

# Assessment of Rotational Anatomy of Distal Femur in Sudanese Population and Its Relevance in Total Knee Arthroplasty

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## Abstract

**Background:** Accurate restoration of normal knee anatomy and alignment is the main goal and objective of knee surgery. In the field of total knee arthroplasty, positioning of the implants in the axial plane is referred to as rotational alignment (Victor et al., 2009). Correct Rotational positioning of femoral and tibial components is critical in total knee arthroplasty (TKA). Failure in implant positioning may result in disproportionate tension on the ligaments, causing complications such as development of pain, stiffness, instability or early loosening of the implant (Aglietti et al., 2008). **Objective:** This study aims to measure the angular relationships of the distal femoral rotational axis in normal Sudanese population. **Material and Methods:** Magnetic resonance imaging (MRI) scans of the knees of 148 Sudanese subjects were used to define the axes and angles. 114 of these subjects were males and 34 were females. The posterior condylar angle (PCA), the Whiteside-zepicondylar angle (W-EP), the condylar twist angle (CTA), and the Whiteside trochlear anteroposterior line—posterior condyle line angle (WAP/PCL) were measured. **Results:** The mean posterior condylar angle (PCA) is 1.69°, the mean condylar twist angle (CTA) is 5.64°, the mean Whiteside-epicondylar angle is 88.98° and the mean Whiteside trochlear anteroposterior line—posterior condyle line angle (WAP/PCL) is 4.64°. **Conclusion:** This study concluded that there is a difference in the angular relationships of the distal femoral rotational axes between the Sudanese, western, Chinese, Indian, Iranian, Brazilian and Japanese. So using a fixed value to define the angular relationships between the axes and performing the cuts according to these fixed values could lead to malrotation of the femoral component.

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## Keywords

Rotational Anatomy, Knee, Sudanese Population

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### 1. Introduction

The knee joint is vulnerable to various degenerative (Lespasio et al., 2017) and inflammatory diseases (Danoff et al., 2013), which destroy the articular cartilage and lead to loss of joint function. Accurate restoration of normal knee anatomy and alignment is the main goal and objective of knee surgery.

In the field of total knee arthroplasty, positioning of the implants in the axial plane is referred to as rotational alignment (Victor et al., 2009). Correct rotational positioning of femoral and tibial components is mandatory in total knee arthroplasty (TKA), and that when this is not achieved may result in disproportionate tension on the ligaments, which lead to complications such as development of pain, stiffness, instability or early loosening of the implant and failure (Rossi et al., 2010).

If the femoral component is inserted inappropriately, malrotation induces patellofemoral maltracking and flexion gap mismatch. Patellar maltracking may end in patella dislocation or severe limited range of motion and flexion gap mismatch results in knee instability (Sun et al., 2007). These complications affect the postoperative clinical outcome and patients' satisfaction and reduce the life span of prostheses. Multiple researches have confirmed the relation between malrotation of femoral component and early failure of TKA (Uehara et al., 2002).

Sometimes intraoperative determination of the bony landmarks of the distal femur and identification of the secondary reference axis is difficult for surgeons.

The most accurate reference for the rotation of distal femur is the surgical transepicondylar axis (S-TEA); the line connecting the tip of the lateral epicondyle to the medial epicondylar sulcus (Ohmori et al., 2017). It is difficult to identify the femoral epicondyle and medial sulcus during surgery (Rossi et al., 2010), so the majority of orthopedic surgeons prefer to use the more accessible posterior femoral condyle axis and cut the anterior and posterior part surfaces at 3 degree of external rotation relative to posterior condyle axis. It is important to put in our mind that there are many factors that change the rotation of the distal femur, and hence change the angle between the posterior condyle axis and the transepicondylar axis such as gender and condyle hypoplasia (Rossi et al., 2010).

Most total knee arthroplasty instruments utilize the posterior condylar line of the femur to guide the implant positioning with a three-degree external rotation in the axial plane. Such a reference has shown to be appropriate in cases of neutral or varus knee alignment; but in cases of valgus knee deformity, this is not an ideal reference (Victor et al., 2009).

There is a recent questioning regarding the use of anatomical parameters as a

reference for implant positioning, without considering the patient's own characteristics such as age, gender, height and race (Ohmori et al., 2017).

