

Anthropometric Measurements of Patella and Distal Femur among Iranian Osteoarthritis Patients during Total Knee Arthroplasty

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Abstract

Background & Aims: Total knee arthroplasty (TKA) is an effective treatment for pain relief and functional recovery in patients suffering from severe osteoarthritis. Despite advances in TKA, patients are not yet comfortable with results. Prosthesis design plays a major role in TKA outcome. Most TKA prostheses are designed based on the anthropometric features of the Caucasian population. Studies have identified ethnic differences in the anatomy of the distal femur and patella. We aimed to measure anthropometric features of patella and distal femur intraoperatively.

Materials & Methods: Femoral mediolateral (ML) width, femoral medial and lateral condyle anteroposterior height (mAP and IAP), patellar height, patellar width and patellar maximum thickness were measured intraoperatively in 47 Iranian patients. The femoral aspect ratio (ML/IAP×100) was also calculated.

Results: In women, the mean (SD) patellar height, width and thickness were 34.19 (3.33) mm, 42.92 (3.93) mm, 22.75 (2.00) mm, respectively. The mean (SD) ML, mAP, Lap, and aspect ratio were 78.07 (5.97) mm, 60.75 (4.37) mm, 62.09 (4.02) mm, 125.58 (10.43) percent, subsequently. On average, the lateral condyle was larger than the medial in women. We also found that mAP correlated with IAP strongly.

Conclusions: We have presented accurate and reliable measurements of anthropometric features of the knee among the Iranian female population. It can be concluded that anthropometric features of the knee among the Iranian women are similar to the Caucasian and European populations but it is higher than the Chinese populations.

Keywords: Anthropometry, patella, distal femur, osteoarthritis, total knee arthroplasty, Iranian population

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Introduction

Total knee arthroplasty (TKA) is considered as a successful treatment in end stages of knee arthritis. About 70 to 84 percent of the patients reported

improvement in function and 72 to 86 percent reported pain relief or reduction (1). The most common cause for TKA is osteoarthritis, but patients with various diseases undergo TKA such as inflammatory arthritis, fractures, dysplasia and neoplasms (2).

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There is a prediction that the number of TKA surgeries will increase in the coming years due to increased population, higher life expectancy, and increasing risk factors for osteoarthritis such as obesity. It has been predicted that the number of TKA surgeries in the United States will grow by 69 percent from 2012 to 2050 (3).

With the advances made in the field of TKA surgeries, the success rates have improved vastly but still 6.2 percent of the patients need revision surgeries in the first ten years after TKA (4). Overall there are three factors associated with the success of TKA: demographic features of the patient, surgical technique, and factors relating to the prosthetic implants (5).

Patella is the biggest sesamoid bone in the body which is located in quadriceps tendon. Patella improves the function of quadriceps muscle in knee extension (6, 7). Patella and patellofemoral joint (PFJ) play an important role in the outcome of TKA. Several TKA complications have been related to PFJ such as anterior knee pain, fracture of patella, injury to the knee extensors, looseness of patellar component, clunk syndrome, and patellar maltracking (8, 9).

Racial and gender diversities have been reported in patella and femur anthropometry. Reports have shown that female patellar thickness is lower than male (10). Also there has been evidence that patellar dimensions are smaller in the Korean population compared to the western population (11). Same results were reported in a study measuring the Indian patellar anthropometry (12). The same diversities were reported for femoral dimensions (13, 14).

Considering the vast effect of race on the anthropometric features, there have been few studies measuring these dimensions in the Iranian population. Mostly these studies have used radiologic images of the knee for this measurement (15, 16). Measuring dimensions using radiologic images is not as accurate as

direct measurements due to X-ray scatter or magnification errors (17).

Most implants used in TKA are designed based on mean anthropometric features of the white and Caucasian populations. Therefore, understanding the correct anthropometric feature for each population is crucial for the successful outcome of TKA. According to our literature review, there has not been sufficient evidence regarding femoral and patellar anthropometry in the Iranian population. Therefore, we aimed to measure anthropometric features of patella and distal femur intraoperatively. We hope that results of this study will lead to a better understanding and provide accurate anthropometric data in order to design suitable components for the Iranian population.

Materials & Methods

This study was approved by the ethics committee of Urmia University of Medical Sciences with the confirmation code of IR.UMSU.REC.1398.491.

