Correlation of Intraoperative Anthropometric Measurement of Resected Thai Distal Femurs between Unisex and Gender-Specific Implants

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Objective: *To measure the intraoperative anthropometric dimensions of Thai distal femurs in order to correlate that data with unisex and gender-specific TKR implants, and to analyze the suitability of gender-specific prostheses for Thai female knees.*
Material and Method: *Two hundred Thai patients (170 females and 30 males) who underwent unilateral TKR were recruited. Three parameters of resected distal femurs were measured intraoperatively including anteroposterior dimensions of medial (APM) and lateral (APL) condyles, and mediolateral (ML) width of total condyles which were compared with the dimensional data of two femoral implant components, Nexgen LPS-Flex and Gender Solution Nexgen LPS-Flex. Scatter diagrams were used to assess compatibility; the final type and size of implanted prostheses were recorded.*
Results: *Thai females had significantly smaller knees than Thai males. The femoral components of both types of prostheses were found to have a tendency toward ML under-coverage in both female and male femurs. These mismatches were more noticeable when small-sized, gender-specific prostheses were used. The overall rate of use of gender-specific components in this study was 15%.*
Conclusion: *The unisex and gender-specific prostheses evaluated in this study do not appear suitable for Thai knees. Particular modifications of implants are required for Thai knees.*

Keywords: *Anthropometric measurement, Total knee arthroplasty, Resected femur, Knee joint prostheses, Knee dimensions*

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There are three important anatomical differences in the shape of female and male knees. Female knees differ in distal femur morphology including increased Q-angle, a less prominent anterior femoral condyle and a reduced mediolateral to anteroposterior femoral condylar aspect ratio[1,2]. Gender-specific designs of total knee replacements (TKR) have been developed to accommodate those differences and to provide a proper fit for female knees. However, those prostheses are designed for Caucasian, not for Asian patients. Previously, several studies reported that the size and morphology of Asian knees are a significantly different from Caucasians knees[3,4]. Mismatches between the knees and the dimensions of prostheses may increase the degree of difficulty during TKRs[5]. There have been several studies which matched the morphology of Asian distal femurs to the currently used TKR prostheses including gender-specific designs; however, most of those studies collected data using advanced imaging technologies, e.g., computed tomography, CT or magnetic resonance imaging, and MRI[6-11]. The authors believe that data obtained from the resected femur during surgery is more reliable and practical. Therefore, the aim of this study is to compare the intraoperative anthropometric data on Thai distal femurs to the current TKR prostheses, both unisex and gender-specific designs.

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Material and Method

The Ethics Committee and the Institutional Review Board of Siriraj Hospital approved this study. A total of 200 consecutive patients who underwent unilateral TKR for treatment of primary osteoarthritis were recruited. Patients who had a previous distal femoral fracture or a substantial bone defect requiring augmentation were excluded. All TKRs were performed by the senior author (KC). After osteophyte removal, the distal femur was cut at five degrees in the

valgus direction using an intramedullary-guided rod. The cut was made at a level seven mm from the medial joint line. The anterior cut flat across the femoral shaft was done using an anterior referencing cutting guide. Whiteside's line and the transepicondylar axis[12-14] were used to determine the rotation of the anterior cut. No anterior femoral notching was observed in this study. The following two dimensions of the resected distal femur were measured: the anteroposterior dimensions of the medial (APM) and lateral femoral condyles (APL) from the anterior cut to the posterior femoral condyles and parallel to Whiteside's line, and the mediolateral (ML) width (distance between the medial and lateral cortex at the transepicondylar axis) (Fig. 1). The surgeon measured all dimensions in millimeters using a sterile Vernier caliper. One of two prosthetic designs, either Nexgen LPS-Flex (Zimmer, Warsaw, Indiana) or Gender Solutions Nexgen LPS-Flex (Zimmer, Warsaw, Indiana), were then implanted. The proper size of the femoral components was determined based on the antero-posterior dimensions of the distal femur and the surgeon's preference. After selecting the proper size, if the mediolateral overhang of the standard prosthesis was more than two mm, the gender-specific implant was considered. Data about anteroposterior (AP) and ML lengths of femoral components were obtained from the manufacturer. The dimensions of the patients' knees were analyzed and matched to the prostheses.

