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Original Research Article

Observation of Anatomical Mechanical Femoral Angle (AMFA) and Mechanical Femoro-Tibial Axis Angle (MFTA) on Ctscanogram Bilateral Lower Limbs in Those Undergoing CT Angiography in Adult Indian Population

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Abstract

Background: The angle formed between the mechanical axis of the femur and the anatomical axis of the femur is the anatomical mechanical femoral angle. The alignment of this angle has great importance in performing a proper distal femoral cut during total knee arthroplasty.

Method:100 knees CT scanogramswere selected for study. Anatomical mechanical femoral angle (aMFA) and mechanical femoro-tibial axis angle (mFTA) in adults were compared radiologically, and variations of these angles were noted.

Results: The femoral mechanical femoral angle (aMFA) was 6.45^0 ($\pm$ 1.24^0)- range 4 to 10^0, the mechanical femoro-tibial axis angle (mFTA) was 1.6^0 ($\pm$ 0.6).

Conclusion: The present correlative study of aMFA and mFTA will be quite useful to orthopedicianartists for distal femoral cuts during knee arthroplasty to maintain normal erect posture post-operatively.

Keywords: Anatomical Mechanical Femoral Angle (aMFA), Mechanical Femoro-tibial Axis Angle (mFTA), CT scanogram.

Introduction

The angle formed between the mechanical axis of the femur and the anatomical axis of the femur is called the Anatomical Mechanical Femoral Angle (aMFA). The angle formed due to gravitational force is because the lower limb has to stand against the gravity. Due to gravitational force, the mechanical axis of the femur is formed to facilitate normal locomotion on the ground against gravity.

The femoral mechanical and anatomic axes deviate by a mean of 6° (± 2.5) in western races [1]. Measurement accuracy is affected by loading, flexion, rotation, image quality, software assistance, and reader experience [2,3] The correlation of these angle axes has greater importance when performing a proper distal femoral cut during total knee arthroplasty [4]. Hence, an attempt was made to correlate both angles axes radiologically before total knee arthroplasty, and the pros and cons of those angles were noted.

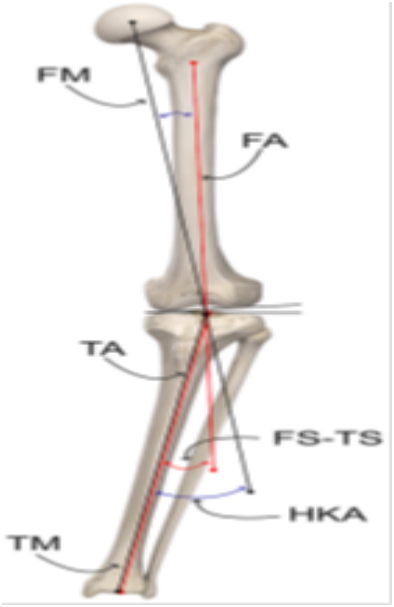


Figure 1: The FS–TSangleis 4 to 6° valgus compared to the HKA angle.

FM = femoral mechanical axis; TM = tibial mechanical axis; FA = femoral anatomical axis; TA = tibial anatomical axis; HKA = hip–knee–ankle angle (mechanical angle) = (mFTA-mechanical femorotibial angle); FS–TS angle = femoral-shaft–tibial-shaft angle (anatomic angle) = (aTFA = anatomical tibio-femoral angle).

Material and Method

The adult patients were screened at the ESIC Medical College PG Institute MSR &Model Hospital in Rajajinagar, Bangalore. A CT scanogram (supine scout film) of both lower limbs was collected from 100 knees undergoing CT angiograms for any indication at ESIC Medical College & PGIMSR, Rajajinagar.

