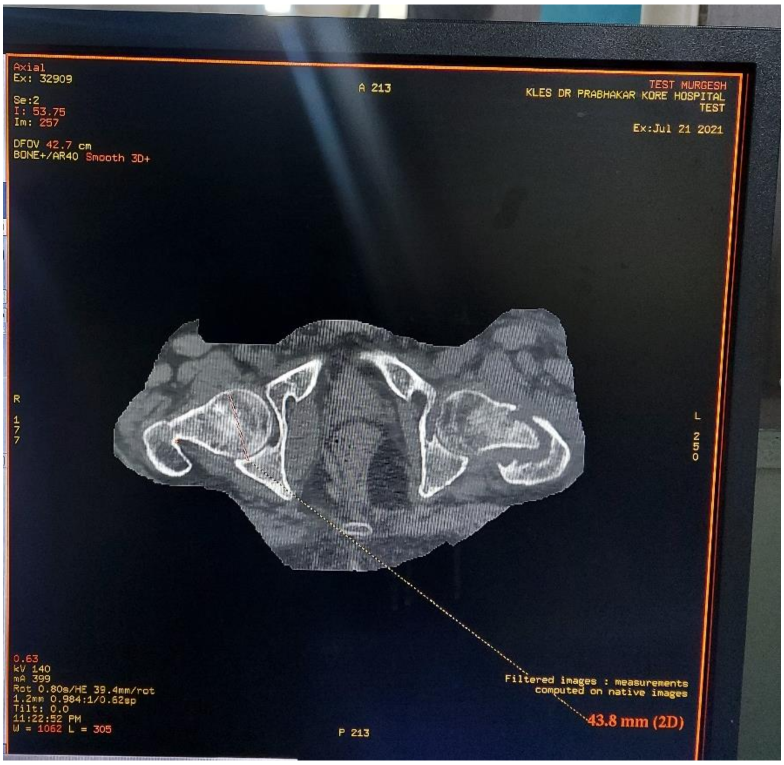
PHOTOGRAPH 1 : CT SCAN MACHINE(128 slice GE Evo Revolution)

PHOTOGRAPH 2 : PATIENT WITH HIP FRACTURE UNDERGOING CT SCAN

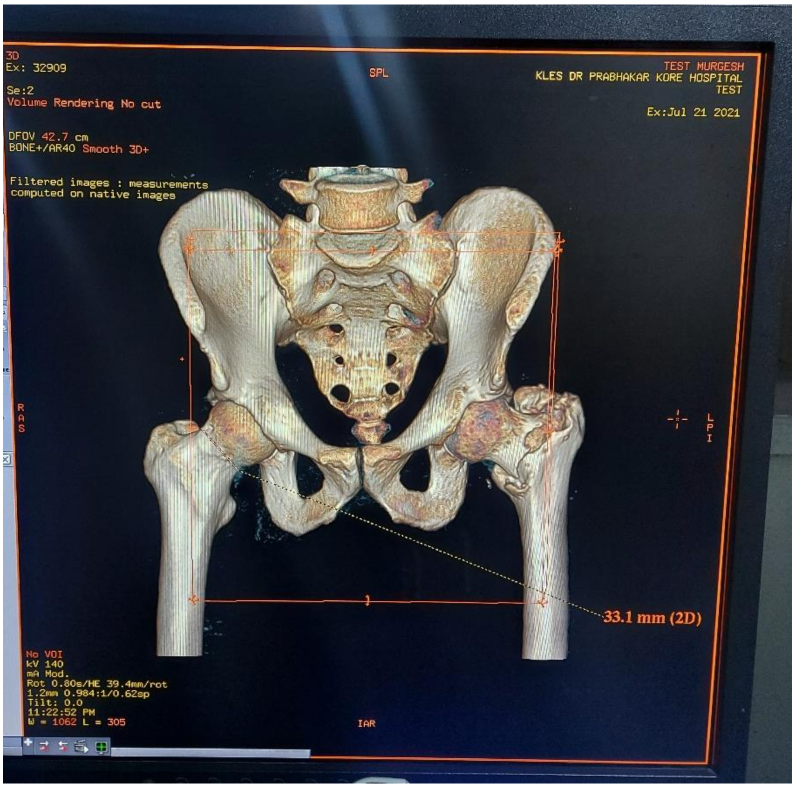
SAMPLE CASE :



