The Knee 21 (2014) 553–556

Contents lists available at ScienceDirect

The Knee

Clinical relevance

Posterior femoral condylar offsets of a Chinese population

Wei Wang [a,b], Tsung-Yuan Tsai [a], Bin Yue [c], Young-Min Kwon [a], Guoan Li [a,*]

[a] Bioengineering Laboratory, Department of Orthopaedic Surgery, Massachusetts General Hospital, Harvard Medical School, 55 Fruit Street, Boston, MA 02114, USA
[b] Department of Orthopaedic Surgery, Second Affiliated Hospital, Medical School of Xi'an Jiaotong University, Xi'an, Shaanxi Province, China
[c] Department of Orthopaedic Surgery, Shanghai Ninth People's Hospital, Shanghai, Shanghai, China

ARTICLE INFO

Article history:
Received 28 November 2012
Received in revised form 26 February 2013
Accepted 13 March 2013

Keywords:
Knee
Knee replacement
Arthroplasty
Posterior condylar offset
Posterior condylar offset ratio

ABSTRACT

Background: The effect of posterior condylar offset (PCO) on maximal flexion of the knee after TKA is controversial. Another parameter, the posterior condylar offset ratio (PCOR), has been recently introduced to describe the posterior condylar geometry. This study measured the posterior femoral condyle geometry of a Chinese population and compared with those of a Western population published in the literature.
Methods: We measured the PCO and PCOR of 100 Chinese knees (50 males, 50 females). The distances from the anterior and posterior femoral shaft cortex line to the most posterior femoral condyle tangent line were defined as the anterior–posterior dimension (ACP) and posterior condylar offset (PCO). The PCOR was calculated as PCO/ACP. The measured PCO and PCOR were compared to those of a Western population reported in the literature.
Results: The PCOs were 25.80 ± 2.71 and 27.32 ± 2.34 mm for the Chinese females and males, respectively, where the PCO of the females was significantly smaller than that of the males ($p < 0.05$). The PCORs were 0.47 ± 0.04 and 0.46 ± 0.03 for the Chinese females and males, respectively, where the PCORs were similar among the Chinese males and females ($p > 0.05$).
Conclusions: While the PCO of the Chinese females was smaller than that of the males, their PCORs were similar. Compared to the data of a Western population reported in literature, the PCO of the Chinese population is significantly smaller, but the PCOR is significantly larger.

1. Inroduction

Although the Asian and Middle Eastern populations are more demanding on deep flexion of the knee in their daily life [1–4], literature reviews indicated that contemporary total knee arthroplasty (TKA) does not enhance knee flexion in Asian patient population and leads to similar maximal flexion angles of the knee compared to Western patients [5–7]. Recently, the ethnic features of the knee have been reported in several studies in order to understand if the contemporary TKA designs are compatible to the anatomies of patients from different races [5,8–10]. Yue et al. [11] showed that in addition to the fact that the knees of a Chinese population were generally smaller than those of a Caucasian population, there are also certain differences in aspect ratios of the tibia and femur between the two populations. Ha et al. [12] measured 1168 Korean knees intra-operatively and showed that, for different reasons, current TKAs do not provide a reasonable fit for small or large Korean knees; that the 'gender-specific' and 'stature-specific' components help for large Korean femurs but offer less satisfactory fits for small femurs. These ethnic differences in knee geometric features have not been considered in the development of ethnic specific total knee arthroplasty prostheses.

Among the various factors that may affect deep knee flexion, the posterior condylar offset (PCO) has been assumed to play a critical role in influencing the flexion capability of the knee after TKAs. There are studies that found a correlation between the PCO with knee flexion [13–15], but there are also studies that did not find a correlation [16–19]. Since the PCO may be affected by the size of the knee, several studies have reported a normalized PCO by the anterior–posterior dimension (ACP) of the distal femur, the posterior condylar offset ratio (PCOR) [20,21], to represent a geometrical feature of the distal femur. However, there is no data reported on the PCORs of Asian populations. This information may be important to examine if contemporary TKA components match the anatomy of Asian populations.

