RESEARCH PAPER

Distal Femoral Rotational Axes of Knees in the Geriatric Population

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Received: 20th Feb, 2026 | **Revised:** 4th Mar, 2026 | **Accepted:** 25th Mar, 2026 | **Available Online:** 10th Apr, 2026

ABSTRACT

Background: Accurate assessment of distal femoral rotational axes is essential for optimal alignment in knee joint evaluation and total knee arthroplasty (TKA), particularly in the geriatric population where degenerative changes may alter anatomical landmarks.

Aim: To delineate the angular relationships of distal femoral rotational axes in individuals aged over 60 years using Magnetic Resonance Imaging (MRI).

Objectives: To quantify the posterior condylar angle (PCA), determine the Whiteside's epicondylar angle (W-EP), and compare findings with existing literature for potential implications in TKA implant design.

Materials and Methods: This cross-sectional study included 100 patients aged above 60 years who underwent MRI of the knee joint. PCA and W-EP were measured using standard anatomical landmarks. Data were analyzed using descriptive and inferential statistics, with comparisons based on gender and laterality.

Results: The mean age was 68.3 ± 2.97 years. The mean PCA was 5.74° ± 1.48°, while the mean W-EP was 94.43° ± 2.05°. No statistically significant differences were observed in PCA with respect to gender ($p = 0.68$) or side ($p = 0.29$). Similarly, W-EP showed no significant variation across gender ($p = 0.44$) or laterality ($p = 0.81$).

Conclusion: Distal femoral rotational parameters demonstrate consistent patterns in the geriatric population, with minimal influence of gender or side. These findings support the reliability of established anatomical landmarks while emphasizing the importance of individualized assessment for improved surgical outcomes in TKA.

Keywords: Distal femur, Posterior condylar angle, Whiteside's line, Epicondylar axis, Geriatric population, MRI, Total knee arthroplasty.

How to cite this article: Rastogi E, Tanwar N, Goyal K. Distal Femoral Rotational Axes of Knees in the Geriatric Population. Int J Drug Deliv Technol. 2026;16(29s):665-670. DOI: 10.25258/ijddt.16.29s.84

Source of support: Nil.

Conflict of interest: The authors declare no conflict of interest.

INTRODUCTION

Accurate restoration of distal femoral rotational alignment is a critical determinant of successful knee function, particularly in the geriatric population where degenerative changes frequently compromise joint anatomy and biomechanics. The distal femur exhibits complex rotational geometry, defined by several anatomical reference axes including the transepicondylar axis, posterior condylar axis, and anteroposterior (Whiteside's) line. These axes serve as essential landmarks in both radiological assessment and surgical procedures such as total knee arthroplasty (TKA). In elderly individuals, progressive osteoarthritic changes, cartilage loss, osteophyte formation, and bone remodeling may alter these anatomical references, making accurate identification more challenging and increasing the risk of rotational malalignment [1,2].

Rotational alignment of the distal femur plays a vital role in ensuring proper patellofemoral tracking, ligament balancing, and overall knee kinematics. Malrotation, particularly internal rotation of the femoral component, has been associated with anterior knee pain, patellar instability, stiffness, and early prosthetic failure following TKA [3,4]. Given that geriatric patients constitute the majority of individuals undergoing knee replacement surgery, understanding age-related variations in distal femoral rotational axes is essential for improving surgical outcomes. Moreover, conventional reliance on a single reference axis may not be sufficient in elderly knees, where anatomical distortions may necessitate the use of multiple axes or imaging modalities for accurate assessment [5].

Advancements in imaging techniques, particularly computed tomography (CT), have significantly enhanced the ability to evaluate distal femoral rotational anatomy with high precision. CT-based measurements allow for three-dimensional assessment of bony landmarks, minimizing observer variability and providing reliable data for preoperative planning [6]. Studies have demonstrated variability in the relationship between the posterior condylar axis and transepicondylar axis among different populations, with notable differences observed in elderly individuals due to degenerative changes [7]. These findings underscore the importance of population-specific and age-specific data in guiding clinical decision-making.