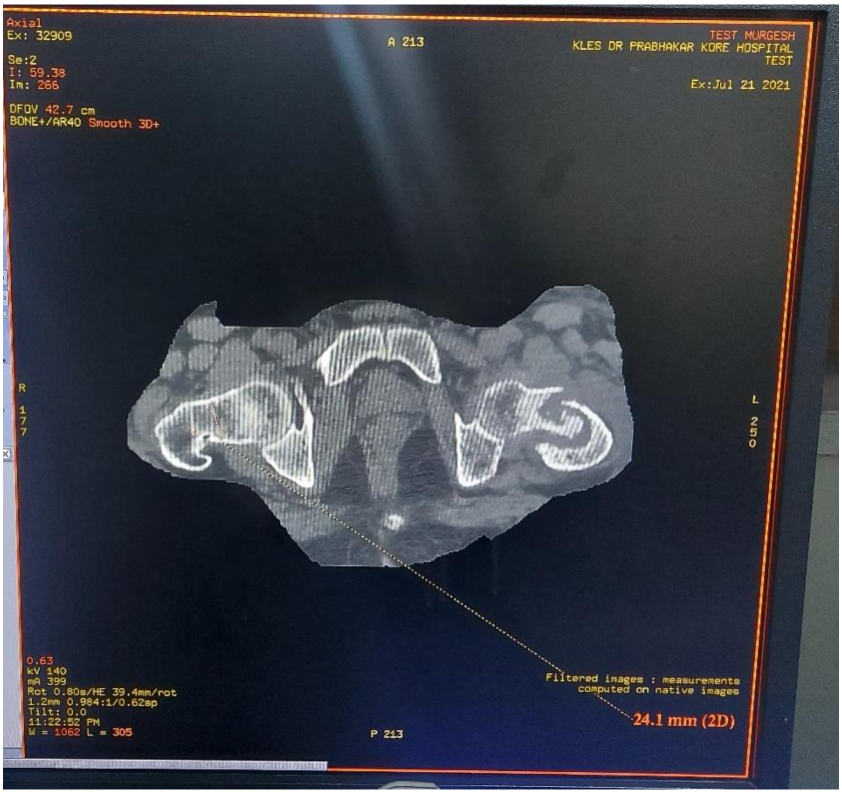
PHOTOGRAPH 3 :FEMORAL HEAD DIAMETERON 3D CT SCAN.



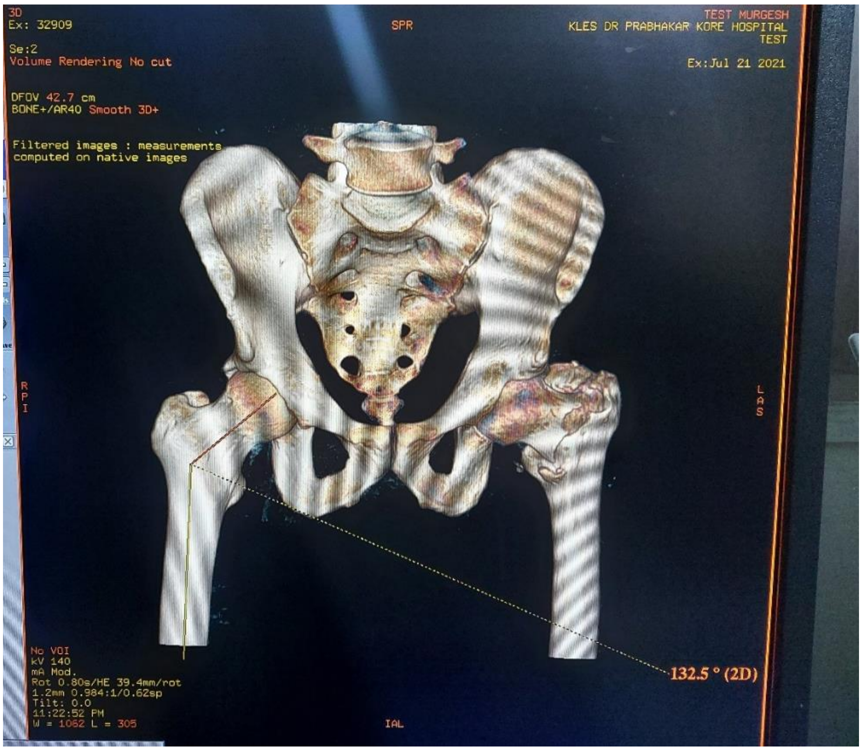
PHOTOGRAPH 4:FEMORAL HEAD DIAMETER ON AXIAL CUTS CT SCAN.