Inclusion Criteria:

1. Those willing to give consent for the study
2. Patients requiring a CT angiogram for any symptom or disease
3. Adults older than 20 years

Exclusion Criteria:

1. Pathologies in the knee currently or in the past like infection, trauma, degeneration, inflammatory diseases, etc.
2. Hip and ankle deformities.
3. Knees with deformity > 3 degrees
4. Femorotibial subluxation

Subjects were screened and were taken up for the study after giving their consent. Data was collected from the patient's history, clinical examination, investigations, etc. from the patient's and hospital's records. A CT angiogram will be taken. CT scans were performed using a 64-MDCT unit (Brilliance 64, Philips Healthcare). The CT scout film containing both the lower limbs, from pelvis to heels, was collected. The proforma for data collection is enclosed.

The patella should be in the centre of the distal femur in the scanogram ideally. However if it is medial to the centre, then it is due to internal rotation (Fig. 3a). Measuring the angles in this position will give wrong values; hence, such images will be excluded from the study. To achieve this position, i.e., the central patella, 8–10° lateral rotation of the feet is classically needed. Displacement (lateral or medial) of the mid-spinous point of the tibia with respect to the mid-condylar point of the femur indicates femoro-tibial subluxation; such subjects were excluded from the study. The subject was made to have his or her hip and knee in full extension, the ankle plantigrade, and patellae facing forward. The lower limb images obtained were used for drawing the mechanical axis of the femur, the anatomical axis of the femur, etc. on the computer. We used the standard image analysis toolbox (i.e., rulers, angle measures, etc.). The following anatomic landmarks were identified: the centre of the femoral head (via Mose circles), the femoral intercondylar point (apex of the femoral notch), the tibial interspinous point (midpoint of the tibial spines), and the tibial mid plafond point (midpoint of the outer edges of the malleoli along the tibial plafond). The line along the centre of the femoral head and the femoral intercondylar point was defined as the femoral mechanical axis. The line along the tibial interspinous point and the tibial midplafond point was defined as the tibial mechanical axis. The anatomical mechanical femoral angle will be

measured on the computer. The HKAA was measured at the intersection of both mechanical axes on the medial side and given as a deviation from straight alignment (180°). The femoro-tibial mechanical axis angle was measured on the computer. Joint-surface lines of the knee and ankle joints were determined by fitting straight lines to the articulating joint surfaces. The knee-joint centre was defined as the mean of the centre points along the joint surface lines of the femoral condyles and the tibial plateau, whereas the centre of the ankle was defined as the centre of the distal tibial joint-surface line after eliminating both malleoli. Joint Line Congruency Angle (JLCA): angle between the tangential of the distal femur and the tangential of the proximal tibia. Each angle was measured twice. The mean of both measurements was utilized.

The duration of the study was from August 2023 to November 2023.

Statistical analysis: The mean, range, and standard deviation of various angles and alignments of the lower limb in 100 knees in the adult Indian population were obtained, and statistical analysis was done. The statistical analysis was carried out in SPSS software. The ratio of males and females was 2:1.

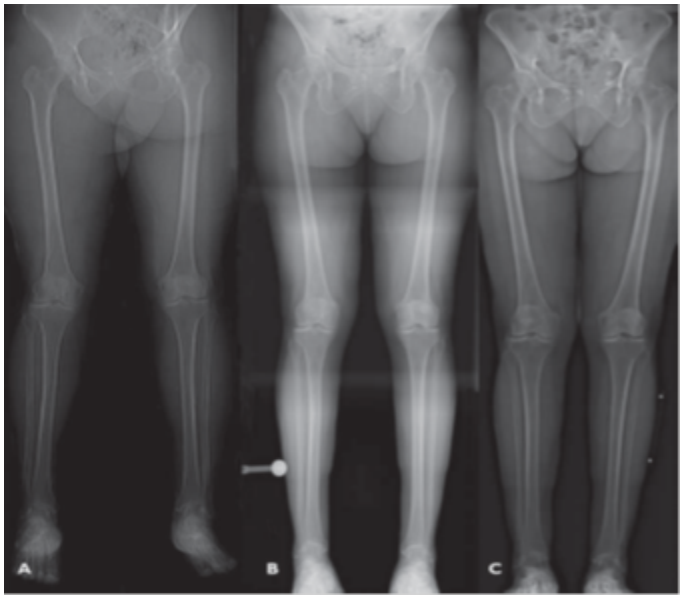


Figure2 A–C Supine CT scout view (A), conventional upright full-length radiograph (B), and upright biplanar linear radiograph (C) of lower limbs are shown.

