Oxford Phase 3 Unicompartmental Knee Arthroplasty in Thailand: Distribution of Prosthetic Size and Height Based on Gender Distribution of Femoral Component Size

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Research article

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Abstract

Introduction: Survivorship of Oxford phase 3 unicompartmental knee arthroplasty (OUKA) is strongly influenced by the size of the femoral component (Fc) and the tibial component (Tc) that are selected. The distribution of prosthetic size, and guidelines to determine the ideal Fc size have been mainly studied in Western population. The aim of this study was to determine the distribution of OUKA prosthetic size, and to investigate the factors that significantly influence the selection of Fc size in Thai patients.

Methods: This retrospective study included 773 OUKA that were performed using Oxford Microplasty[®] Instrumentation during 2003-2019. Patient age, gender, side, body weight (BW), height, body mass index (BMI), size of femoral and tibial components, and the matching between components were recorded. The distribution of implant size and their matching was analyzed. Patient characteristics were compared among the Fc sizes. Area under the receiver operating characteristic (AuROC) curve was calculated to measure the performance of significant continuous variables for determining Fc size.

Results: The distribution of Fc size was extra-small (XS) 6.5%, small (S) 65.7%, medium (M) 20.6%, large (L) 7.2%, and extra-large (XL) 0%. The distribution of Tc size included AA 20.2%, A 31.6%, B 24.3%, C 16.3%, D 6.0%, E 1.7%, and F 0%. The most common Fc and Tc sizes in females was S and A, respectively, and in males M and C, respectively. The most common matching pattern used in females and males was S-A (32.3%) and M-C (27.6%), respectively. Concerning factors that influence Fc prediction, we found significant differences in gender, BW, height, and BMI among the Fc sizes. After calculating the AuROC for BW, height, and BMI, we found height to have the highest AuROC with statistical significance. Height based on gender distribution was also analyzed.

Conclusion: In Thai patients, the predominant size of Fc was S for females, and M for males. The predominant size of Tc was A for females, and C for males. The most common matching pattern was S-A for females, and M-C for males. Gender and height were identified as the factors that most strongly influence the prediction of Fc size.

Introduction

Oxford unicompartmental knee arthroplasty (OUKA) is an effective procedure for treating medial compartmental osteoarthritic knee with reportedly good long-term survivorship (1, 2). OUKA was first introduced in 1976, and it has undergone several subsequent modifications. OUKA phase 3, which is the latest design, was introduced in 1998 with new implant size and surgical instrumentation (3, 4).

Since the proper size, accurate position, and accurate alignment of the implant directly influence the survivorship of OUKA (5, 6), OUKA phase 3 has five femoral component (Fc) sizes, and seven tibial component (Tc) sizes to better match patient anatomy (4). Moreover, OUKA phase 3 includes Oxford Microplasty[®] Instrumentation (Zimmer Biomet, Warsaw, IN, USA) that was shown to reduce the risk of malalignment, to help determine an adequate level of tibial resection, and to help avoid unnecessary bone removal (3).

However, the design of the OUKA prosthesis is based on data from Western population. Differences in morphologic features between Western and Asian knees have been reported in previous studies (7, 8). Thus, the distribution of OUKA size in Asian patients might be different from those observed in Western patients. Furthermore, since determination of the proper Fc size is one of the most difficult steps during surgery, several methods have been proposed. Although preoperative radiographic templating is commonly used, Bothra, *et al.* (9) found that it had only slight to moderate reliability. Alternatively, Fawzy, *et al.* (10) developed and proposed a height based on gender guideline to determine the ideal Fc size. However, their guideline was established based on Western data. Therefore, the method proposed by Fawzy, *et al.* (10) may not be appropriate for use in Asian population.

The aim of this study was to determine the distribution of OUKA prosthetic size at our center, and to investigate the factors that influence the selection of Fc size in Thai patients.