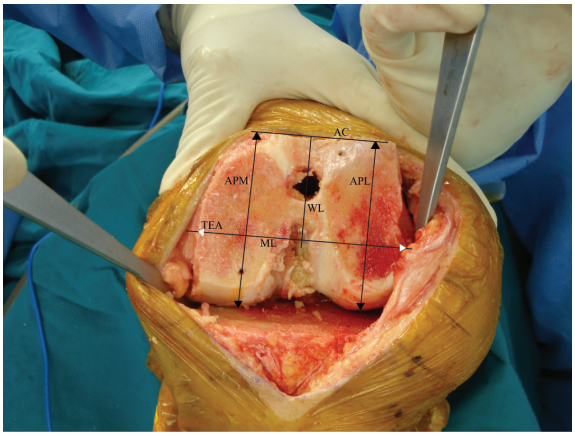

Fig. 1 Measured dimensions of the resected distal femur (APM = anteroposterior dimensions of medial femoral condyle; APL = anteroposterior dimensions of lateral femoral condyles; ML = mediolateral width; AC = anterior cut; WL = Whiteside's line; TEA = transepicondylar axis).

Statistical analysis

The data were analyzed using SPSS statistical software, version 17.0 (SPSS Inc., Chicago, Illinois). For quantitative data, the mean, standard deviation and range were calculated. Differences in outcomes were analyzed using the Student's t-test. The *p*-value less than 0.05 were regarded as statistically significant. Scatter diagrams were plotted to assess the compatibility between prostheses and patients data.

Results

There were 170 female and 30 male knees included in this study. The mean age and body mass index of the women were 70.6±7.1 years (range 46 to 85) and 26.6±4.1 kg/m^2 (19.4 to 35.9), respectively, and of the men were 71.7±7.2 years (54 to 82) and 25.3+3.3 kg/m^2 (18.8 to 33.4), respectively. Although all dimensions of females, including APM, APL, and ML, were significantly smaller than for males (p<0.001), no differences in the calculated ratio between genders were observed in the present study (p>0.05). A summary of the intraoperative anthropometric data of the resected distal femurs is shown in Table 1.

The scatter plot of femoral APM and ML dimensions (Fig. 2) show that both female and male femurs are generally wider than those provided by both types of femoral components. These findings reflect the ML under-coverage of resected bones. The mismatches which occurred were more noticeable when small-sized, gender-specific prostheses were

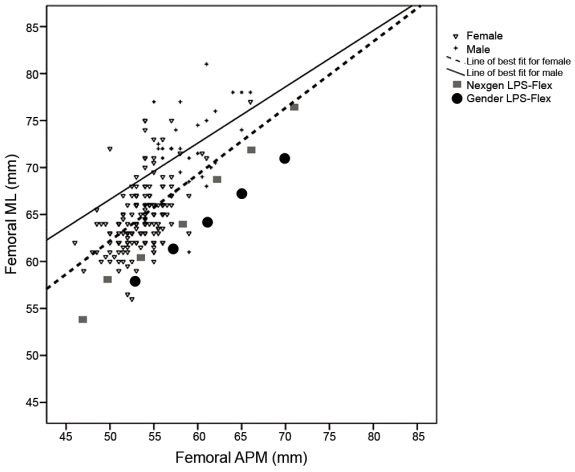

Fig. 2 Scatter plot of the mediolateral width (ML) versus anteroposterior dimensions of medial femoral condyle (APM) in females and males, showing the lines of best fit for both genders.

