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Anthropometric studies of distal femur and proximal tibia using magnetic resonance imaging methods in public hospitals

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Abstract

Background: The therapeutic choice for managing osteoarthritis is total knee arthroplasty (TKA). One of the important things in preparation for TKA operations is the determination of implant size. The TKA prosthesis used in Indonesia is based on European population measurements, whereas the size of Asians is smaller than the size of the Caucasian. **Purpose**: This study aims to determine the anthropometric size of the femur bone in the distal part and the tibia of the proximal part. **Method**: The subjects were 100 knee magnetic resonance imaging (MRI) patients who met the inclusion and exclusion criteria. In the data analysis, the Pearson correlation test was used to determine the relationship between all parameters. **Result:** In the measurement of distal femur parameters, a significant relationship was found between TEA (p = 0,000), AML (p = 0,000), PML (p = 0,000), and AP group (p = 0.003) with sex/gender and age. There is a relationship between the proximal tibia of width parameters ML (p = 0,000 and p = 0.002), and MPW (p = 0,000 and p = 0,000) with sex/gender and age. MPH by age with p-value = 0.001. LPW by gender (p = 0.001), while other parameters have no significant relationship. **Conclusion**: that the size of the distal femoral parameters and the proximal tibia were not affected by the patient's ethnicity and BMI but were significantly affected by age and sex/gender.

Keywords: anthropometry, distal femur, proximal tibia

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INTRODUCTION

Knee osteoarthritis is one of the most common diseases experienced by patients in the field of orthopedics (Dong, et al. 2018. Neogi, & Zhang, 2013. Heidari, 2011; Ubua, et al, 2018). The therapeutic choice for managing osteoarthritis is total knee arthroplasty (TKA). TKA is one of the operations in the orthopedics field which has the highest success rate and cost-effective (Lundblad, Kreicbergs, & Jansson, 2008. Ho, Cheng, & Liau, 2006. Keating, 2002).The main objective of TKA operations is to obtain alignment between the femur and tibia and to achieve a neutral mechanical axis to achieve mechanical load balance and reduce pressure on the implant pressure surface or bone cement (Rand, 1991).

Achieving accurate alignment, minimal overhangs and bone coverage implants determines the success of TKA operations. One of the important things in preparation for TKA operations is the determination of implant size. The TKA prosthesis used in Indonesia is based on western population measurements (Hidayat, et al. 2015), in which the size of Asians is smaller than the size of Caucasian (Hitt, et al. 2003). dr. Soetomo regional public hospital as a national reference center in the eastern part of Indonesia has the advantage that various ethnic groups seek treatment and it is hoped that the data obtained will be more diverse.

Generally, CT-Scan is used for anthropometric studies on bones. However, MRI is preferred to use due to its several advantages. MRI gives the same value on intraoperative measurements (Ha, & Na, 2012) and the difference compare to CT-Scan is only 0.22 mm (Rathnayaka, et al. 2012). The MRI also has a much smaller radiation risk compared to CT-Scan.

The absence of data regarding the morphology of the distal femur and proximal tibia size on the Indonesian

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population using the MRI method underlies the conduct of this study. This issue becomes very important because a prosthesis made based on accurate knee morphological data on every gender of the Indonesian population will give good results. This study aims to determine the anthropometric size of the distal femur bone (Soleimanha et al., 2018) and proximal part of tibia on the population (patients) of Dr. Soetomo's Regional Public Hospital.

METHOD

This study was an observational analytic study with a cross-sectional design. In this study, there are 4 variables studied and then analyzed based on age, gender, BMI (body mass index) and ethnicity. The research subjects were knee MRI examinations that were evaluated on sagittal, axial and coronal pieces with inclusion criteria, ie patients aged 17-60 years and had never experienced fractures in the distal femur and proximal tibia. The exclusion criteria were patients with a previous history of surgery on the distal femur and proximal tibia, had received continuous corticosteroid therapy, had congenital abnormalities, had tumors in the bones and soft tissues that disrupted bone integrity, and had tumors that disturbed intra-articular surfaces.