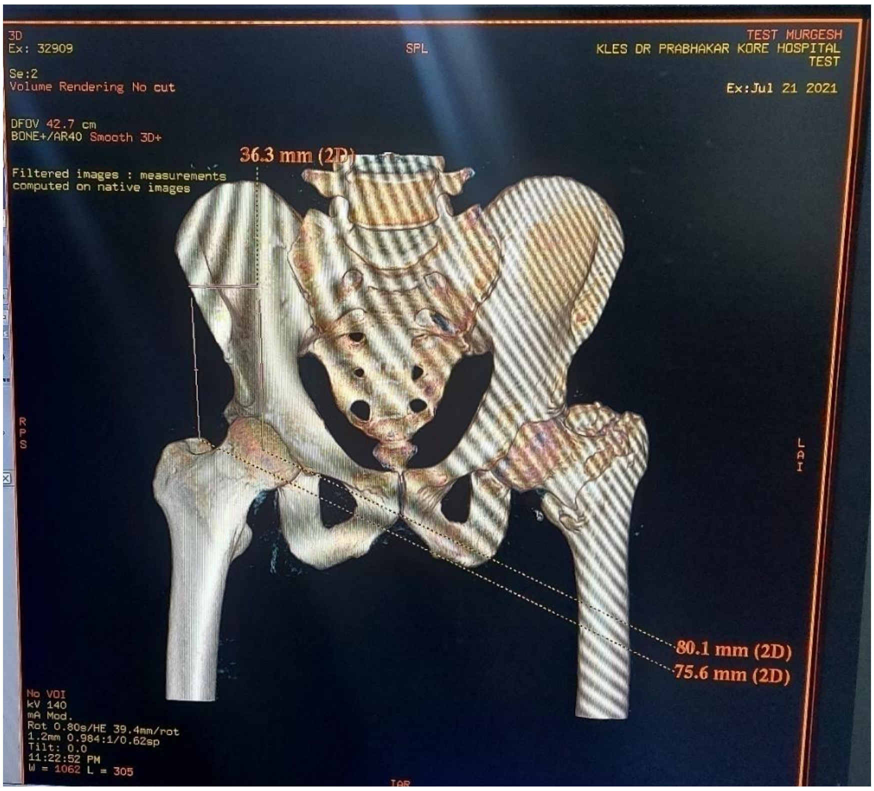
PHOTOGRAPH 5 :FEMORAL NECK DIAMETER 3D CT SCAN.



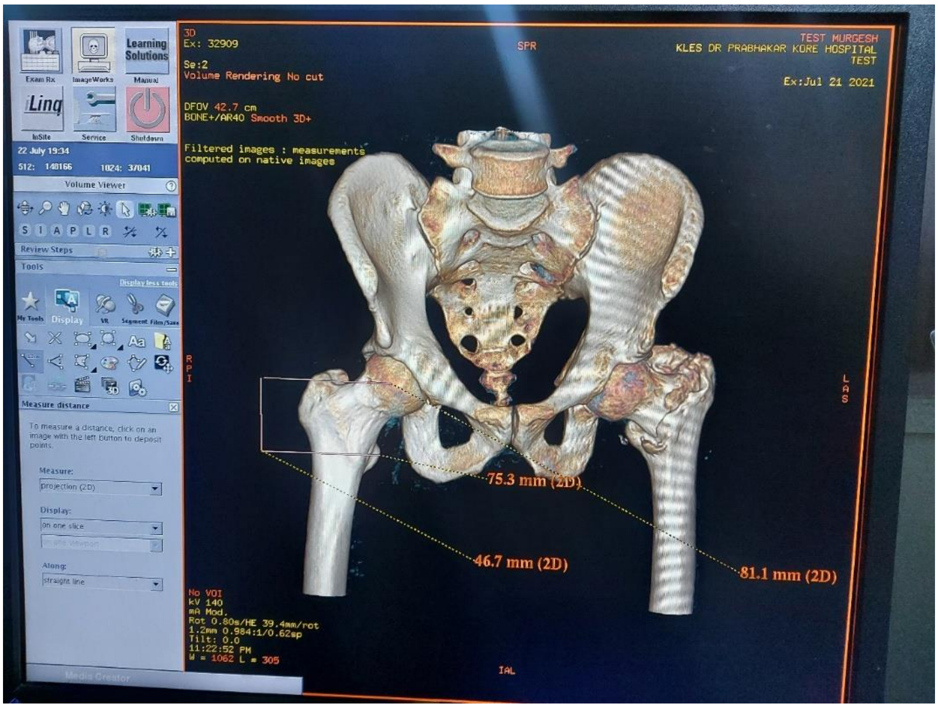
PHOTOGRAPH 6 :FEMORAL NECK DIAMETERONAXIALCUTS CT SCAN.