Materials And Method

This study was approved by our center's institutional review board, and it was registered in the Thai Clinical Trials Registry (TCTR20210922002). This study retrospectively reviewed 773 knees from 677 patients that underwent OUKA phase 3 using Oxford Microplasty Instrumentation at our institute during 2003 to 2019. All operations were performed by 1 or more of 5 experienced arthroplasty surgeons. The optimal size of Fc was selected using the spoon-based reference. The relationship between the front of the spoon and an estimate of where the articular cartilage surface would have been before the arthritis developed was considered for determination of the Fc size. The femoral sizing spoon, tibial saw guide, and G-clamp were used to determine the proper level of tibial resection. After performing the tibial resection, the excised plateau was used to select the optimal size Tc. The tibial template of the opposite side was laid on the cut surface of the excised plateau to select the Tc size with the proper width. Patient characteristics, including age, gender, operative side, body weight (BW), height, and body mass index (BMI), were collected. Prosthesis-specific details, including Fc size, Tc size, and matching of femoral-tibial component size, were also recorded.

Statistical analysis

Kolmogorov-Smirnov test was used to check continuous data for normal distribution. Continuous data are described as mean $\pm$ standard deviation for normally distributed data, and as median and range for non-normally distributed data. Categorical data were described as number and percentage. Comparison of continuous data among Fc sizes was performed using analysis of variance (ANOVA) or Kruskal-Wallis test. Chi-square test or Fisher's exact test was used to compare categorical data. To evaluate the prediction performance of significant continuous variables to distinguish among Fc sizes, the area under the receiver operating characteristic (AuROC) curve with 95% confidence interval (CI) was calculated. The continuous variable with the largest AuROC was considered to be the factor that most strongly influences the selection of Fc size. Statistical significance was set at a *p*-value <0.05.

Results

The median age of patients in this study was 64.0 years (range: 44-86), and most cases were female (81.2%) (Table 1). The distribution of Fc size is described, as follows: extra-small (XS) 6.5%, small (S) 65.7%, medium (M) 20.6%, large (L) 7.2, and extra-large (XL) 0%. The distribution of Tc size is described, as follows: AA 20.2%, A 31.6%, B 24.3%, C 16.3%, D 6.0%, E 1.7%, and F 0%. The distribution of matching between femoral and tibial component sizes in overall patients is shown in Figure 1. The distribution of femoral component and tibial component sizes in females and in males is shown in Figure 2. The most common Fc and Tc size used in females was S and A, respectively. Whereas the most common Fc and Tc size used in males was M and C, respectively. Similar to the results of matching, the most common matching pattern used in females and males was S-A (32.3% of females) and M-C (27.6% of males), respectively (Figure 3).

Table 1
Patient demographic and anthropometric data for overall patients, and compared among the four femoral component (Fc) sizes

Data	Overall (n=773)	Femoral component size				<i>p</i>
		XS (n=50)	S (n=508)	M (n=159)	L (n=56)	
Age (years)	64.0 (44-86)	64.5 (53-83)	63.0 (46-86)	63.0 (44-86)	65.0 (54-84)	0.239
Gender						<0.001
-Female	626 (81.2%)	47 (94.0%)	489 (96.3%)	89 (56.0%)	3 (5.4%)	
-Male	145 (18.7%)	3 (6.0%)	19 (3.7%)	70 (44.0%)	53 (94.6%)	
Side						0.652
-Right	397 (51.4%)	29 (58.0%)	258 (50.8%)	84 (52.8%)	26 (46.4%)	
-Left	376 (48.6%)	21 (42.0%)	250 (49.2%)	75 (47.2%)	30 (53.6%)	
BW (kg)						
-Overall	66.0 (42.8-117.5)	59.6 (42.8-73.9)	64.1 (43.0-110.9)	71.3 (46.5-108.7)	80.1 (57.0-117.5)	<0.001
-Female	64.7 (42.8-110.9)	60.0 (42.8-73.9)	64.0 (43.0-110.9)	72.4 (46.5-108.7)	71.6 (60.7-84.8)	<0.001
-Male	71.3 (48.0-117.5)	58.0 (48.0-61.0)	67.0 (51.4-76.0)	69.3 (50.0-88.5)	81.1 (57.0-117.5)	<0.001
Height (cm)						
-Overall	156 (139-182)	150 (140-165)	155 (139-169)	161 (145-176)	169 (154-182)	<0.001
-Female	155 (139-175)	150 (140-165)	154 (139-169)	158 (145-175)	161 (160-162)	<0.001