Table 1. Intraoperative anthropometric data of resected distal femurs

Dimension*	Female (n = 170)	Male (n = 30)	*p*-value#
APM (mm)	53.6±2.6 (46.1-66.0)	59.2±3.3 (54.0-66.2)	<0.001
APL (mm)	51.6±2.4 (44.2-62.3)	56.5±3.2 (51.5-63.0)	<0.001
ML (mm)	64.7±3.6 (56.0-77.0)	72.1±4.4 (61.1-81.0)	<0.001
ML/APM ratio	1.21±0.06 (1.07-1.44)	1.22±0.08 (1.03-1.40)	0.396
ML/APL ratio	1.26±0.07 (1.10-1.47)	1.27±0.07 (1.12-1.43)	0.167
APM/ML ratio	0.83±0.04 (0.69-0.94)	0.82±0.05 (0.71-0.97)	0.451
APL/ML ratio	0.80±0.04 (0.68-0.91)	0.79±0.04 (0.70-0.89)	0.177

APM = anteroposterior dimensions of the medial femoral condyle; APL = anteroposterior dimensions of the lateral femoral condyle; ML = mediolateral width

* All values are presented as mean ± standard deviation (range)

t-test

implanted in male patients. In the femoral ML/APM ratio analysis (Fig. 3), the ratios tended to be greater in smaller knees: males had higher ratios than females for any given APM. Nonetheless, those ratios had a tendency to be smaller than with the prostheses, with the exception of the largest Nexgen LPS-Flex (size G). This means that the use of currently available prostheses commonly resulted in ML under-coverage in Thai knees. This effect was more prominent with small sized components. Finally, 29 female knees (17.1%) and 1 male knee (3.3%) were replaced with gender-specific knee prostheses. The distribution of implants actually used is shown in Fig. 4.

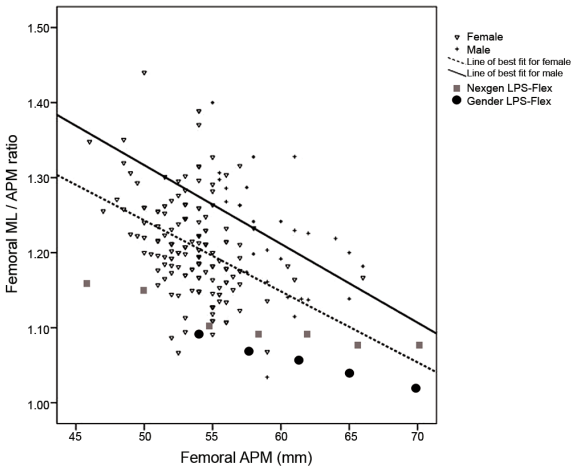

Fig. 3 Scatter plot of the mediolateral width/antero-posterior dimensions of medial femoral condyle ratio (ML/APM) versus anteroposterior dimensions of medial femoral condyle (APM) in females and males, showing the lines of best fit for both genders.

Discussion

Although several studies have demonstrated that Asian knees are usually smaller than Caucasian knees[3,4,15], that morphologic data was obtained from normal cadavers or imaging studies using either plain radiographs or CT scans. In the opinion of the authors, an intraoperative measurement of a knee's dimensions is a simpler, more reliable and more practical method for clinical use. However, there have been few studies focused on this measurement method with Asian knees[5,16,17] and none have been done in Thailand. Ho et al[16] reported that the mean AP and ML lengths of 70 Chinese distal femurs were 63.7±5.1 and 70.2±5.4 mm, respectively. The Nexgen LPS prosthesis (Zimmer, Warsaw, Indiana) tended to overhang the ML width in that study. In another study of a series of

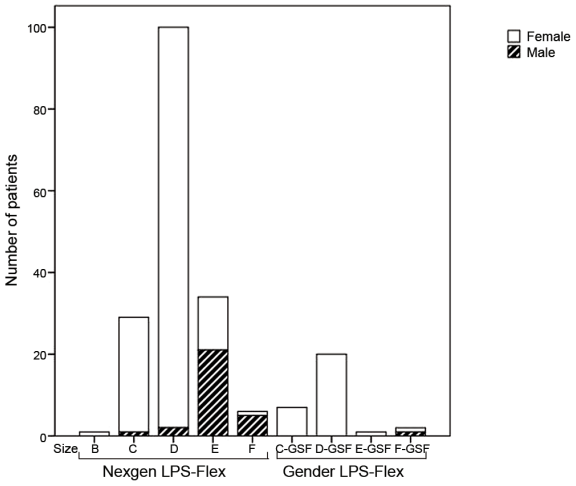

Fig. 4 The distribution of size and type of prostheses used in this study.