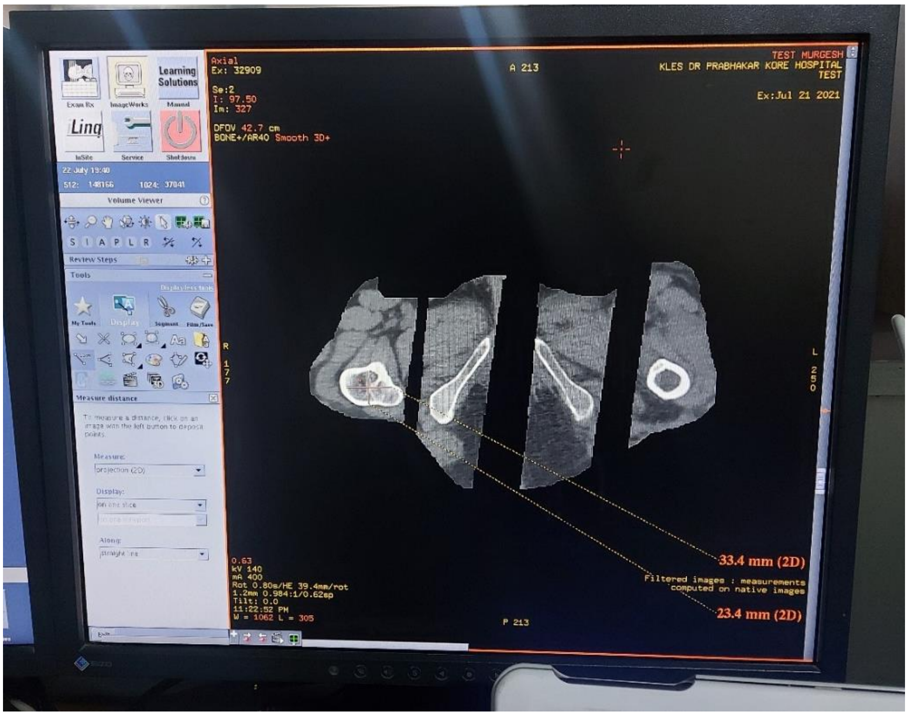
PHOTOGRAPH 7 :- NECK SHAFT ANGLEON 3D CT SCAN.



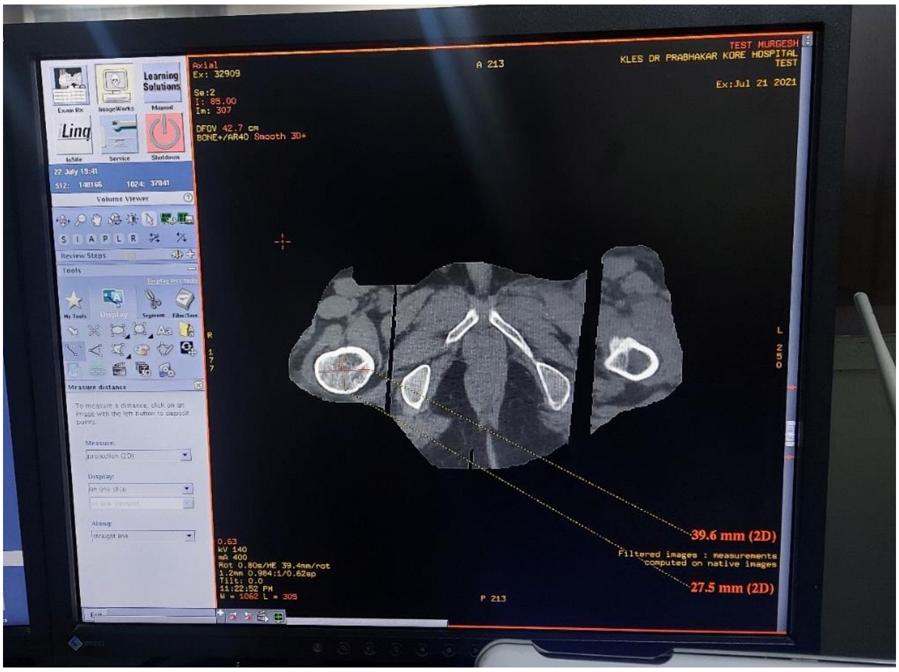
PHOTOGRAPH 8 :HORIZONTAL OFFSETON 3D CT SCAN.



PHOTOGRAPH 9 : VERTICAL OFFSET ON 3D CT SCAN.