Furthermore, gender-based and ethnic variations in distal femoral rotational alignment have also been reported, suggesting that a standardized approach may not be universally applicable [8]. In geriatric populations, these variations may be further accentuated by osteoporosis, prior microtrauma, or chronic joint pathology. Therefore, a comprehensive evaluation of distal femoral rotational axes is necessary not only for surgical precision but also for understanding the biomechanics of the aging knee joint [9].

In this context, the present study aims to analyze the distal femoral rotational axes in the geriatric population using advanced imaging modalities, with the objective of identifying patterns, variations, and clinically relevant correlations. Such insights are expected to contribute to improved surgical planning, enhanced prosthetic alignment, and better functional outcomes in elderly patients undergoing knee-related interventions [10].

The present study is designed to delineate the angular relationships of distal femoral rotational axes in individuals aged over 60 years using Magnetic Resonance Imaging (MRI) of the knee joint, with a focus on enhancing the understanding of age-related anatomical variations. Specifically, it aims to quantify the posterior condylar angle (PCA) and determine the Whiteside's epicondylar angle (W-EP) in this geriatric population, both of which are critical parameters in assessing femoral rotational alignment. By systematically evaluating these angles, the study seeks to identify characteristic patterns or deviations that may arise due to degenerative changes associated with aging. Furthermore, the findings will be compared with existing literature to evaluate consistency or variation across populations, with the broader objective of assessing whether such data could contribute to refining surgical techniques and guiding potential modifications in the design and alignment strategies of Total Knee Arthroplasty (TKA) implants tailored for elderly patients.

MATERIALS AND METHODS

Study Design: Prospective, observational study

Setting: Department of Radio-Diagnosis, MMIMSR, Mullana (IEC approved)

Duration: 18 months

Study Population:

Patients >60 years with clinical features of knee osteoarthritis referred for MRI

Sample Size:

100 patients (calculated using nMaster 2.0; 80% power, 95% CI)

Inclusion Criteria:

- Age >60 years
- Both genders
- Symptomatic knee osteoarthritis
- Provided informed consent

Exclusion Criteria:

- MRI evidence of trauma, tumor, or infection
- Unwilling patients

Statistical Analysis: We put the data into Microsoft Excel and then used SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5 to look at it. Mean ± standard deviation was used to show continuous variables, and frequencies and percentages were used to show categorical variables. The unpaired t-test was utilized to examine continuous variables between independent groups, whereas the paired t-test was employed for comparisons within the same group. The Chi-square test or Fisher's exact test was used to look at categorical variables, depending on which one was better. A p-value of less than 0.05 was seen to be statistically important.

RESULT

Table 1: Age Distribution

Parameter	Value
Total Patients	100
Mean Age (years)	68.3
Standard Deviation (SD)	2.97

Minimum Age	62
Maximum Age	74

Table 2: Overall PCA and Whiteside's Epicondylar Angle

Parameter	Mean (°)	SD (°)	Minimum (°)	Maximum (°)
Posterior Condylar Angle (PCA)	5.74	1.48	2.4	7.9
Whiteside's Epicondylar Angle (W-EP)	94.43	2.05	92	97.4

Table 3: Gender Distribution in PCA

Gender	N (%)	Mean PCA (°)	SD (°)	p-value
Male	38 (38%)	5.81	1.55	0.68
Female	62 (62%)	5.7	1.44	

Table 4: Side Distribution in PCA

Side	N (%)	Mean PCA (°)	SD (°)	Range (°)	p-value
Left	42 (42%)	5.53	1.71	2.4–7.9	0.29
Right	58 (58%)	5.9	1.27	3.4–7.9	

Table 5: Gender Distribution in Whiteside's Epicondylar Angle (W-EP)

Gender	Mean (°)	SD (°)	Minimum (°)	Maximum (°)	p-value
Male	94.3	2.2	92	97.4	0.44
Female	94.4	1.9	92	98.4	

Table 6: Side Distribution in Whiteside's Epicondylar Angle (W-EP)

Side	N	Mean (°)	SD (°)	Minimum (°)	Maximum (°)	p-value
Right	58	94.43	2.09	92	97.4	0.81
Left	42	94.53	2.11	92	98.5	