All patients that underwent TKA in hospital, Urmia, Iran from April to August 2020 were included in the study. Patients with either of following criteria were not included in the study:

- Advance rheumatoid arthritis or osteoarthritis. In order to categorize the severity, Kellgran and Lawrence system of classification was used. Patients who scored more than two were not included.
- History of fractured femur, Knee
- Limb deformities such as genu varum and genu valgum
- History of torn knee meniscus and ligaments
- History of prior surgery involving the knee
- Degenerative changes of patella that disrupts the anatomy

Demographic features including age, sex, height, and weight were obtained from their medical files.

All dimensions were measured during the TKA operation using a caliper. For more accurate measurement the surrounding synovial tissue was sharply incised then all osteophytes were removed using Rongeur.

Mediolateral (ML) width of the femur was measured in transepicondylar axis before the resection of distal femur. Anteroposterior height of medial condyle (mAP) and lateral condyles (LAP) were measured after resection of distal femur. The aspect ratio for each patient was calculated by dividing ML width by AP height of lateral condyle multiply by 100.

Before resurfacing of the patella, height (maximum linear distance between apex and inferior surface), width (maximum distance between lateral and medial border), and thickness (maximum distance between anterior and posterior surfaces) were measured.

All data were introduced into Statistical Package for Social Sciences, version 26.0 (IBM Corp, Armonk, NY, USA) for statistical analysis. Description of quantitative variables was accomplished using means and standard deviation (SD). Also frequency and percentages were used to describe qualitative data. $p < 0.05$ was

considered as level of significance throughout the study.

Results

47 patients who met the eligibility criteria were recruited for the study. Only 6 (12.8 percent) of the participants were male. The mean age for participants was 69.02 ± 7.32 years. Other demographic features are detailed in Table 1.

Anthropometric features of 23 left knees and 24 right knees were recorded during TKA. The mean maximum thickness of patella was 22.75 ± 2.00 millimeters in women and 21.50 ± 2.58 in men. The mean ML width of distal femur was 78.07 ± 5.97 millimeters in women and 78.66 ± 5.42 in men. Measured anthropometric dimensions are summarized in Table 2.

Considering the low number of male participants, the analytical investigation was only carried out on female participants. Correlation analysis showed significant correlation between LAP with patellar height and thickness, mAP and ML width of femur. mAP also showed a significant correlation with patellar dimensions. Table 3 describes the results of correlation analysis of anthropometric features among women.

Table 1. Demographic feature for the sample population

	Female		Male		Total	
	Mean	SD	Mean	SD	Mean	SD
Age (year)	62.89	7.45	74	3.74	69.02	7.32
Weight (Kg)	81.26	10.80	82.00	10.25	81.36	10.62
Height (Cm)	161.31	5.38	166.50	7.09	161.97	5.81
BMI (Kg/m ²)	31.43	4.07	29.51	3.06	31.19	3.98

Table 2. Demographic feature for the sample population

	Female		Male		Total	
	Mean	SD	Mean	SD	Mean	SD
Patellar height (mm)	34.19	3.33	37.50	3.56	34.61	3.50
Patellar width (mm)	42.92	3.93	46.16	4.66	43.34	4.12

	Female		Male		Total	
	Mean	SD	Mean	SD	Mean	SD
Patellar thickness (mm)	22.75	2.00	21.50	2.58	22.59	2.10
Femur ML width (mm)	78.07	5.97	87.66	5.42	79.29	6.68
mAP (mm)	60.75	4.37	65.83	4.16	61.40	4.63
lAP (mm)	62.09	4.02	66.83	2.63	62.70	4.16
Aspect ratio	125.58	10.43	130.66	5.78	126.23	10.06

Table 3. Correlation analysis of anthropometric features in women

		age	weight	height	BMI	Patellar height	Patellar thickness	Patellar width	ML width of femur	mAP
lAP	R	0.057	0.168	0.024	0.167	0.379	0.491	0.297	0.342	0.761
	p-value	0.722	0.292	0.883	0.297	0.015	0.001	0.059	0.029	0.000
mAP	R	0.068	0.178	0.061	0.188	0.365	0.553	0.536	0.185	
	p-value	0.672	0.265	0.706	0.240	0.019	0.000	0.000	0.246	
ML femoral width	R	0.283	-0.168	0.001	-0.210	0.401	0.301	0.347		
	p-value	0.073	0.294	0.996	0.188	0.009	0.056	0.026		
Patellar width	R	0.084	-0.221	0.096	-0.218	0.530	0.559			
	p-value	0.601	0.165	0.549	0.170	0.000	0.000			
Patellar thickness	R	0.113	-0.146	-	-0.075	0.336				
	p-value	0.481	0.363	0.649	0.639	0.032				
Patellar height	R	-0.075	-0.352	-	-0.361					
	p-value	0.642	0.024	0.675	0.020					

Discussion

The prevalence of knee osteoarthritis is on the rise due to several factors including population ageing and higher rates of obesity (3). TKA is an effective method of treatment in patients with severe osteoarthritis which leads to pain relief and improvements in knee function (18). Despite the advances in TKA over the years, complete satisfaction after surgery is still the main challenge for physicians (19).