Data presented as median and range or number and percentage

A *p*-value <0.05 indicates statistical significance

Abbreviations: XS, extra-small; S, small; M, medium; L, large; BW, body weight; BMI, body mass index

Data	Overall (n=773)	Femoral component size				<i>p</i>
		XS	S	M	L	
		(n=50)	(n=508)	(n=159)	(n=56)	
-Male	165 (145-182)	153 (150-156)	157 (145-167)	167 (145-176)	169 (154-182)	<0.001
BMI (kg/m²)						
-Overall	26.9 (17.7-46.6)	25.4 (18.7-35.2)	26.6 (17.7-42.8)	27.6 (17.9-46.6)	27.9 (20.9-39.3)	0.014
-Female	27.0 (17.7-46.6)	25.4 (18.7-35.2)	26.7 (17.7-42.8)	29.0 (18.4-46.6)	28.0 (23.4-32.3)	<0.001
-Male	26.6 (17.9-39.3)	24.8 (19.7-27.1)	26.2 (21.1-31.0)	25.3 (17.9-32.4)	27.8 (20.9-39.3)	0.002
Data presented as median and range or number and percentage						
A <i>p</i> -value <0.05 indicates statistical significance						
Abbreviations: XS, extra-small; S, small; M, medium; L, large; BW, body weight; BMI, body mass index						

A comparison of study variables among the Fc sizes revealed significant differences for gender, BW, height, and BMI (Table 1). Boxplots of the median (range) values for BW, height, and BMI compared between genders for each femoral component size are shown in Figure 4. Receiver operating characteristic (ROC) curve analysis was performed and the AuROC for BW, height, and BMI was calculated for overall patients, and for each gender. The results showed height to have the highest AuROC value in both genders for XS, in both genders for S, in females for M, and in females for L. In males, BMI had the highest AuROC value for M, and BW had the highest AuROC value for L (Table 2). We also found that gender significantly influences the selection of Tc size. The distribution of Tc size in both genders is shown in Table 3.

Table 2
The AuROC for BW, height, and BMI to predict femoral component (Fc) size

Femoral component sizes		Parameters	AuROC	95% CI	<i>p</i> -value
Extra-small	Overall	BW	0.74	0.68-0.80	<0.001
		Height	0.75	0.69-0.82	<0.001
		BMI	0.61	0.52-0.69	0.013
	Female	BW	0.70	0.64-0.77	<0.001
		Height	0.71	0.63-0.79	<0.001
		BMI	0.61	0.52-0.69	0.016
	Male	BW	0.95	0.90-1.00	0.007
		Height	0.95	0.90-0.99	0.008
		BMI	0.70	0.44-0.96	0.238
Small	Overall	BW	0.66	0.62-0.70	<0.001
		Height	0.75	0.71-0.79	<0.001
		BMI	0.52	0.47-0.56	0.504
	Female	BW	0.59	0.53-0.64	0.002
		Height	0.60	0.54-0.65	0.001
		BMI	0.55	0.50-0.60	0.075
	Male	BW	0.74	0.65-0.83	0.001
		Height	0.86	0.79-0.94	<0.001
		BMI	0.51	0.39-0.64	0.884
Medium	Overall	BW	0.68	0.63-0.72	<0.001
		Height	0.76	0.72-0.80	<0.001
		BMI	0.53	0.48-0.58	0.319
	Female	BW	0.73	0.68-0.79	<0.001
		Height	0.74	0.69-0.80	<0.001
		BMI	0.63	0.57-0.69	<0.001
A <i>p</i> -value <0.05 indicates statistical significance					
Abbreviations: AuROC, area under the receiver operating characteristic curve; BW, body weight; BMI, body mass index; Fc, femoral component; CI, confidence interval					

Femoral component sizes		Parameters	AuROC	95% CI	<i>p</i> -value
Large	Male	BW	0.62	0.53-0.71	0.011
		Height	0.51	0.42-0.61	0.837
		BMI	0.65	0.56-0.74	0.002
	Overall	BW	0.82	0.76-0.87	<0.001
		Height	0.92	0.89-0.95	<0.001
		BMI	0.58	0.51-0.66	0.042
	Female	BW	0.68	0.39-0.96	0.291
		Height	0.88	0.84-0.93	0.022
		BMI	0.54	0.19-0.89	0.810
	Male	BW	0.79	0.71-0.87	<0.001
		Height	0.73	0.64-0.81	<0.001
		BMI	0.68	0.59-0.77	<0.001
A <i>p</i> -value <0.05 indicates statistical significance					
Abbreviations: AuROC, area under the receiver operating characteristic curve; BW, body weight; BMI, body mass index; Fc, femoral component; CI, confidence interval					