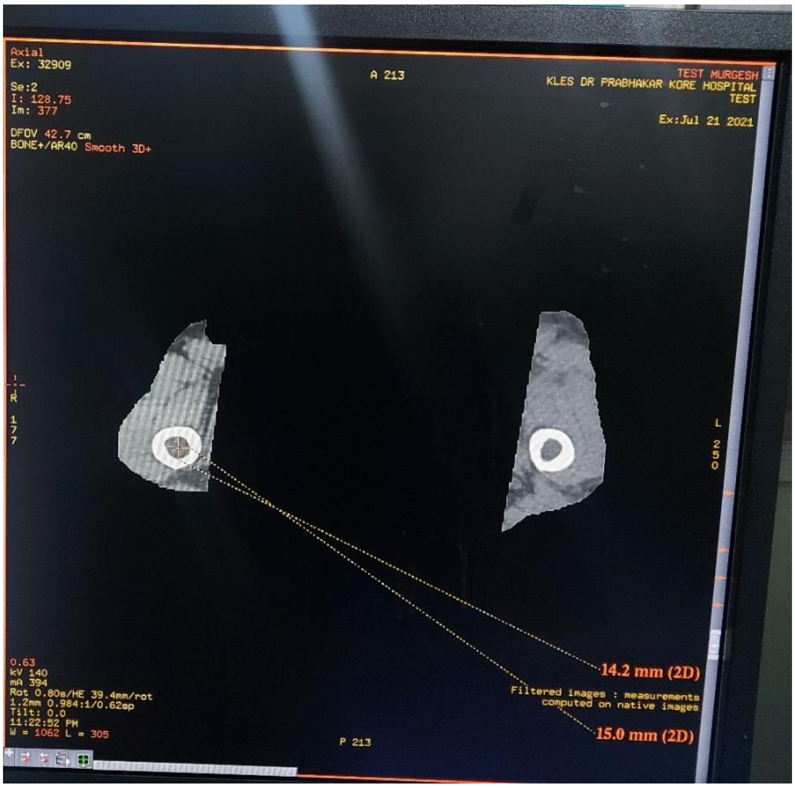


PHOTOGRAPH 10 :CANAL WIDTHAT MID POINT OF L.T ON AXIAL CUTS CT SCAN.



PHOTOGRAPH 11 :CANAL WIDTH AT 20MM ABOVE L.T ON AXIALCUTS CT SCAN.

PHOTOGRAPH 12 : - CANAL WIDTH AT 20MM BELOW L.T ON AXIAL CUTS CT SCAN.



PHOTOGRAPH 13 :CANAL WIDTH AT 50MM BELOW L.T ON AXIALCUTS CT SCAN.