Therefore, the objective of this study was to measure the PCOR of a Chinese population using similar measurement techniques previously used to investigate Western patients [13,20,22]. Both male and females were studied. Further, the PCORs of the Chinese population were compared to those of a Western population [20]. We hypothesized that although there is a size difference between the two populations, the geometric feature (PCOR) is similar between the Chinese and Western populations.

2. Materials and methods

The knees of 100 Chinese (50 males, 50 females) were scanned using a helical CT scanner (GE Medical System, Milwaukee, WI). The mean age

* Corresponding author at: Bioengineering Laboratory, Department of Orthopaedic Surgery, Massachusetts General Hospital/Harvard Medical School, 55 Fruit St., GRJ-1215, Boston, MA 02114, USA. Tel.: +1 617 726 6472; fax: +1 617 724 4392.
E-mail address: gli1@partners.org (G. Li).

0968-0160/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.knee.2013.03.010

of the subjects was 47 years. There were 50 right and 50 left knees. The images were acquired in a field view of 360 × 360 mm and 0.625 mm in thickness in the longitudinal direction of the knee (resolution: 512 × 512 pixels). The CT images were imported into solid modeling software (Rhinoceros®, Robert McNeel and Associates, Seattle, WA) and automatically segmented to construct 3D bony models of the femur (Fig. 1).

To measure the PCO in sagittal plane, we adopted a method that is similar to that of Johal et al. [20]. Using this method, the femur was projected on its sagittal plane where the contours of both femoral condyles overlap (Fig. 1). In the sagittal plane, the femoral long axis was drawn with equal distance to the anterior–posterior edges of the femoral shaft (Fig. 1). One line was drawn parallel to the anterior femoral shaft cortex and another parallel to the posterior femoral shaft cortex. A third line was drawn parallel to the posterior femoral shaft cortex line, but tangent to the most posterior femoral condyles to represent the posterior condylar tangent line. The anterior–posterior dimension of the distal femur was defined as the distance between the anterior femoral shaft cortex line and the posterior femoral condyle tangent line, which was noted as ACP in Fig. 1. The posterior femoral condyle offset (PCO) was determined as the distance between the posterior femoral shaft cortex line and the posterior femoral condyle line that was noted as PCO in Fig. 1. The posterior femoral condyle offset ratio (PCOR) was calculated as the ratio of the posterior femoral condyle offset and the anterior–posterior dimension of the distal femur, i.e., PCO/ACP [20].

The PCO, ACP and PCOR of the female and male subjects were compared using a one way ANOVA. Further, we also analyzed the correlation of the PCOR with the PCO and the ACP of the femur to examine the effect of the size of the knee on PCOR. The data of the Chinese population was compared with the data of a Western population reported by Johal et al. [20] using a Chi-square test [23].

3. Results

The anterior–posterior dimension of the femora (ACP) was 56.92 ± 3.72 mm and the posterior femoral condyle offset (PCO) was 26.56 ± 2.63 mm for the Chinese population (Table 1). For the Chinese females, the PCO was 25.80 ± 2.71 mm and the PCOR was 0.47 ± 0.04; and for the Chinese males, the PCO was 27.32 ± 2.34 mm and the PCOR was 0.46 ± 0.03 (Table 1). The PCO of the Chinese females is significantly lower than that of the males ($p = 0.008$). The PCOR was not significantly different between the females and males ($p = 0.233$).

The correlations between the PCO and ACP and between the PCOR and ACP of the Chinese population were depicted in Figs. 2 and 3 together with the data of the Western population obtained from the literature [20]. The PCO has a positive correlation with the ACP for both the females ($R^2 = 0.4723$) and males ($R^2 = 0.4226$) (Fig. 2). The PCOR has no correlation with the ACP for the females ($R^2 = 0.0307$) and males ($R^2 = 0.0156$) (Fig. 3).