The unit of analysis is the results of measurements on the distal femur, namely the Transepicondylar axis (TEA), Central anteroposterior axis (CAP), anteroposterior width on the medial and lateral condyle (MAP and LAP), Anterior mediolateral width (AML) and posterior mediolateral width (PML), the average width of anteroposterior (AP), in proximal tibia, is the result of measurement of mediolateral width (ML), anteroposterior width, lateral plateau height (LPH), lateral plateau width (LPW), medial plateau height (MPH), medial plateau width (MPH) MPW) which is analyzed based on age, gender, BMI and ethnicity.

Sampling is done by consecutive sampling method, MRI data is taken from the patient's medical records through PT Buana as the second party appointed by Dr. Soetomo Regional General Hospital as the patient electronic data store or collector. All MRI data of patients' knees that met the inclusion and exclusion criteria were taken then followed by measurements. The MRI electronic data obtained was then opened using the OsiriX program (Pixmeo SARL, Geneva, Switzerland), then measured using a digital ruler of the program. The distal femur measured by the width of the TEA, MAP, LAP, it measured from the width between the outermost points of the anterior and posterior sides lateral to the femoral condyle, the width of AML, PML, CAP, average width of AP. At proximal tibia, the average width of AP, ML width, LPH length, LPW width, MPH width, MPW width, MPW were measured. Data analysis is used to see the correlation between the parameters used, so the Pearson correlation test is used.

Table 1. Measurement Result of The Distal Femur Parameters

Measurement Result of The Distal Femur Parameters			
	Minimum	**Maximum**	**Mean ± Sd Deviation (mm)**
Transepicondylar axis	66.00	88,20	76,34 ± 5,89
Anterior mediolateral width	25,50	42,40	36,19 ± 4,03
Posterior mediolateral	44,15	75,25	55,76 ± 7,01
Central anteroposterior axis	16,30	32,10	23,33 ± 3,19
Medial anteroposterior	49,80	69,80	58,78 ± 4,30
Lateral anteroposterior	50,80	70,50	58,69 ± 3,99
Anteroposterior	52,40	71,60	60,52 ± 4,04

Table 2. Measurement Result of the Tibia Proximal Bone Parameters

Measurement Result of The Tibia Proximal Bone Parameters			
	Min	**Max**	**Mean**
Mediolateral	63,50	86,60	74,16 ± 5,97
Lateral plateau height	29,40	73,60	44,47 ± 8,73
Medial plateau height	38,90	68,80	49,29 ± 5,56
Lateral plateau width	30,10	42,50	35,52 ± 3,44
Medial plateau width	32,20	45,30	38,65 ± 3,88
Tibia anteroposterior	25,20	68,60	39,90 ± 8,6

RESULT

In this study, 100 patients were obtained who met the inclusion and exclusion criteria. The majority of tribes or ethnic groups evaluated are Javanese as many as 55 patients (55%). Other tribes that can be evaluated are Bataknese (3%), Madurese (11%), Osing (4%), Sundanese (5%), Timor (7%) as well as Chinese (14%) and Arabic (1%). The data taken are those that meet the inclusion and exclusion criteria and are taken in 8 mm pieces in sagittal, axial and coronal positions. The research result revealed that the largest average width of the distal femur is the TEA distal femur of 76.34 ± 5.89 mm, while the smallest average is CAP of 23.33 ± 3.19 mm. The method used for measuring the parameters of the tibia proximal bone is the same as the measurement of the distal femur bone, as well as the measurement of one limb and sample used.

The results of measurements obtained proximal tibial ML width of 74.16 ± 5.97 mm, LPH length of 44.47 ± 8.73 mm, MPH length of 49.29 ± 5.56 mm, tibia LPW width of 35.52 ± 3.44 mm, and tibial MPW width of 38.65 ± 3.88 mm. In tibial anteroposterior (tAP) measurements, a size of 39.90 ± 8.6 mm was obtained.