## 2. Research Question

Should the orthopaedic surgeons in Sudan position the implants of the total knee replacement in different angles compared to western population because of the different anatomy between the two populations?

## 3. Methodology

### 3.1. Study Design

This is an observational descriptive study done in Khartoum State, Alamal Hospital. The study was conducted from June 2019 to November 2020.

### 3.2. The Study Population

Sudanese patients attended to the radiological clinic to do MRI for different indications.

### 3.3. Inclusion Criteria

Any patient between 20 - 55 years of age. But patients with previous knee fracture, knee surgery, infection or severe osteoarthritic changes were excluded.

### 3.4. Sample size

148 knees were studied.

The following formula was used to measure the sample size:

$$SS = \left[ Z^2 p(1 - p) \right] / C^2$$

where  $SS$  = Sample size,  $Z$  = Given  $Z$  value,  $p$  = Percentage of population,  $C$  = Confidence level  $Pop$  = Population.

We measured the following angles:

- 1) The posterior condylar angle (PCA): the angle which is formed by the posterior condylar line and the surgical-transepicondylar axis (TEA) (**Figure 1**).
- 2) The condylar twist angle (CTA): the angle which is formed by the posterior condyle line and the anatomical transepicondylar axis (**Figure 1**).
- 3) The Whiteside-epicondylar angle (W-EP): the angle which is formed by the Whiteside trochlear anteroposterior line and the anatomical-transepicondylar axis (**Figure 1**).
- 4) The Whiteside trochlear Anteroposterior line—posterior condyle line angle (WAP/PCL): The angle which is formed by the posterior condyle line and a line perpendicular to Whiteside line (AP axis) (**Figure 1**).

Data were collected by radiologist from the hospital record and analyzed using statistical package for social science (SPSS, version 22).

Ethical considerations: approval from ethical committee at Faculty of Medi-

cine and health sciences Omdurman Islamic University was obtained.

#### 4. Results

The data of 148 cases were analyzed. The mean age of the patients was 35.2 years (ranging from 20 - 55 years).

The mean of the condylar twist angles is  $5.64^\circ \pm 1.54^\circ$  (Table 1). They range between ( $2.3^\circ$  to  $9.5^\circ$ ). The Mean condylar twist angle of the males is  $5.59^\circ \pm 1.56^\circ$  and of the females is  $5.80^\circ \pm 1.46^\circ$  with no significant difference between the two genders ( $p$  value = 0.360).

The mean of the posterior condylar angles is  $1.69^\circ \pm 1.12^\circ$  (Table 1). They range between ( $-1.5^\circ$  to  $4.8^\circ$ ). The mean posterior condylar angle of the males is  $1.65^\circ \pm 1.14^\circ$  and of the females is  $1.81^\circ \pm 1.06^\circ$  and there is no significant difference between the two genders ( $p$  value = 0.474).

The mean of the white side-epicondylar angles (W-EP) is  $88.98^\circ \pm 1.60^\circ$  (Table 1). They range between  $85.6^\circ$  to  $93.8^\circ$ . The mean whiteside—epicondylar angle of the males is  $88.99^\circ \pm 1.64^\circ$  and of the females is  $88.98^\circ \pm 1.49^\circ$  with no significant difference between two genders ( $p$  value = 0.317).

The mean of the white side-anteroposterior trochlear line—posterior condylar line angles (WAP/PCL) is  $4.64^\circ \pm 2.17^\circ$  (Table 1). They range between  $4^\circ$  to  $10.5^\circ$ . The mean WAP/PCL angle of the males is  $4.66^\circ \pm 2.12^\circ$  and of the females is  $4.60^\circ \pm 2.34^\circ$  with no significant difference between two genders ( $p$  value = 0.429).

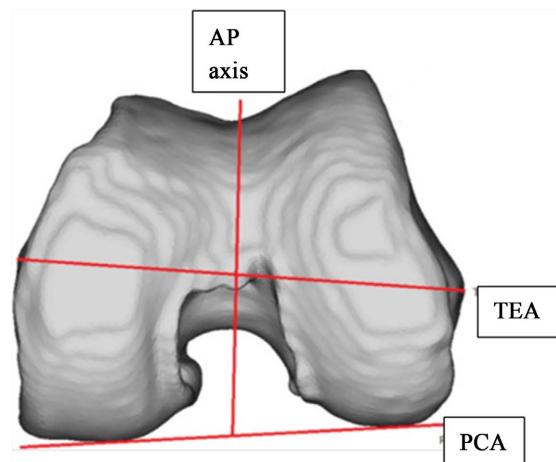


Figure 1. The axes of distal femur.