Table 3
Distribution of tibial component (Tc) size in females and males

Gender	Overall (N=774)	AA (n=157)	A (n=244)	B (n=188)	C (n=126)	D (n=46)	E (n=13)	<i>p</i>
Female	629 (81.3%)	151 (96.2%)	234 (95.9%)	165 (87.8%)	71 (56.3%)	8 (17.4%)	0 (0.0%)	<0.001
Male	145 (18.7%)	6 (3.8%)	10 (4.1%)	23 (12.2%)	55 (43.7%)	38 (82.6%)	13 (100.0%)	
A <i>p</i> -value <0.05 indicates statistical significance								

Concerning the factors found to most significantly influence the selection of Fc size, gender was the most significant categorical variable, and height was the most significant continuous variable. Using these two significant factors, the distribution of Fc size relative to patient height in females and males is shown in Table 4.

Table 4
Distribution of femoral component (Fc) size relative to patient height in females and males

Femoral component size					
Female	XS	S	M	L	p-value
Height (cm)					<0.001
≤150.0	25 (16.0%)	124 (79.5%)	7 (4.5%)	0 (0.0%)	
150.1-155.0	12 (5.9%)	178 (88.1%)	12 (5.9%)	0 (0.0%)	
155.1-160.0	9 (4.6%)	143 (73.0%)	43(21.9%)	1 (0.5%)	
>160.0	1 (1.4%)	44 (59.5%)	27 (36.5%)	2 (2.7%)	
Male	XS	S	M	L	
Height (cm)					<0.001
≤155.0	2 (14.3%)	8 (57.1%)	3 (21.4%)	1 (7.1%)	
155.1-160.0	1 (4.3%)	5 (21.7%)	12 (52.2%)	5 (21.7%)	
160.1-165.0	0 (0.0%)	5 (13.9%)	18 (50.0%)	13 (36.1%)	
165.1-170.0	0 (0.0%)	1 (2.4%)	27 (64.3%)	14 (33.3%)	
>170.0	0 (0.0%)	0 (0.0%)	10 (33.3%)	20 (66.7%)	
A p-value <0.05 indicates statistical significance					
Abbreviations: XS, extra-small; S, small; M, medium; L, large					

Discussion

This is the first and largest study in Thailand to evaluate and report the prosthesis size distribution of OUKA phase 3. The ratio of female to male knees in our study was approximately 4:1. This ratio is higher than those reported from previous studies of Asian patients (11, 12). S size and A size were the most common Fc and Tc component sizes, respectively, among females. M size and C size were the most common Fc and Tc component sizes, respectively, among males. The male patients in our study were generally taller than the females. This factor explains the difference in implant size between genders. Although all Fc sizes were used (except extra-large) with several Tc sizes, the optimal matching patterns were XS-AA, S-A, M-C, and L-D. The S-A and M-C matching patterns were the most frequently used patterns in females and males, respectively. All of our matching pattern data were similar to the data reported from a study conducted in Chinese patients (11). In Indian patients, Malhotra, *et al.* (12) included 130 OUKA and found the most common Fc size to be XS for females, and S for males. The Fc size in that study was relatively smaller than that found in our study. From a study conducted in Western population,

Fawzy, *et al.* (10) found that 54% of cases used the M size Fc. However, they did not report the Fc sizes used in each gender.

The results of our study revealed gender and height to be the factors that most significantly influence the selection of the Fc size. These findings are similar to those reported from previous studies in both Western and Asian patients (10, 11). A study in Western patients conducted by Fawzy, *et al.* (10) reported the use of height alone for predicting Fc size to be correct in 56%, acceptable in 38%, and unacceptable in 6%. However, when they used height based on gender, the accuracy was higher, as follows: correct in 75%, acceptable in 25%, and 25% unacceptable. Wang, *et al.* (11) also confirmed gender alone, and height based on gender to be important parameters for Fc selection in Chinese patients. In contrast, Lustig, *et al.* (13) found that patient height correlated with Fc size in males, but not in females. Their small sample size and lower size variation among implants among female patients might explain their results.