1,168 Korean knees, Ha et al[5] found that the Nexgen LPS-Flex prosthesis had a tendency toward ML under-coverage for small knees and ML overhang for large knees. The under-coverage was more prominent when using Gender Solutions Nexgen LPS-Flex in small knees. However, those results could not be directly compared with the present study because the AP height was measured before anterior femoral cutting unlike the method used in the present study.

Only two studies were located which used the same intraoperative measurements as the present study. One studied Asians[17] and the other Caucasians[18]. The data from the three studies are shown in Table 2. Like the study by Lonner et al[18], the present study found that Asian distal femurs were smaller than for Caucasians. Nevertheless, the APM/ML ratios, called the aspect ratio in some studies[1,17], for Thai knees have a similar aspect ratio to Caucasian knees. This is in disagreement with a previous study from Singapore[17]. Even though Chin et al[17] claim that Singapore might have an ideal population to represent Asian knees as it is a multiracial Asian country, Thai patients were not included in that study. The present study found that Thai knees have a smaller AP dimension but similar ML width compared to Singapore knees. Thus, Thai knees have a greater risk of ML under-coverage. The scatter plots in this study demonstrate that Thai femurs are wider than typical prosthesis widths, even unisex prostheses. By reason of their narrower ML dimension, gender-specific designs give a poorer fit in Thai knees and result in more ML under-coverage. Under-coverage alters the stress distribution and affects patellar tracking[19], drawbacks which might result in the reduced long-term survival of TKA[20]. Therefore, although these components were used as an option for reducing the ML overhang in unisex components, the currently available gender-specific prostheses are not suitable for Thai knees. The overall rate of using gender-specific components in the present study was 15%.

Conclusion

It is suggested that the unisex and gender-specific prostheses used in the present study are not suitable for Thai knees as they do not provide the best fit of femoral components. Specific modifications of implants are required for Thai knees.

Limitations of the study

The present study is the first report of intraoperative anthropometric data in Thai knees. There are some limitations in the study. First, the majority of the patients were women. Ideally, the number of patients of both genders should be roughly

Table 2. Comparison of the data from three studies that used the same intraoperative measurements

Data*	The current study	Chin et al[17]	Lonner et al[18]
Country	Thailand	Singapore	USA
Female:male	170:30	290:62	100:100
APM (mm)			
Female	53.6 (46.1-66.0)	68.1 (60.5-77.5)	56.3 (44.0-70.0)
Male	59.2 (54.0-66.2)	73.8 (65.6-83.1)	62.3 (52.5-74.0)
APL (mm)			
Female	51.6 (44.2-62.3)	66.5 (57.5-75.5)	NA
Male	56.5 (51.5-63.0)	71.3 (64.6-80.6)	NA
ML (mm)			
Female	64.7 (56.0-77.0)	63.0 (51.0-77.0)	67.5 (57.5-87.0)
Male	72.1 (61.1-81.0)	73.0 (64.0-80.0)	76.9 (45.0-89.0)
APM/ML ratio			
Female	0.83 (0.69-0.94)	1.09 (0.92-1.39)	0.84 (0.57-1.03)
Male	0.82 (0.71-0.97)	1.00 (0.91-1.18)	0.81 (0.66-1.34)
APL/ML ratio			
Female	0.80 (0.68-0.91)	1.06 (0.89-1.36)	NA
Male	0.79 (0.70-0.89)	0.98 (0.84-1.14)	NA