ANNEXTURE - IV

SN	AGE	SEX	CT NO.	I.P NUMBER	DIAGNOSIS	HORIZONTAL OFFSET	VERTICAL OFFSET	FEMORAL HEAD DIAMETER	NECK DIAMETER	NECK SHAFT ANGLE		CANAL WIDTH			CANAL WIDTH			
											AT MID PO	AT L.T	20 MM ABOVE L.T		20 MM BELOW L.T		50MM BELOW L.T	
											AP	TRANSVERSE	AP	TRANSVERSE	AP	TRANSVERSE	AP	TRANSVERSE
1	59	M	C45525	115467	RIGHT I.T FRACTURE	52.5	63.7	40.4	27.5	124	22.4	20.4	34.4	36.4	12.1	17	12.7	14.6
2	60	M	C39961	106383	LEFT I.T FRACTURE	43.9	72.5	40	29.4	121.6	23.7	17.7	39.2	45.2	18.8	16.3	17.6	14.1
3	75	M	C45678	105645	RIGHT NECK FEMUR FRACTURE	44	43	44.1	32.5	120.4	14.9	13.3	38.1	37.1	13.9	13.2	18	14.4
4	76	M	C32426	105965	RIGHT I.T FRACTURE	50.3	48.8	47.7	27.8	123.3	31.5	39.6	51.1	47.7	25.7	28.3	24.6	19.2
5	72	F	C41475	102546	LEFT I.T FRACTURE	40.3	51.5	46.1	27.6	124	25.5	35.2	44.2	44.9	21.3	26.8	16.9	18.8
6	50	F	C42616	112455	LEFT ACETABULUM FRACTURE	40	54.2	40.2	31.8	124	24.3	23.5	48.1	48.6	17	12.4	13.6	10.4
7	90	F	C43099	124532	LEFT NECK OF FEMUR FRACTURE	32	46.1	38.3	20.7	124	16.3	16.5	32.9	40.2	10.4	12.1	12.3	12.7
8	66	F	C45060	103542	LEFT I.T FRACTURE	49.5	56.2	42.6	25.1	123.8	23	28.4	40.1	52	19.8	25.6	19.6	19.6
9	23	M	C27755	103245	RIGHT I.T FRACTURE	46.7	57.8	44.6	36.7	124	18.7	13.6	34.5	36.1	13.9	11.2	16.3	12
10	80	F	C43503	104356	RIGHT I.T FRACTURE	41.8	52.6	41.8	25.2	124	21.7	17.3	35.9	41.1	13.3	13.3	12.6	13.6
11	84	F	C39536	104564	LEFT GREATER TROCHANTER FRACTURE	44.6	44	42.6	29.2	124	23.1	25	44.5	47.3	17.8	16.2	14.2	11.7
12	52	F	C38529	113465	RIGHT NECK FEMUR FRACTURE	56.6	47.7	46.1	30.8	115.7	26.1	26.8	38.1	47	19	24.2	16.4	17.8
13	84	F	C42221	125434	LEFT I.T FRACTURE	49.6	42.8	45.4	29.1	122.4	24	29.5	38.5	48.7	22	16.3	16.5	14.4
14	27	M	C32486	106654	RIGHT NECK FEMUR FRACTURE	47.3	59.9	46.6	27	124	12.1	8.4	28.3	38.8	10.7	9.3	10.5	11.6
15	43	M	C36788	118765	LEFT GREATER TROCHANTER FRACTURE	59.1	67.5	45.4	33.1	122.6	23.1	31.7	43.6	44.5	13.7	11.7	14.7	12.6
16	50	M	C32909	126678	LEFT I.T FRACTURE	36.3	46.7	44.8	30.1	121.5	21.4	27.4	37.5	49.6	14.9	17.9	15	14.2
17	70	M	C37480	105467	LEFT NECK OF FEMUR FRACTURE	54.3	45.4	49.6	31.6	124	22.2	28.4	38.4	45.5	18.5	21.6	16.3	15.9
18	73	M	C45786	125674	LEFT I.T FRACTURE	35.3	64.6	42.7	33.7	124	21.3	16.2	40	43.7	12.9	12.5	14.1	10.7
19	51	M	C54678	126456	LEFT I.T FRACTURE	47.8	45.5	45.2	33.1	124	22.2	28	40.6	52.9	13.1	13.6	13.2	13.6
20	74	M	C31841	125876	LEFT I.T FRACTURE	34.4	42.6	50.6	32.6	124	17.8	24.7	31.5	50.6	19.4	25.3	15.9	17.5
21	24	M	C40214	132457	RIGHT I.T FRACTURE	28.5	35.4	46	28.8	122.3	22.8	30.9	37.3	49.4	17.7	18.2	15.7	13.1
22	84	M	C47086	143245	LEFT I.T FRACTURE	37	54.7	43.5	34.2	124	23.7	32.3	43	56.1	18.8	19.1	18.3	14.4
23	69	M	C36932	145987	LEFT NECK OF FEMUR FRACTURE	50.4	35.7	41	26.2	121.1	20.7	13.7	38.1	47.5	15.8	14.3	13.8	15.6
24	68	F	C35789	108292	RIGHT NECK FEMUR FRACTURE	42.8	50.6	43.7	30.5	124	22	26.8	36.7	44.8	16.7	18.3	14.6	13.5
25	56	F	C32564	105013	RIGHT I.T FRACTURE	48.8	54.6	49.4	31.8	124	18.6	13.6	34.6	37.7	12.7	11.3	16.4	18.8
26	82	M	C46546	105218	LEFT I.T FRACTURE	49.7	43.6	47.4	28.1	121.8	23.8	28.8	36.5	46.8	21.2	17.1	17.4	15.8
27	87	M	C54378	106957	RIGHT NECK FEMUR FRACTURE	45.5	51.3	42.8	29.4	124	23.2	27	44.5	47.4	19.6	16.4	12.4	14.2
28	50	F	C53567	106753	RIGHT NECK FEMUR FRACTURE	46.7	56.7	45.5	29	123.6	13.2	11.8	30.2	36.5	11.4	9.2	13.6	10.4
29	77	M	C32456	106648	LEFT NECK OF FEMUR FRACTURE	44.5	46.6	48.4	27.3	135	22.1	26.2	42.2	45.2	19.4	17.22	14.6	15.3
30	69	M	C31254	106256	RIGHT ACETABULUM FRACTURE	37.5	58.2	50.4	30.6	121.6	24.2	26.6	36.2	45.4	15.6	18.7	15.5	14.2