Table 1. The mean, range, and SD of the measured angles.

Angle	Range	Mean	SD
PCA	$-1.5^\circ - 4.8^\circ$	$1.69^\circ$	$1.12^\circ$
CTWA	$2.3^\circ - 9.5^\circ$	$5.64^\circ$	$1.54^\circ$
W-EP	$85.6^\circ - 93.5^\circ$	$88.98^\circ$	$1.60^\circ$
WAP/PCL	$4^\circ - 10.5^\circ$	$4.64^\circ$	$2.17^\circ$

## 5. Discussion

The importance of rotational alignment of the femoral component in TKA is now increasingly recognized. Several studies stated the importance of proper rotational alignment of the femoral component in TKA (Victor et al., 2009). Rotational malalignment still accounts for an unacceptable number of failures in total knee arthroplasty (Rossi et al., 2010).

Rotational alignments depends upon the anterior and posterior cuts of the distal femur. performing these cuts in a three degrees external rotation based on the posterior condylar axis or the other axes may result in malalignment because these axes are not fixed. They differ according to many factors including the race (Victor et al., 2009).

As a result of this study, the mean PCA in Sudanese population is about 1.69°. This is less than the mean angle of the western population and less than that of Chinese and Brazilian populations, but it is similar to the Iranian population (Table 2).

Berger et al. examined 75 anatomic specimen femurs in USA. The mean PCA was 4.7 in the males and 5.2 in the females. Griffin et al. used MRI to measure the PCA in patients with minor soft tissue pathology  $3.11 \pm 1.75$  degree (Griffin et al., 1998) (Table 2).

Daniel et al., who studied this angle among southern Chinese, stated that the mean PCA is 5.1 degree in males and 5.8 in females. Their mean angle is bigger even than that of the western population (Yip et al., 2004) (Table 2).

The Loures et al. study rotational assessment of distal femur in Brazilian population and the mean PCA was 6.89°. The Brazilian mean PCA is larger than the Chinese and the Western ones (Loures et al., 2015) (Table 2).

Jabalameh et al. studied measured the PCA in Iranian Population and the mean angle was  $1.9 \pm 1.85$  degree. It is the most approximate mean PCA to the Sudanese' one (Jabalameh et al., 2006) (Table 2).

As a result of our study the mean CTA is 5.64° which is approximate to the mean angles of the western and Iranian populations which are 5.5° and 5.68° respectively. The Brazilian is 6.89° and the Indian 4.67° (Table 2).

The mean WAP/PCL angle in our study is 4.64° which is greater than that of western and Iranian (3.8° - 3.1° respectively) but is smaller than the Chinese o (7°) and similar to the Brazilian one (4.64°) (Table 2).

**Table 2.** Comparison between PCA, CTA, WAP/PCA, and W-EP in different races.

Race	PCA	CTA	WAP/PCA	W-EP
Sudanese	1.69°	5.64°	4.64°	88.98°
Western	3.5°, 3.1°, 3°	4.7°, 6.7°, 6.4°	3.8°, 3.1°	<90°
Chinese	5.1°, 3.67°		7°	91.7°
Iranian	1.9°	5.68°	3.7°	
Brazilian	2.89°	6.89°	4.47°	

The mean whiteside-epicondylar (W-EP) angle in this study is 88.98°. The mean angle of western population is approximate (90°) and of the Indian and Chinese is greater (92.7°, 90.5° respectively) (**Table 2**).

## 6. Conclusion

The posterior condyle axis and the other axes are used as references to make the rotational alignment of the distal femur differ among different races, so it is unwise to adopt a fixed degree of external rotation in all cases. Preoperative CT scanning can help to determine the rotational landmarks of the distal femur more accurately.

Sudanese orthopaedic surgeons should put these differences in their minds when doing knee replacement surgeries in order to put the implants in angles suitable to Sudanese population.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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