All research data obtained were analyzed the relationship between sample characteristics including age, sex/gender, BMI and ethnicity. In the measurement of the distal femur parameters and their relationship with the characteristics of the sample (the TEA), obtained a significant relationship between TEA and gender (p = 0,000) as well as age (p = 0.001). There was no relationship between TEA and BMI (p = 0.326) and rates (p = 0.338). In the measurement of AML, it is found that there is a relationship between AML and gender, age with p = 0,000. And there is no relationship between AML and BMI (p = 0.264) and rates (p = 0.078). In PML

Table 3. Pearson's Gender Correlation Test with Measurement of The Distal Femur Parameters

Pearson's Correlation Test Parameter Measurement of The Distal Femur			
Parameter	**Female**	**Male**	**P-Value**
Transepicondylar axis	73,89 ± 6,1	79,34 ± 3,8	0,000
Anterior mediolateral width	34,63 ± 4,4	38,10 ± 2,4	0,000
Posterior mediolateral	52,98 ± 6,6	59,16 ± 5,8	0,000
Central anteroposterior axis	23,24 ± 3,0	23,43 ± 3,3	0,764
Medial anteroposterior	60,14 ± 3,3	60,14 ± 3,3	0,004
Lateral anteroposterior	59,96 ± 3,0	59,96 ± 3,0	0,003
Anteroposterior	61,81 ± 3,0	59,47 ± 4,4	0,003

Table 4. Pearson's Age and BMI Correlation Test with Measurement of The Distal Femur Parameters

Parameters		Age		BMI	
		R	P	R	P
Transepicondylar axis	Pearson Correlation	-,324**	,001	,142	,159
Anterior mediolateral width	Pearson Correlation	-,209*	,037	,264**	,008
Posterior mediolateral	Pearson Correlation	-,238*	,017	,057	,570
Central anteroposterior axis	Pearson Correlation	-,156	,122	-,005	,961
Medial anteroposterior	Pearson Correlation	-,370**	,000	,065	,522
Lateral anteroposterior	Pearson Correlation	-,372**	,000	,148	,141
Anteroposterior	Pearson Correlation	-,367**	,000	,109	,281

Table 5. Pearson's Correlation Test of Sex/gender by Measurement of The Tibia Proximal Parameters

Pearson's Correlation Test Parameters of Proximal Tibia Measurement			
Parameters	**Female**	**Male**	**P-Value**
Mediolateral	71.71 ± 5,9	77.16 ± 4.1	0.000
Lateral plateau height	43.62 ± 8,7	45.52 ± 8.8	0.280
Medial plateau height	48.49 ± 5,5	50.27 ± 5.0	0.111
Lateral plateau width	34.47 ± 3.4	36.82 ± 3.3	0.001
Medial plateau width	37.24 ± 3.8	40. 37 ± 2.8	0.000
Tibia anteroposterior	39.40 ± 8.5	40.52 ± 8.8	0.349

Table 6. Pearson's Age and BMI Correlation Test with Measurement of The Tibia Proximal

Parameters		Age		BMI	
		R	P	R	P
Mediolateral	Pearson Correlation	-0,304**	0.002	0.125	0.216
Lateral plateau height	Pearson Correlation	-0.093	0.357	-0.090	0.373
Medial plateau height	Pearson Correlation	-0,325**	0.001	-0.017	0.869
Lateral plateau width	Pearson Correlation	-0.110	0.277	0,239*	0.017
Medial plateau width	Pearson Correlation	-0,365**	0.000	-0.028	.0779
Tibia anteroposterior	Pearson Correlation	-0.073	0.469	-0.059	0.561

measurements obtained relationship between PML with sex/gender (p = 0,000) and age (p = 0.017). There was no relationship between PML and BMI (p = 0.641) and ethnicity (p = 0.108).

In CAP measurement, there was no significant correlation between CAP and gender (p = 0.855), age (p = 0.301), BMI (p = 0.938) and ethnicity (p = 0.934). In MAP width measurement there was a relationship between MAP and gender (p = 0.004) and age (p = 0.000). There was no relationship between MAP and BMI (p = 0.277) and ethnicity (p = 0.831). In the measurement of AP distal femur width, there was a relationship between AP by gender (p = 0.003) and age (p = 0.000). There was also no relationship between AP and BMI (p = 0.228) and ethnicity (p = 0.693).

The analysis was also performed on the proximal tibia measurement data. In the proximal measurement of the tibia at the ML width parameter, there was a significant relationship between ML and gender and age. There was no relationship between ML and BMI (p = 0.310) and ethnicity (p = 0.153). In LPH measurements there was no association between LPH and gender (p = 0.134), age (p = 0.311), BMI (p = 0.881), and ethnicity (p = 0.468). In MPH measurement there was a relationship between MPH and age. There was no significant relationship between MPH and gender (p = 0.059), BMI (p = 0.527), and ethnicity (p = 0.798).