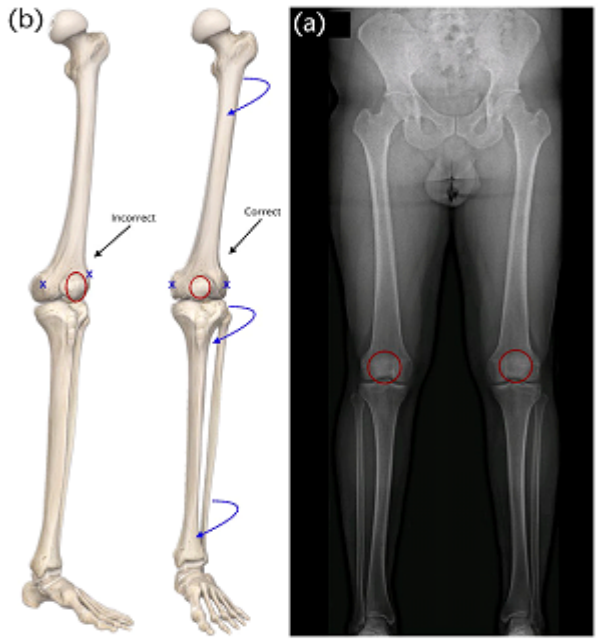


Figure 3(a) and (b) Correct full-length anteroposterior image.

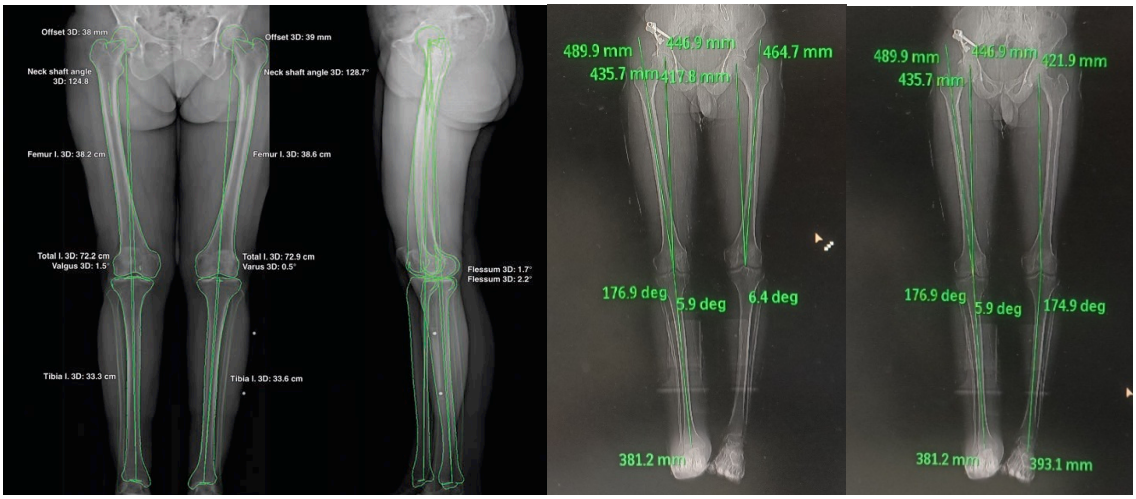


Figure 4. CT scout film showing various measurements and axes.

All the data was tabulated in the master chart. The data were then analyzed.

Observation and Results

Table 1: Variations of anatomical mechanical femoral angle (aMFA) were 6.45^{O} (±1.24) and ranged from 4^{O}-10^{O}.