As we mentioned before, recognizing knee anthropometric features in each race and population might help achieve this goal. Measuring anthropometric features of the knee can be done by few methods

including using imaging studies such as MRI and CT scan, measuring bone dimensions in cadavers, and direct measurement during knee surgeries (20-22).

Measurement using imaging studies is more convenient and can be accomplished on greater sample populations. However, this method of measurement is associated with some errors such as magnification error and is dependent on expertise of the operator (17, 23).

Therefore, it seems that direct measurements during operation are more accurate and can be used in prosthesis development. But providing samples for this type of measurement is more challenging. As in our study the male sample population was not great enough

to judge or compare to other studies and it cannot be used for generalization.

Rooney et al. (17) evaluated anthropometric features of the knee during TKA in the British population. Measured ML femoral width in women was similar to our study. Also measured patellar thickness, height and width in their study was similar to our findings.

Griffin (24) used MRI images of the knee for measurements of anthropometric features in the American population. The mean ML width of the femur in women for this study was shorter than our study. This discrepancy can be related to the differences in the method of measurement. Also in Griffin's study, routine MRI images for patients with the mean age of 42.8 years were investigated. The mean age of participants in our study was 69.02 years. Griffin's study population are younger patients with fewer osteoarthritis features and since prosthesis and TKA surgeries are usually used for older population, results of our study seem to be more representative of the target population.

Chmell measured patellar thickness during TKA among the American osteoarthritis patients. The maximum patellar thickness in this study was similar to our measurements (25). Clarke et al. investigated patellar dimensions among the American population directly during TKA surgery. Maximum patellar thickness measured in this study was also similar to our findings (10).

Yue et al. (26) compared knee dimensions of the Chinese population with white men and women using 3D reconstructed MRI and CT scan images. The measured ML femoral width in our study was similar to white women population in Yue's study, but it was greater than the measured ML width of the Chinese population. Calculated aspect ratio in both women population of Yue's study was similar to our calculated ratio.

Huang used reconstructed CT images to measure patellar thickness in the Chinese population (27). The CT images used in this study were obtained from younger patients with cruciate ligament tears. The patellar thickness measured in this study was shorter than our study which could be the result of different measurement methods and populations.

Loures (28) directly measured knee dimension during TKA operation in the Brazilian population. The mean ML femoral width in our study was greater than what Loures has measured, but the AP height of medial and lateral condyles in both studies were similar.

In literature we have found two studies that measured anthropometric features of the knee in the Iranian population. Birjandinejad (15) used MRI and Moghtadaei (16) used CT images for these measurements. The mAP, Lap, and ML femoral width measured in our study was greater than the measured dimensions in both studies. This could be related to several factors. The different method of measurement used in both studies is one factor to be considered. Also, as we mentioned before, the images used were for trauma patients, patients with soft tissue damages which are usually younger patients than patients with osteoarthritis.

The main limitation of our study was the small sample population which was not acceptable for generalization in men. Due to this limitation we could not investigate the differences in knee anthropometric features between genders. Also, the compatibility of common prosthesis used in Iran with patients was not investigated. We suggest further studies investigate the direct measurements of knee dimension in greater sample populations.

Conclusion

We have presented accurate and reliable measurements of anthropometric features of the knee in

the Iranian female population. It can be concluded that anthropometric features of the knee in the Iranian women are similar to the Caucasian and European populations but it is higher than the Chinese population. These measurements can be used for developing race and sex-appropriate prostheses for TKA in osteoarthritis patients.