Figure: 1.Mean Values of PCA and W-EP

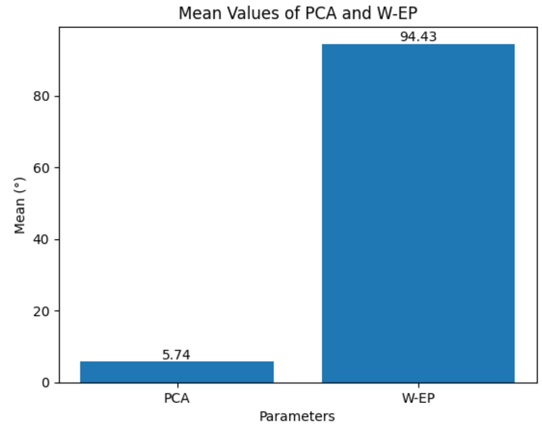

Figure: 2. Side Distribution of Patients

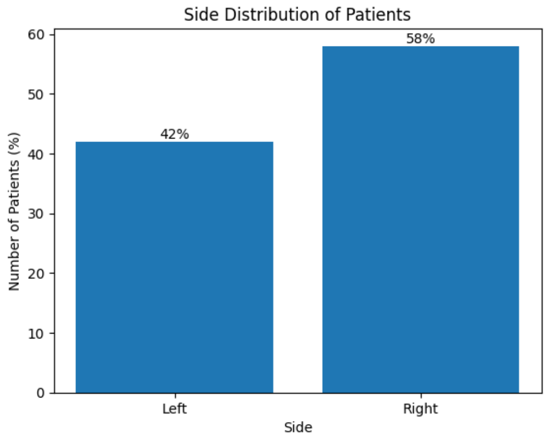

Table 1: Age Distribution

A total of 100 patients was included in the study, all aged above 60 years. The mean age of the study population was 68.3 years, with a standard deviation of 2.97 years, indicating a relatively homogeneous geriatric cohort. The age of the participants ranged from a minimum of 62 years to a maximum of 74 years, reflecting a narrow age distribution centered around the late elderly group.

Table 2: Overall PCA and Whiteside's Epicondylar Angle

The overall analysis of distal femoral rotational parameters revealed that the mean posterior condylar angle (PCA) was 5.74°, with a standard deviation of 1.48°. The PCA values ranged from 2.4° to 7.9°, demonstrating moderate variability among individuals. The mean Whiteside's epicondylar angle (W-EP) was found to be 94.43°, with a standard deviation of 2.05°, and values ranging from 92° to 97.4°, indicating relatively consistent measurements across the study population.

Table 3: Gender Distribution in PCA

On gender-based comparison, males (n = 38; 38%) had a mean PCA of 5.81° ± 1.55°, whereas females (n = 62; 62%) had a mean PCA of 5.70° ± 1.44°. Although males demonstrated a slightly higher mean

PCA, the difference between the two groups was statistically not significant (p = 0.68), suggesting no meaningful gender-based variation in PCA within the geriatric population.

Table 4: Side Distribution in PCA

With respect to laterality, the left knee (n = 42; 42%) showed a mean PCA of 5.53° ± 1.71°, with a range of 2.4° to 7.9°, while the right knee (n = 58; 58%) demonstrated a mean PCA of 5.90° ± 1.27°, with a range of 3.4° to 7.9°. Although the right side exhibited a marginally higher mean PCA, the difference was not statistically significant (p = 0.29), indicating comparable rotational alignment between both sides.

Table 5: Gender Distribution in Whiteside's Epicondylar Angle (W-EP)

The comparison of Whiteside's epicondylar angle between genders revealed a mean value of 94.3° ± 2.2° in males and 94.4° ± 1.9° in females. The minimum and maximum values ranged from 92° to 97.4° in males and 92° to 98.4° in females. The observed difference between genders was statistically not significant (p = 0.44), indicating that W-EP remains consistent irrespective of gender in the elderly population.

Table 6: Side Distribution in Whiteside's Epicondylar Angle (W-EP)

Analysis based on laterality showed that the right knee (n = 58) had a mean W-EP of 94.43° ± 2.09°, with values ranging from 92° to 97.4°, whereas the left knee (n = 42) demonstrated a mean of 94.53° ± 2.11°, with a range of 92° to 98.5°. The difference between the two sides was minimal and statistically not significant (p = 0.81), suggesting symmetrical distribution of Whiteside's epicondylar angle in the geriatric population.