Table 2: The study of various axial alignments was 128.2 (± 3.2) FNSA were frontal, 174.5 (± 2.7); FNSA sagittal, 84.5 (± 2.2); MPFA, 85.6 (± 1.2); ALDFA, 88.5 (± 1.2). MLDFA, 82.6 (± 1.2) MPTA, 88.2 (± 1.8), LDTA, 88.7 (± 2), PPFA, 84.5 (± 2.2) PDFA, 80.2 (± 2.2) PPTA, 82.4 (± 2.2) ADTA, 1.6 (± 0.6) MTFA, (HKAA), 1.2 (± 0.6) JLCA

Discussion

The present observational study of anatomical mechanical angle (AMFa) and mechanical femoro-tibial axis angle (MFTA) on a CT sonogram in the bilateral lower limb of patients undergoing CT angiography The aMFA was 6.45^{O} (± 1.24) and ranged from 4-10^{O} (Table 1). In the study of various avail alignment study 128.2 (± 3.2) FNSA (frontal), 174.5 (± 2.7) FNSA sagittal, 84.5 (± 2.2) MFPA, , 85.6 (± 1.2) ALDFA, 88.5 (± 1.2) MLDFA, 82.6 (± 1.2) MPTA, 88.2 (± 1.8) LDTA, 88.7 (± 2) DPFA, 84.5 (± 2.2) PDFA, 80.2 (± 2.2) PPTA, 82.4 (± 2.2) ADTA, 1.6 (± 0.6) MTFA (HKAA), 5.2 (± 0.8) ATFA, 1.2 (± 0.6) JLCA (Table-2) (Fig 1, 2, 3 and 4). These findings are more or less in agreement with previous studies [5,6,7]

Restoration of neutral mechanical alignment has for decades been the goal of total knee arthroplasty. Neutral coronal alignment has been linked to implant survival [8,9]. Normal values of axial alignment are affected by age, sex, and ethical issues [10]. Similar studies are also observed in the Indian population because bone is the most plastic tissue next to blood; hence, it adopts environmental, nutritional, and professional factors; hence, these angles must be evaluated radiologically for any orthopaedic surgeries.

The use of an intramedullary guide for the distal femoral cut is currently standard practice in total knee arthroplasty. Most of the instrumentation systems offer a standard 6-degree cutting block to guide the distal femoral cut in order to match the commonly reported 6-degree physiological valgus angulation of the femur [11]. Knee operations such as high tibial osteotomy, total knee arthroplasty, and total hip arthroplasty often aim to correct a deformity towards normal alignment. However, such normal anatomy remained an area of controversy because of the adaptation of bones in different regions or ethnic groups.

The average value of 6^{0} valgus angle (aMFA) is consistent with most published studies, which is also the commonly used angle for Distal femoral resection. But the range varies from 4 to 10^{0}, Choosing the 6^{0} angle for all patients leads to erroneous distal femoral resection in such outliers. So it is safer to calculate the aMFA in each case of TKR to produce a consistent distal femoral resection matching the anatomy of that particular patient.

The anatomical tibiofemoral angle (aTFA) or femoral [12] shaft tibial shaft angle (FS-TS) is drawn from the centre of the proximal femoral shaft towards the knee and a line from the centre of the tibial shaft distal to the knee. Femoral tibial alignment is a prominent risk factor for osteoarthritis incidence and progression [13,14]. The ratio of knee-hip osteoarthritis in different populations also deviates from the normal angles in India and abroad population too [15]. The distal femoral and proximal tibial varus angulations may justify the discrepancy.

The antero-posterior (AP) long-leg radiograph is considered the gold standard for determining the axial alignment of the knee, but CT sonogram scout film (CTS) is an ideal technique to find out the accuracy of angles.