References

- Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clin Orthop Relat Res* 2010;468(1):57-63.
- Singh JA. Epidemiology of knee and hip arthroplasty: a systematic review. *Open Orthop J* 2011;5:80-5.
- Inacio M, Paxton E, Graves S, Namba R, Nemes S. Projected increase in total knee arthroplasty in the United States—an alternative projection model. *Osteoarthritis Cartilage* 2017;25(11):1797-803.
- Pabinger C, Berghold A, Boehler N, Labek G. Revision rates after knee replacement. Cumulative results from worldwide clinical studies versus joint registers. *Osteoarthritis Cartilage* 2013;21(2):263-8.
- Grelsamer RP. Patellofemoral complications following total knee arthroplasty. *J Arthroplasty* 1997;12(2):216.
- Azar FM, Canale ST, Beaty JH. *Campbell's Operative Orthopaedics*. Elsevier; 2020.
- Standring S. *Gray's anatomy e-book: the anatomical basis of clinical practice*. Elsevier Health Sciences; 2015.
- Assiotis A, To K, Morgan-Jones R, Pengas IP, Khan WJEJoOS, Traumatology. Patellar complications following total knee arthroplasty: a review of the current literature. *Eur J Orthop Surg Traumatol* 2019;29(8):1605-15.
- Putman S, Boureau F, Girard J, Migaud H, Pasquier GJO, Surgery T, et al. Patellar complications after total knee arthroplasty. *Orthop Traumatol Surg Res* 2019;105(1):S43-S51.
- Clarke HD, Spangehl MJ. Gender optimized patellar component designs are needed to better match female patellar anatomy. *Knee* 2014;21(6):1250-3.
- Kim TK, Chung BJ, Kang YG, Chang CB, Seong SC. Clinical implications of anthropometric patellar dimensions for TKA in Asians. *Clin Orthop Relat Res* 2009;467(4):1007-14.
- Jain R, Kalia RB, Das L. Traumatology. Anthropometric measurements of patella and its clinical implications. *Eur J Orthop Surg Traumatol* 2019;29(8):1765-9.
- Conley S, Rosenberg A, Crowninshield R. The female knee: anatomic variations. *J Am Acad Orthop Surg* 2007;15:S31-S6.
- Lim H-C, Bae J-H, Yoon J-Y, Kim S-J, Kim J-G, Lee J-M. Gender differences of the morphology of the distal femur and proximal tibia in a Korean population. *Knee* 2013;20(1):26-30.
- Birjandinejad A, Zandi R, Karimi E. Anthropometric measurements of distal femur to design the femoral component of total knee arthroplasty for the Iranian population. *Arch Bone Jt Surg* 2020;8(3):400-6.
- Moghtadaei M, Moghimi J, Shahhoseini G. Distal femur morphology of Iranian population and correlation with current prostheses. *Iran Red Crescent Med J* 2016;18(2):e21818.
- Rooney N, FitzPatrick DP, Beverland DE. Intraoperative knee anthropometrics: correlation with cartilage wear. *Proc Inst Mech Eng H* 2006;220(6):671-5.
- Canovas F, Dagneaux L. Quality of life after total knee arthroplasty. *Orthop Traumatol Surg Res* 2018;104(1s):S41-s6.
- Aumiller WD, Dollahite HA. Advances in total knee arthroplasty. *JAAPA* 2016;29(3):27-31.
- McNamara CA, Hanano AA, Villa JM, Huaman GM, Patel PD, Suarez JC. Anthropometric Measurements of Knee Joints in the Hispanic Population. *J Arthroplasty* 2018;33(8):2640-6.
- Miyatake N, Sugita T, Aizawa T, Sasaki A, Maeda I, Kamimura M, et al. Comparison of intraoperative

- anthropometric measurements of the proximal tibia and tibial component in total knee arthroplasty. *J Orthop Sci* 2016;21(5):635-9.
22. Terzidis I, Totlis T, Papathanasiou E, Sideridis A, Vlasis K, Natsis K. Gender and Side-to-Side Differences of Femoral Condyles Morphology: Osteometric Data from 360 Caucasian Dried Femori. *Anat Res Int* 2012;2012:679658.
23. Baldwin JL, House CK. Anatomic dimensions of the patella measured during total knee arthroplasty. *J Arthroplasty* 2005;20(2):250-7.
24. Griffin FM, Math K, Scuderi GR, Insall JN, Poilvache PL. Anatomy of the epicondyles of the distal femur: MRI analysis of normal knees. *J Arthroplasty* 2000;15(3):354-9.
25. Chmell M, McManus J, Scott RD. Thickness of the patella in men and women with osteoarthritis. *Knee* 1995;2(4):239-41.
26. Yue B, Varadarajan KM, Ai S, Tang T, Rubash HE, Li G. Differences of knee anthropometry between Chinese and white men and women. *J Arthroplasty* 2011;26(1):124-30.
27. Huang A-B, Luo X, Song C-H, Zhang J-Y, Yang Y-Q, Yu J-K. Comprehensive assessment of patellar morphology using computed tomography-based three-dimensional computer models. *Knee* 2015;22(6):475-80.
28. Loures FB, Góes RFdA, Palma IMd, Labronici PJ, Granjeiro JM, Olej B. Anthropometric study of the knee and its correlation with the size of three implants available for arthroplasty. *Rev Bras Ortop* 2016;51(3):282-9.