31	82	F	C56098	106372	RIGHT NECK FEMUR FRACTURE	55.6	44.3	46.5	33.4	124	21.4	29.6	36.4	45.6	13.6	17.3	16.5	14.8
32	82	F	C51124	106929	LEFT ACETABULUM FRACTURE	28.7	32.4	44	30.2	123.5	24.7	28.5	35.6	46.6	19.3	27.2	16.2	18.6
33	80	M	C51213	106180	RIGHT I.T FRACTURE	51.8	42.2	47.6	28.5	124	19.4	26.3	42.4	52.5	17.3	23.4	17.8	14.4
34	63	M	C57786	106416	LEFT I.T FRACTURE	38.7	54.6	44.3	33.2	124	21.4	26.4	39.6	51.8	16.7	19.6	12.5	15.2
35	55	M	C54455	106756	LEFT NECK OF FEMUR FRACTURE	52.1	60.2	38.4	28.5	124	27.6	27.6	35.6	48.6	14.5	17.4	16.7	19.5
36	74	F	C41017	106654	RIGHT I.T FRACTURE	43.6	49.8	45.5	30.2	124	22.7	26.6	34.6	38.7	18.7	17.4	15.6	18.7
37	72	F	C51021	105643	RIGHT NECK FEMUR FRACTURE	29.6	34.7	47.7	28.5	124	21.8	31.3	35.7	46.8	16.6	19.3	14.8	17.7
38	78	M	C62134	109856	LEFT ACETABULUM FRACTURE	27.6	32.1	40.9	25.7	118.8	32.5	39.6	41.7	46.9	19.5	15.7	15.8	13.6
39	68	F	C59801	180896	RIGHT I.T FRACTURE	33.8	57.4	43.6	26.3	124	22.6	25.4	42.5	45.6	19.4	23.5	16.5	20.8
40	74	M	C65324	100318	LEFT I.T FRACTURE	30.6	52.7	42.4	30.2	124	30.5	29.3	38.7	42.3	18.3	21.6	17.6	15.6
41	67	M	C56454	100789	LEFT ACETABULUM FRACTURE	52.4	46.7	48.8	35.5	124	23.6	25.3	41.5	50.2	16.5	20.6	14.6	11.5
42	60	F	C60867	107854	LEFT NECK OF FEMUR FRACTURE	41.6	52.4	43.5	31.8	135	28.8	26.1	38.6	42.7	13.7	21.4	18.6	15.4
43	28	M	C57678	104687	RIGHT NECK FEMUR FRACTURE	47.8	55.4	44.1	29.4	124	16.6	18.6	32.2	38.6	15.4	23.5	16.6	14.7
44	85	M	C60987	102976	LEFT I.T FRACTURE	42.7	48.5	46.6	32.3	122.3	20.4	23.2	36.8	46.4	20.5	18.3	15.3	19.6
45	75	M	C66450	107643	RIGHT NECK FEMUR FRACTURE	53.8	35.6	42.7	27.6	124	21.5	25.6	34.7	43.6	14.7	17.4	18.4	16.7
46	77	M	C65778	107456	LEFT ACETABULUM FRACTURE	43.8	70.5	38.8	30.6	122.5	24.8	18.4	38.3	46.7	19.4	16.8	16.4	19.2
47	62	F	C57769	108552	LEFT I.T FRACTURE	35.4	62.5	41.6	32.4	124	22.6	25.5	38.4	42.5	13.8	15.4	15.5	11.6
48	59	F	C57186	108432	LEFT I.T FRACTURE	43.4	45.7	45.1	28.5	124	20.2	24.6	41.2	43.3	17.3	13.2	13.6	16.7
49	60	F	C67894	101836	RIGHT I.T FRACTURE	48.2	34.7	38.2	25.4	122.6	18.6	12.6	36.2	45.6	13.7	12.4	12.6	12.6
50	69	F	C46709	101452	RIGHT ACETABULUM FRACTURE	43.6	45.7	43.1	29.7	124	20.2	24.1	41.2	47.3	17.3	15.2	14.6	13.7
51	61	M	C43251	101268	LEFT NECK OF FEMUR FRACTURE	36.2	46.5	40.6	27.4	123.2	25.4	25.7	34.2	46.3	12.7	14.6	19.8	17.6
52	56	M	C69076	101952	RIGHT I.T FRACTURE	57.1	46.4	47.3	34.8	124	23.4	31.7	38.3	46.5	15.6	19.4	17.5	15.7
53	77	M	C76750	103929	LEFT NECK OF FEMUR FRACTURE	47.6	44.7	44.6	32.8	124	21.2	15.2	41.3	42.8	13.8	11.7	15.3	11.2
54	78	F	C50079	101515	LEFT ACETABULUM FRACTURE	42.5	48.7	45.4	29.3	124	23.7	17.3	43.2	53.4	17.3	15.2	12.5	13.6
55	73	F	C76680	109213	RIGHT I.T FRACTURE	53.7	42.6	37.3	30.6	124	19.6	20.4	39.6	44.7	11.5	14.8	11.8	19.5
56	68	F	C56081	102265	LEFT NECK OF FEMUR FRACTURE	34.1	44.4	38.7	30.3	121.7	24.7	24.4	34.9	44.5	10.7	13.1	14.8	17.6
57	56	M	C78809	106759	RIGHT ACETABULUM FRACTURE	54.2	45.6	45.2	32.6	124	24.6	25.5	41.2	43.7	14.8	11.5	16.7	15.8
58	67	M	C54001	112054	LEFT I.T FRACTURE	47.6	55.7	42.2	34.8	123.6	27.8	26.6	27.6	41.7	13.4	12.7	13.6	19.7
59	75	M	C46042	108596	RIGHT NECK FEMUR FRACTURE	49.6	54.6	41.3	33.7	120.6	23.7	24.4	31.6	32.3	12.6	16.8	11.2	14.6
60	69	M	C39870	105990	LEFT NECK OF FEMUR FRACTURE	50.1	39.6	32.6	26.8	124	16.9	17.4	35.5	40.6	13.2	12.1	13.7	17.8
61	85	M	C87660	106629	RIGHT ACETABULUM FRACTURE	32.6	45.6	35.5	21.6	124	21.8	22.7	29.6	34.5	17.6	21.5	16.8	22.6
62	68	F	C32445	105590	LEFT I.T FRACTURE	49.3	58.6	37.7	24.2	123.3	19.3	18.5	33.3	35.7	14.2	19.1	13.6	15.9
63	70	M	C55645	110238	LEFT ACETABULUM FRACTURE	44.8	71.7	38.1	31.3	124	21.6	15.8	36.3	43.1	16.7	14.2	15.3	12.2