Summary and Conclusion

A CT scanogram has proved to be an ideal technique to measure various angles of the long bones of the body. Ultimately, the outcomes of surgery depend on the skill of orthopedician under expert radiological reports. The anatomical, mechanical femoral angles (AMFa) and mechanical femoro-tibial axis angles (MFTA) depend on sex, age, nutritional status, environmental factors, and genetic factors. The average value of 6^0 valgus angles (aMFA) is consistent with most published studies, which is also the commonly used angle for Distal femoral resection. But the range varies from 4 to 10^0, Choosing the 6^0 angle for all patients leads to erroneous distal femoral resection in such outliers. So it is safer to calculate the aMFA in each case of TKR to produce a consistent distal femoral resection matching the anatomy of that particular patient. Hence, before any knee arthroplasty, analysis of various axes and angles of the lower limbs has to be carried out.

Limitation of Study: Owing to the tertiary location of the research centre, the small number of patients, and the lack of the latest techniques, we have limited findings and results.

- This research paper was approved by the ethical committee of ESIC Medical College PG Institute Medical Sciences and Research Centre and Model Hospital, Rajajinagar, Bangalore-560010.
- No Conflict of Interest
- Self Funding

Table 1 Variation of the Anatomical Mechanical Femoral Angle (aMFA), in osteoarthritis knees among studies and world regions

Authors	Region	aMFA angle, mean (range, SD)
Kharwadkar et al.	UK	5.40° (range 3.3° to 7.6°, SD 0.9°)
Deakin et al.	USA	5.70° (range 2° to 9°, SD 1.2°)
Bardakos et al.	UK	5.60° (range 2° to 9°, SD 1.0°)
Curtin et al.	USA	5.35° (range 1° to 10°)
Mullaji et al.	India	7.30° (SD 1.6°)
Jingjit et al.	Thailand	6.46° (range 4° to 10°, SD 1.26°)
Lalit maini et al	India	6.2º +/- 0.7º (range 5 to 7º)
Present study	South Karnataka (India)	6.45º (± 1.24) (range 4º to 10º)

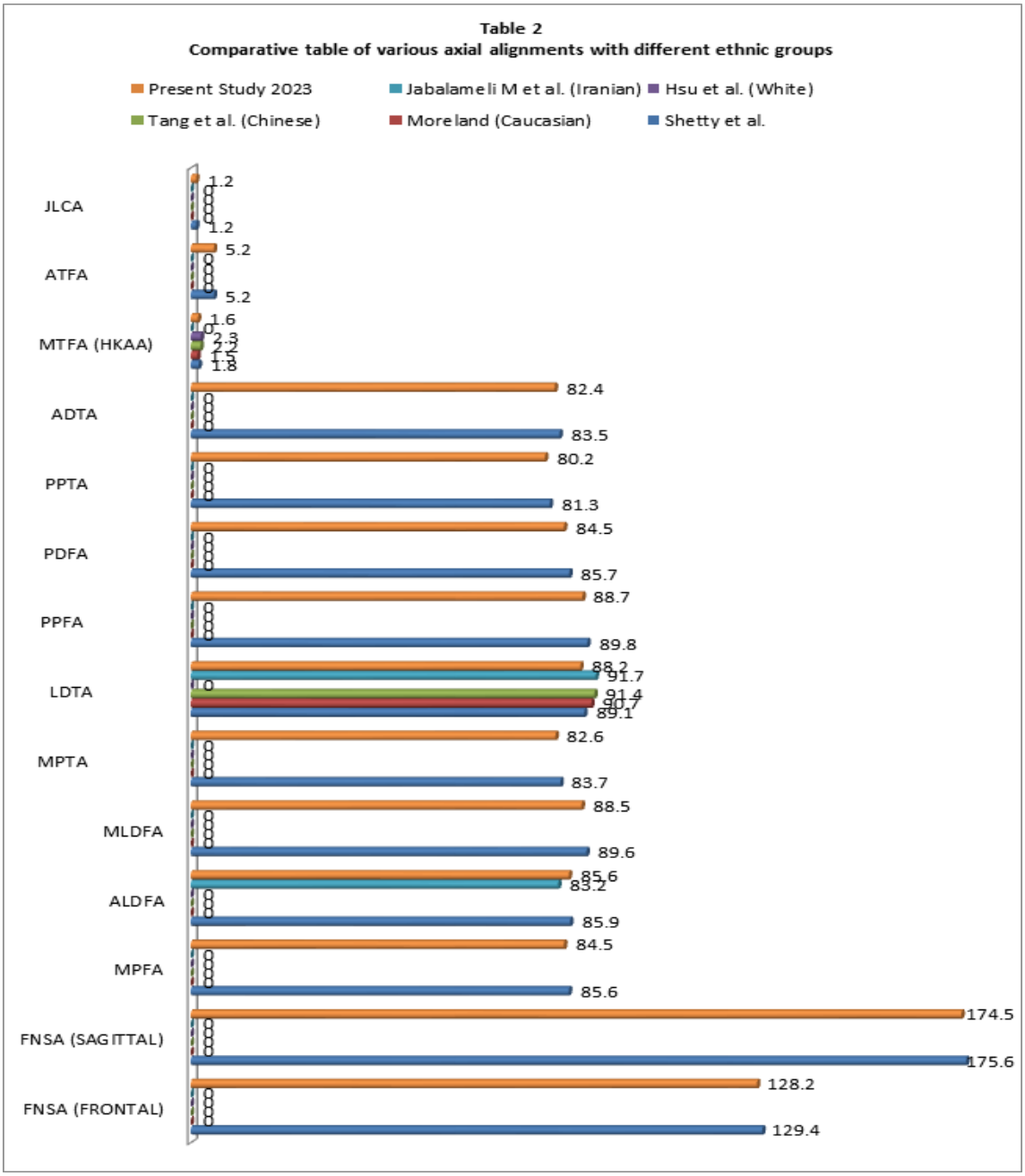
aMFA = Anatomical Mechanical Femoral Angle

