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Anthropometric Comparison between Indian and Arabian Knees with Respect to Total Knee Replacement

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Abstract

Implants used for total knee replacement (TKR) in most Asian countries are not designed originally for the Asian population, and studies have shown anthropometric differences with respect to TKR among various ethnic groups. For this reason, implants designed for a specific population may not provide an anatomic fit when used in other populations. To avoid the consequences associated with such a misfit, the concept of ethnic-specific implant design is being introduced. In this study, the knee anthropometry of the Indian and Arabian patients was compared. They were operated with implants which were not ethnic-specific designs. Since the consequences associated with implant misfit apply equally to both the Indian and Arabian population, it is essential to compare the knee anthropometry of these two populations. Anthropometric measurements of the distal femur and proximal tibia of the Indian and Arabian knees were obtained intraoperatively using a Vernier caliper. Their respective aspect ratios (ARs) were calculated and statistically compared. It was found that the ARs of both tibia and femur of Indian and Arabian population did not show any statistical difference. There was no statistical difference between Indian and Arabian males ($p = 0.345$) and between Indian and Arabian females ($p = 0.8210$). However, a statistical difference in tibial AR (p-value $= 0.049$) and femoral AR (p-value $= 0.003$) was found significant when a comparison was made between the knees of Indian males and Indian females in the study. The above results suggested that TKR implants designed anatomically to suit the Indian population can also suit the Arabian population and vice versa. The obtained data can help implant designers to come up with ethnic-specific TKR implants.

Keywords

- anthropometry
- morphology
- proximal tibia
- distal femur
- aspect ratio
- anteroposterior
- mediolateral
- Vernier caliper
- Indian population
- Arabian population
- ethnic groups

Total knee replacement (TKR) involves the placement of implants over resected surfaces of the proximal tibia and distal femur. Adequate coverage of the resected bony surface by proper fitting implants play a vital role in its successful outcome.[1] To achieve this, the chosen size of the implants must not only suit the anteroposterior (AP) dimension, but also the mediolateral (ML) dimension of the resected bony surface.[2]

In most of the implant designs, the size of the femoral component is chosen corresponding to the AP measurement of the distal femur. In most of the conventional systems for a

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particular size of the AP dimension chosen, the ML dimension of the femoral implant is fixed. This narrows the surgeon's choice of providing an optimum implant cover over the bone in the ML dimension. The AP positioning and dimension of the femoral implant decide the flexion gap and influences the tension of the quadriceps mechanism.[3]

For knees placed with an anterior referencing approach, an oversized femoral component can contribute to a tight flexion space or a relatively loose extension space. The undersizing the femoral component can contribute to flexion instability[2–4] postcam impingement and potentially higher rates of component wear. For knees placed with a posterior referencing approach, an oversized component can contribute to adverse patellofemoral joint symptoms from overstuffing, while undersizing can result in anterior femoral notching with a potential risk for supracondylar femur fracture[5] in extreme cases.

The ML positioning and dimension of the femoral implant determines adequate coverage of the resected bony surface in the ML direction, allowing even stress distribution and smooth tracking of the patellar component.[2,4] ML oversizing may contribute to soft tissue impingement, and ML undersizing may lead to uneven stress distribution and component migration.[2] Similar considerations may apply to the proximal tibia. Hence, while designing implants for a particular population or ethnic group, it is the proportion between the two (aspect ratio [AR]) that determines optimal fit rather than the absolute dimensions of the implant (ML or AP).[6–8]

Recent studies on knee anthropometry show that the present TKR designs do not consider racial anthropometric differences.[9–13] The studies comparing anthropometry of various ethnic groups have led to the conclusion that ethnic-specific TKR designs can minimize the suboptimal results that can occur due to implant misfit.[14–16] Even though smaller size implants are used for smaller knees and larger ones for larger knees, mismatch happens due to the difference in the proportion between the ML and AP dimensions.

Materials and Methods

Our study was a prospective observational study comparing the femoral and tibial ARs of Indian and Arabian knees in relation to TKR. We evaluated 137 consecutive primary TKRs (93 patients) performed in Aster Medcity Hospital, Kochi between July 2017 and July 2018. This included 91 TKRs performed for 61 Indian patients and 46 TKRs performed for 32 Arabian patients. Revision TKR and knees with severe deformities and bone loss were excluded to avoid erroneous results. Informed consent for the study was obtained from all the patients, and the study was approved by the scientific and ethical review board of our institution (independent ethics committee number: AM/EC/42–2017).