To compare the data measured from the Western population [20], the PCOs of the Western females (27.19 ± 2.15 mm) and males (29.01 ± 2.04 mm) are significantly larger than those of the Chinese populations ($p = 0.000$ and $p = 0.000$) (Table 2). However, the PCORs of the Western population (female: 0.45 ± 0.02 mm; male: 0.44 ± 0.02 mm) are significantly smaller than those of the Chinese population (female: 0.47 ± 0.04 mm; male: 0.46 ± 0.03 mm) ($p = 0.002$ and $p = 0.002$), respectively, indicating that for any given ACP, the posterior condylar offset is greater in Chinese patients.

Table 1
Femoral measurements categorized by sex in a Chinese population.

	Male (n = 50)	Female (n = 50)	p-Value	Entire population
	$\bar{x} \pm std$ (mm)	$\bar{x} \pm std$ (mm)		
PCO (A)	27.32 ± 2.34	25.80 ± 2.71	0.008	26.56 ± 2.63
ACP (B)	59.10 ± 2.81	54.74 ± 3.20	0.000	56.92 ± 3.72
PCOR (A/B)	0.46 ± 0.03	0.47 ± 0.04	0.233	0.47 ± 0.03
C (=B–A)	31.78 ± 2.20	28.94 ± 2.38	0.000	30.36 ± 2.69
PCO/C	0.87 ± 0.10	0.90 ± 0.13	0.204	0.88 ± 0.12

4. Discussion

This study investigated the morphologic features of the distal femur of a Chinese population. We found that in the Chinese population, although the femur of the males is larger in size than that of the females, the posterior femoral condylar offset ratio (PCOR) is not significantly different between them. We also found that in the Chinese population, both females and males, the magnitudes of the PCO are positively correlated to the anterior–posterior dimension (ACP), but no correlation of the PCOR with the anterior–posterior dimension was observed. Compared with the data of a Western population reported by Johal et al. [20], we found that the posterior femoral condyle offsets of the Chinese population were significantly smaller than those of the Western population in both males and females, but the PCORs of the Chinese population were significantly larger than those of the Western population. This indicated that not only the sizes of the knees are different between the two populations, but also the shapes of the posterior femoral condyles are different.

Few studies have reported the PCO of Asian populations. Kim et al. [18] measured the pre-operative radiographs of Korean patients for TKA operations and reported the posterior condylar offsets of 26.55 mm. Hanratty et al. [17] reported the mean pre- and post-operative posterior condylar offsets of 25.9 mm and 26.9 mm in a Western population. These data are close to our measurements of the PCO of the Chinese population. No data has been reported on the PCORs of Asian populations.

The data of this paper may reveal an interesting geometric feature of the knees of the Chinese population. The posterior femoral condylar offset ratios were found to be similar among the male and female subjects in the Chinese population, although the PCO values increased with the anterior–posterior dimension of the femur. This implies that the PCOR may represent a common feature of the Chinese population. Furthermore, despite that the PCO of the Chinese population is smaller than that of the Western population; the PCOR of the Chinese population is actually higher than that of the Western population. This may indicate that the PCOR could be a morphological characteristic among the two racial populations and it may be important to use posterior referencing instruments in TKA in order to avoid overresecting the posterior condyles.

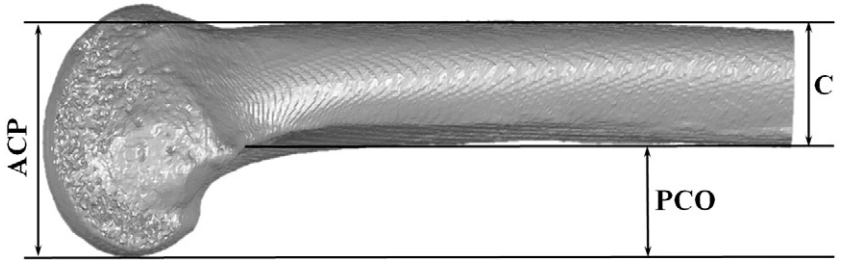

Fig. 1. A right femoral model reconstructed from CT images was projected on the sagittal plane for measurement of distal femoral parameters. The posterior condylar offset (PCO), anterior–posterior dimension (ACP) and A–P width of the distal femoral shaft (C).