APM = anteroposterior dimensions of the medial femoral condyle; APL = anteroposterior dimensions of the lateral femoral condyle; ML = mediolateral width; NA = not available

* Values are presented as mean (range)

equal. However, the ratio of females to males in the present study is proportional to the routine TKR service provided by this institution. Second, the distribution of knee prostheses used is mostly confined to sizes C through E. Lack of data from small and large knees may have influenced the outcomes. Third, the prostheses matched were from a single company. Although other companies have various prosthetic designs with different dimensions, Zimmer Company is the only company that provides gender-specific implants in Thailand. Lastly, the present study analyzed only the reduced ML width of the gender-specific component. An increased Q-angle and thinned anterior flange were not assessed; those changes may provide some benefit to Thai patients.

What is already known on this topic?

Several studies demonstrate that Asian knees are usually smaller than Caucasian knees. However, those morphologic data is obtained from normal cadavers or imaging studies, either plain radiographs or CT. There are few studies used the intraoperative measurement method as our study.

What this study adds?

This study is the first report of intraoperative anthropometric data in Thai distal femurs. We suggest that the used unisex and gender-specific prostheses are not suitable for Thai knees. Particular modifications of implants are required for Thai knees

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Potential conflicts of interest

None.

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ความสัมพันธ์ระหว่างขนาดของกระดูกต้นขาส่วนปลายในคนไทยภายหลังการตัดแต่งกระดูกต้นขาส่วนปลายเพื่อผ่าตัดเปลี่ยนข้อเข่าเทียมกับขนาดของข้อเข่าเทียมทั้งชนิดจำเพาะและไม่จำเพาะต่อเพศ

วิบูลย์ วานิชย์เจริญพร, กีรติ เจริญชลวานิช, จตุรงค์ พรรัตนมณีวงศ์

วัตถุประสงค์: *เพื่อศึกษาวัดขนาดของกระดูกต้นขาส่วนปลายในคนไทยระหว่างการผ่าตัดแล้วนำมาเปรียบเทียบกับขนาดของข้อเข่าเทียมทั้งจำเพาะ และไม่จำเพาะต่อเพศ*

วัสดุและวิธีการ: *ระหว่างการผ่าตัดเปลี่ยนข้อเข่าเทียมในผู้ป่วยหญิงไทย 170 ราย และผู้ป่วยชายไทย 30 ราย ทำการวัดขนาดกระดูกต้นขาส่วนปลายใน 3 ตำแหน่ง คือ ขนาดในแนวหน้าหลังของปุ่มกระดูกด้านใน ขนาดในแนวหน้าหลังของปุ่มกระดูกด้านนอก และขนาดความกว้างของกระดูกต้นขาส่วนปลาย แล้วทำการบันทึกลงในแผนภาพการกระจาย เพื่อหาความสัมพันธ์กับขนาดของข้อเข่าเทียม*

ผลการศึกษา: *กระดูกต้นขาส่วนปลายของผู้หญิงมีขนาดเล็กกว่าผู้ชายอย่างมีนัยสำคัญ ข้อเข่าเทียมที่ใช้มีแนวโน้มที่จะมีขนาดแคบกว่ากระดูกต้นขา ส่วนปลายในทั้ง 2 เพศ โดยความไม่พอดีกันนี้จะพบได้ชัดเจนมากขึ้น เมื่อใช้ข้อเข่าเทียมที่มีขนาดเล็กและจำเพาะต่อเพศ โดยในการศึกษานี้พบมีอัตราการใช้ข้อเข่าเทียมจำเพาะต่อเพศที่ร้อยละ 15*

สรุป: *ข้อเข่าเทียมทั้ง 2 ชนิดนี้ยังมีขนาดที่ไม่เหมาะสมกับคนไทยจำเป็นต้องมีการพัฒนาปรับปรุงให้เหมาะสมกับข้อเข่าของคนไทย*