The measurements were taken using a Vernier caliper. The knees were exposed through an anterior parapatellar approach, and the measurements were taken after the removal of osteophytes. The measurements were made by a surgical assistant who was blinded of the analysis. The intraoperative measurements of the distal femur were made by taking the largest anteroposterior (AP) measurement of lateral condyle of the femur as the femoral anteroposterior measurement (fAP), and the mediolateral (ML) measurement at femoral epicondyle level as the femoral mediolateral (fML) measurement (►**Figs. 1** and **2**). For proximal tibia, the largest AP measurement at the level of the tibial intercondylar region was taken as the tibial anteroposterior (tAP) measurement and the largest ML measurement at the level of tibial condyles was taken as the tibial mediolateral (tML) measurement (►**Figs. 3** and **4**). Tibial aspect ratio (tAR) and femoral aspect ratio (fAR) were then calculated (tAR = tML/tAP and fAR = fML/fAP).

Statistical Analysis

The observed data were tabulated, coded, and analyzed using SPSS version 17 for Windows. Descriptive data were represented as mean and standard deviation. Mann–Whitney U test was used to assess the statistical significance of the variables tAR and fAR between the two groups and genders as they did not follow a normal distribution.

Results

A total of 91 Indian (26 males and 65 females) and 46 Arabian (23 males and 23 females) knees were included in the analysis. The calculated mean AR of both the femur and the tibia were compared between the Indian and the Arabian population. A p-value of < 0.05 was considered statistically significant. The ARs of tibia and femur did not show any statistically significant difference between Indian and Arabian males or between Indian and Arabian females. The ARs of the total Indian and the total Arabian knees also did not show any statistically significant difference. However, a statistical difference in tAR (p-value = 0.049) and fAR (p-value = 0.003) was found when a comparison was made between the knees of Indian males and the Indian females in the study. The authors depicted the morphology of knees between Arabian and Indian male and female patients in ►**Table 1**. Other descriptive variables including the AP and the ML dimensions of both the tibia and the femur of both the populations are depicted in ►**Table 2**.

Discussion

In TKR, the optimal anatomic fit between the prosthesis and the resected surface of bone is a vital factor for its successful outcome.[1] Most of the existing TKR implants are not designed to suit any specific ethnic groups or population. Studies have proven anthropometric variations in the knee with respect to TKR among various ethnic groups.[15,17,18] Even though smaller size implants are chosen for smaller knees and larger ones for larger knees, misfit occurs due to the proportional variation in anthropometric dimensions of the knee.[10,11] To minimize the consequences associated with implant misfit as a result of such anthropometric differences, ethnic-specific TKR implants are being introduced.

In Indian hospitals, implants designed by various international manufacturers, that do not consider racial differences, are being used not only for Indian patients but also for