Table 2 Comparative table of various axial alignments with different ethnic groups

Various axial angles (degree)	Shetty et al.	Moreland (Caucasian)	Tang et al. (Chinese)	Hsu et al. (White)	Jabalameli M et al. (Iranian)	Present Study 2023
FNSA (FRONTAL)	129.4±3.6					128.2 ±3.2
FNSA (SAGITTAL)	175.6±2.9					174.5 ±2.7
MPFA	85.6±2.4					84.5 ±2.2
ALDFA	85.9±1.1				83.2±3	85.6 ±1.2
MLDFA	89.6±1.3					88.5 ±1.2
MPTA	83.7±1.4					82.6 ±1.2
LDTA	89.1±1.9	90.7±3.2	91.4±3.1		91.7±2.8	88.2 ±1.8
PPFA	89.8±2					88.7 ±2
PDFA	85.7±2.3					84.5 ±2.2
PPTA	81.3±2.3					80.2 ±2.2
ADTA	83.5±2.2					82.4 ±2.2
MTFA (HKAA)	1.8±0.8	1.5	2.2	2.3		1.6 ±0.6
ATFA	5.2±0.9					5.2 ±0.8
JLCA	1.2±0.8					1.2 ±0.6

Femoral neck shaft angle (frontal plane) (FNSA), Femoral neck shaft angle (sagittal plane), Medial proximal femoral angle (MPFA), Anatomical lateral distal femoral angle (ALDFA), Mechanical lateral distal femoral angle (MLDFA), Medial proximal tibial angle (MPTA), Lateral distal tibial angle (LDTA), Posterior proximal femoral angle (PPFA), Posterior distal femoral angle (PDFA), Posterior proximal tibial angle (PPTA), Anterior distal tibial angle (ADTA), Joint line convergence angle (knee joint) (JLCA), Mechanical tibio-femoral angle (MTFA)(=mFTA= mechanical Femoro-tibial angle) = (Hip knee ankle angle = HKAA), Anatomical tibio-femoral angle (ATFA)(= aFTA= anatomical femorotibial angle).

Table 2
Comparative table of various axial alignments with different ethnic groups



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