In LPW measurements, there was a significant relationship between LPW and gender. There was no association between LPW and age (p = 0.073), BMI (p = 0.053) and ethnicity (p = 0.067). Analysis of MPW parameters revealed a significant relationship between MPW and gender and age. There was no MPW relationship with BMI (p = 0.759) and ethnicity (p = 0.557). There was also no relationship between tAP and gender (p = 0.349), age (p = 0.469), ethnicity (p = 0.709) and BMI (p = 0.561).

DISCUSSION

The results in this study are under the most recent studies which found a significant relationship between TEA with sex/gender/gender and age, and there was no relationship between body weight, height, BMI, and ethnicity (Jabalameli, et al. 2016). In the measurement of TEA, obtained results of 76.34 ± 5.89 mm. This measurement is related to determining the rotational position of the femur and tibia in conducting TKA (Aglietti,et al. 2008). This is different from previous studies which obtained a result of 56.70 ± 1.41 mm (Taşdemir, et al. 2017). The results of this study are close to other studies with results of 71.1 ± 3.6 mm (Fan, et al. 2017).

In this study there was a relationship between AML distal femur width and gender, this was the same as the study conducted by (Hitt, et al. 2003), but there was no significant relationship between AML with age, weight, height, and BMI. The measurement obtained the distal femur AML width of 36.19 ± 4.0 mm. In a study conducted by Fan L et al., a size of 33.8 ± 2.3 mm was obtained (Fan, et al. 2017).

The result of PML analysis revealed a significant relationship between distal femur PML and sex/gender/gender, which is in line with research conducted by (Hitt, et al. 2003), there was also a significant relationship between PML and age, but there was no relationship between PML with body weight, height agency, and BMI. Other studies resulted in 46.3

± 3.0 mm (Fan, et al. 2017). The result of the measurement of the distal femur PML width was 55.76 ± 7.01 mm, and the average CAP width was 23.33 ± 3.19 mm. CAP in other studies can also be referred to as the whiteside line, where this influences in determining the central axis of the femur so that it can influence the rotation position of the femur TKA component (Cerveri, et al. 2011, Manili, Muratori, & Fredella, 2007).

There is a significant relationship between distal femur MAP with age and sex/gender/gender but there is no relationship between BMI and ethnicity, there is a significant relationship between distal femur LAP with age and sex/gender/gender but there is no relationship between BMI and ethnicity. In this study, the anteriorposior width of the distal femur medial condyle (MAP) was 58.78 ± 4.30 mm, the anterior-posterior width of the distal femur lateral condyle (LAP) was 58.69 ± 3.99 mm. The results in this study show similarity with previous studies in which, the LAP was 58.3 ± 3.9 mm and MAP 59.6 ± 3.6 mm (Fan, et al. 2017).

In AP, there is a significant relationship between sex/gender and age with the average width of the distal femur AP. This is in line with other studies (Hussain, et al. 2013), and there is a significant relationship between ethnic groups and AP. This result show similarities and in line with previous research done by Hussain et al (2013). Other studies obtained an AP size of 57.8 ± 3.9 mm (Fan, et al. 2017). In this study, the AP distal femur width was obtained at 60.52 ± 4.04 mm. There is a significant relationship between proximal tibia ML with age and sex/gender, but there was no relationship between ML with weight, height, and BMI. This shows similarities and in line with previous research conducted by (Long, et al. 2012). This study obtained proximal tibial width mediolateral (ML) width measurements of 74.16 ± 5.97 mm. This result is greater than the Chinese population.

The results of this study show good similarity in several parameters with previous studies. This shows that the parameters or factors that affect the size of the distal femur and the proximal tibia vary greatly. In this study, it was found that age and sex/gender parameters had the strongest relationship with distal femur size and proximal tibia. Other factors in this study are BMI and ethnicity which have less influence on the results of this study.

The results of this study are also specific to the case that occurred at the Dr. Soetomo Regional General Hospital, Surabaya, Indonesia. These anthropometric results are limited to ethnicity, BMI, sex/gender, and age factors, so the results in this study cannot be generalized to other studies with various cases.

CONCLUSION

Based on the results of this study it is known that age and gender are the most important factors correlating to the size of the distal femur and proximal tibia. BMI and ethnicity factors in this study did not show a strong influence on the size of the distal femur and proximal tibia.

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