DISCUSSION

The present study evaluated the distal femoral rotational axes in a geriatric population and demonstrated a relatively homogeneous age distribution with a mean age of 68.3 ± 2.97 years. This is comparable to the findings of Victor J et al. [11], who reported a mean age of 67.8 years in their cohort assessing femoral rotational alignment using imaging modalities. Similarly, Matsuda S et al. [12] included elderly patients with a mean age in the late sixties, highlighting that degenerative knee changes become more pronounced in this age group, thereby justifying focused anatomical evaluation in geriatric populations.

In the current study, the mean posterior condylar angle (PCA) was found to be 5.74° ± 1.48°, which is consistent with the observations of Yoshioka Y et al. [13], who reported a PCA of approximately 5.5° in their anatomical study. Similarly, Poilvache PL et al. [14] documented PCA values ranging from 4° to 6°, closely aligning with the present findings. Minor variations may be attributed to differences in imaging techniques (MRI vs CT) and population demographics, particularly age-related cartilage wear influencing posterior condylar morphology.

The mean Whiteside's epicondylar angle (W-EP) in this study was 94.43° ± 2.05°, which is in agreement with the results reported by Arima J et al. [15], who demonstrated a mean W-EP angle of approximately 94° in normal and osteoarthritic knees. Additionally, Nagamine R et al. [16] reported similar values with minimal variability, reinforcing the reliability of Whiteside's line as a consistent anatomical landmark, even in the presence of degenerative changes.

Gender-based comparison of PCA in the present study showed no statistically significant difference (p = 0.68), with males having a slightly higher mean PCA (5.81°) compared to females (5.70°). This finding is consistent with Griffin FM et al. [17], who reported no significant gender differences in femoral rotational alignment parameters. Likewise, Hofmann AA et al. [18] observed that although minor anatomical variations exist, they do not significantly impact PCA values between genders.

Similarly, side-based comparison of PCA in the current study revealed no statistically significant difference between left and right knees (p = 0.29). This is in line with the findings of Berger RA et al. [19], who concluded that femoral rotational axes are generally symmetrical bilaterally. Such symmetry supports the use of contralateral knee anatomy as a reference during preoperative planning in cases where one knee is severely deformed.

With respect to Whiteside's epicondylar angle, no significant gender difference was observed (p = 0.44), which is consistent with the findings of Siston RA et al. [20], who demonstrated that W-EP remains relatively constant across genders. Furthermore, side-based comparison of W-EP in the present study also showed no significant difference (p = 0.81), corroborating previous studies that emphasize the reproducibility and bilateral symmetry of Whiteside's line as a reliable intraoperative reference.

Overall, the findings of the present study are largely consistent with existing literature, confirming that distal femoral rotational parameters such as PCA and W-EP demonstrate minimal variation with respect to gender and laterality in the geriatric population. These results reinforce the validity of using standard anatomical landmarks in total knee arthroplasty while also highlighting the importance of individualized assessment in elderly patients due to subtle anatomical variations associated with aging.

CONCLUSION

In conclusion, the present study provides a comprehensive evaluation of distal femoral rotational axes in the geriatric population using MRI, highlighting consistent and clinically relevant anatomical patterns. The mean posterior condylar angle (PCA) and Whiteside's epicondylar angle (W-EP) observed in this study were comparable with existing literature, reinforcing their reliability as key reference parameters for assessing femoral rotational alignment. Importantly, no statistically significant differences were found with respect to gender or laterality, suggesting that these anatomical axes remain relatively stable across demographic subgroups in elderly individuals. These findings underscore the utility of standard rotational landmarks in guiding surgical procedures such as total knee arthroplasty (TKA). However, subtle variations observed within the population emphasize the need for individualized preoperative assessment, particularly in geriatric patients with degenerative changes. Overall, this study contributes valuable data that may aid in optimizing surgical accuracy and improving functional outcomes in knee arthroplasty.

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