Various methods for determining the Fc size have been proposed. Although the use of preoperative radiographic templating is common, the lack of reliability reported from previous study raised concerns about the OUKA templating system (9). Fawzy, *et al.* (10) also reported the accuracy of template prediction to be 67%. Regarding the use of Tc size to predict Fc size, our study found all Fc sizes (except extra-large) to be matched to multiple Tc sizes. This irrelevance rendered this method useless in clinical practice. The optimal Tc size was found to be dependent upon the depth of the vertical cut that affected the excised tibial plateau width, while the optimal Fc size was dependent upon the size of the femoral sizing spoon. The height based on gender guideline proposed by Fawzy, *et al.* (10) is currently the most popular method; however, this method was derived from data collected from Western population. This guideline was reported to be inaccurate when applied in Asian population (11, 12). In our study, the S-sized Fc was predominant in females with all ranges of height. In males, the M-sized Fc was predominant in males with a height ranging with 155.1-170.0 cm. The S- and L-sized Fcs were predominant in males with height ≤ 155.0 and >170.0 cm, respectively. No patients received the XL-sized Fc in our study (Table 4). From our results, the Fawzy, *et al.* (10) guideline cannot be reliably applied in Thai patients.

In the present study, uncertainty prevailed regarding the best method to predict Fc size preoperatively. The final decision was made during the operation. Although Oxford Microplasty® Instrumentation was reported to reduce the risk of malalignment of Fc in both the coronal and sagittal planes compared to the conventional instrumentation (3), its efficacy relative to the selection of the optimal Fc size is still questionable. Malhotra, *et al.* (12) reported the overall accuracy of the femoral sizing spoon to be 75% when used as an intraoperative guide. To improve accuracy during the operation, Tu, *et al.* (14) used an intraoperative C-arm intensifier guide method for determining Fc size that yielded accuracy of up to 92%. However, their method required more intraoperative steps and a longer operative time.

Limitations

This study has some mentionable limitations. First, our study included a relatively small number of patients, and the number of males was much smaller than the number of females. This made it difficult

for us to develop a reliable height based on gender guideline for Thai people. Second, because our patients are smaller than their Western counterparts, our study had no data specific to XL-sized Fc for either gender. This finding was also reported in Chinese and Indian patients (11, 12). Third, our analysis focused mainly on the Fc size because we consider it to be easier to assess the Tc size using the tibial template intraoperatively. Fourth, some errors could occur during the use of the femoral sizing spoon. Severe bone loss over the medial femoral condyle could cause underestimation of the Fc size. In contrast, posterior osteophytes or partial thickness cartilage loss could cause overestimation of the Fc size.

Conclusion

This study reported the distribution of OUKA phase 3 prosthesis using Oxford Microplasty® Instrumentation in Thailand. In Thai patients, the predominant size of Fc was S for females, and M for males. The predominant size of Tc was A for females, and C for males. The most common matching pattern was S-A for females, and M-C for males. Gender and height were identified as the factors that most strongly influence the prediction of Fc size.

Declarations

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Conflict of interest declaration

All authors declare no personal or professional conflicts of interest relating to any aspect of this study.

Funding disclosure

This was an unfunded study.

Ethical approval

This study included human participants. It had been approved by Siriraj Institutional Review Board (SIRB).

Informed consent

Since this study was a retrospective chart review. Informed consent was obtained by phone from all individual participants included in the study.

This protocol was registered before enrollment of the first participant

Trial registration

Availability of data and materials

The data that support the results of this study are available from the corresponding author upon reasonable request.

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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Figures

Figure 1

The distribution of matching between femoral and tibial component sizes in overall patients

Figure 2

The distribution of femoral component (left) and tibial component (right) sizes in females and in males

Figure 3

The distribution of matching between femoral and tibial component sizes compared between genders

Figure 4

Boxplots of the median (range) values for body weight (left), height (middle), and body mass index (right) compared between genders for each femoral component size