ANNEXTURE - IV

64	86	M	C77686	106678	RIGHT NECK FEMUR FRACTURE	41.2	50.3	45.7	28.6	124	23.9	33.3	42.2	44.7	18.2	24.8	16.7	19.8
65	38	M	C67098	105571	LEFT ACETABULUM FRACTURE	31.6	44.2	33.6	24.8	124	19.7	30.8	37.7	39.6	21.5	23.7	17.7	21.3
66	40	M	C56733	107668	RIGHT I.T FRACTURE	54.2	45.6	44.3	28.7	119.8	24.5	24.1	36.1	45.2	17.3	22.7	14.8	16.7
67	60	F	C56443	101554	LEFT NECK OF FEMUR FRACTURE	30.2	44.2	36.1	18.7	122.6	14.7	14.7	30.6	38.1	8.4	10.2	12.8	14.7
68	53	M	C58790	101345	RIGHT I.T FRACTURE	41.2	48.4	47.3	25.4	124	23.4	33.3	42.3	41.4	19.8	24.6	15.7	16.7
69	38	M	C65554	107445	LEFT I.T FRACTURE	46.3	54.4	40.7	33.3	124	16.7	15.6	32.6	34.8	12.7	9.3	14.6	11.7
70	47	F	C76675	110645	RIGHT I.T FRACTURE	47.2	44.4	45.8	28.7	124	30.6	36.3	48.2	45.5	22.7	26.6	23.7	18.6
71	52	F	C54532	113345	LEFT ACETABULUM FRACTURE	31.3	43.7	37.5	22.6	124	18.4	30.3	34.8	42.3	12.4	14.1	14.9	15.1
72	60	F	C65090	108875	RIGHT NECK FEMUR FRACTURE	42.2	41.3	42.1	30.6	119.3	12.8	11.3	36.2	37.3	11.9	12.3	16	12.3
73	70	M	C68890	107651	LEFT NECK OF FEMUR FRACTURE	37.2	47.7	45.8	31.1	124	23.3	29	41.6	53.3	18	20.8	16.4	14.8
74	58	F	C69087	108997	RIGHT NECK FEMUR FRACTURE	29.5	36.3	47.2	29.8	123.3	23.8	31.9	38.3	50.4	19.8	20.5	17.6	14.1