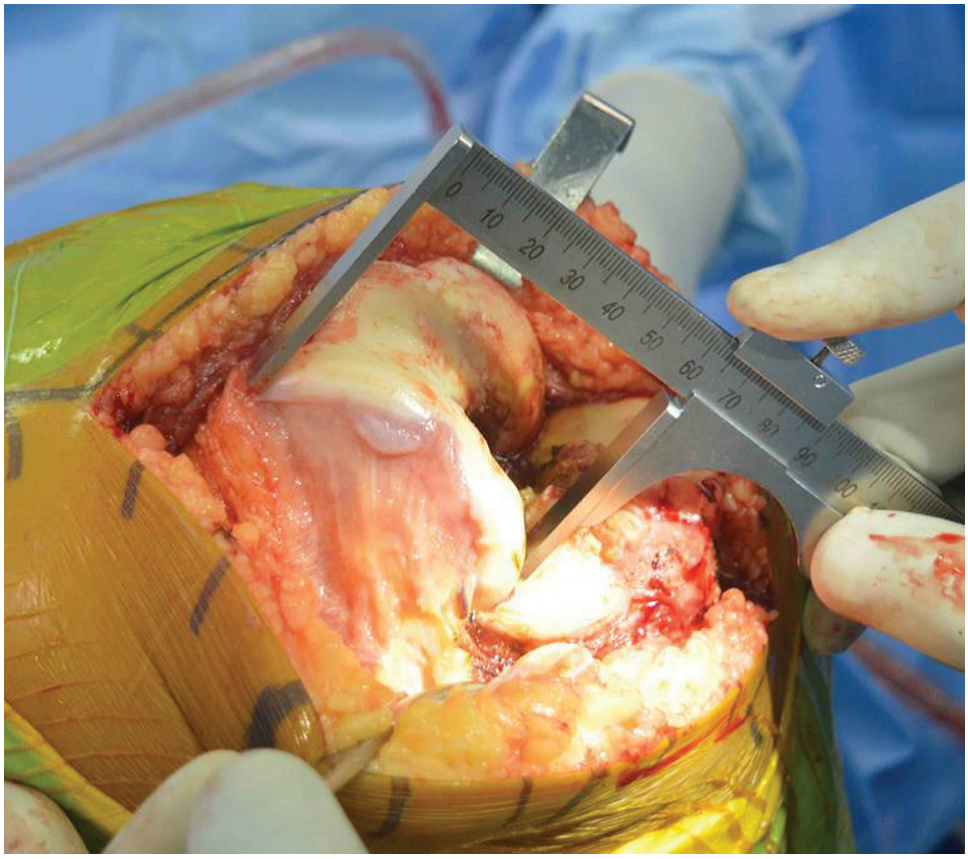

Fig. 1 Femoral anteroposterior measurement.

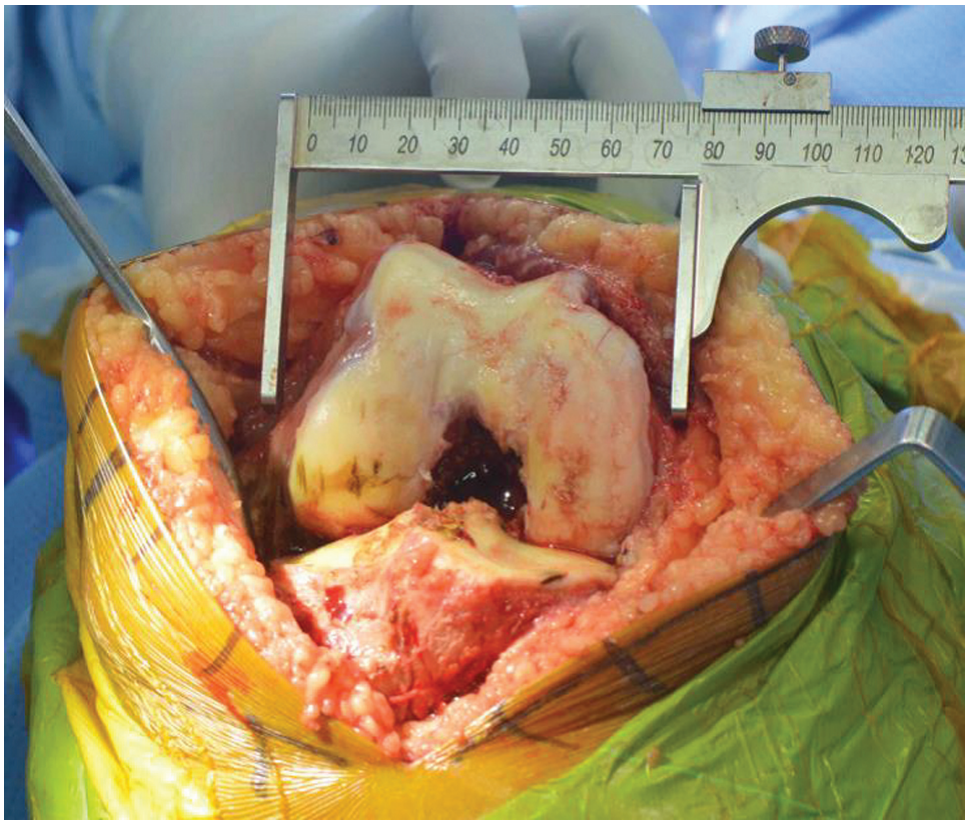

Fig. 2 Femoral mediolateral measurement.

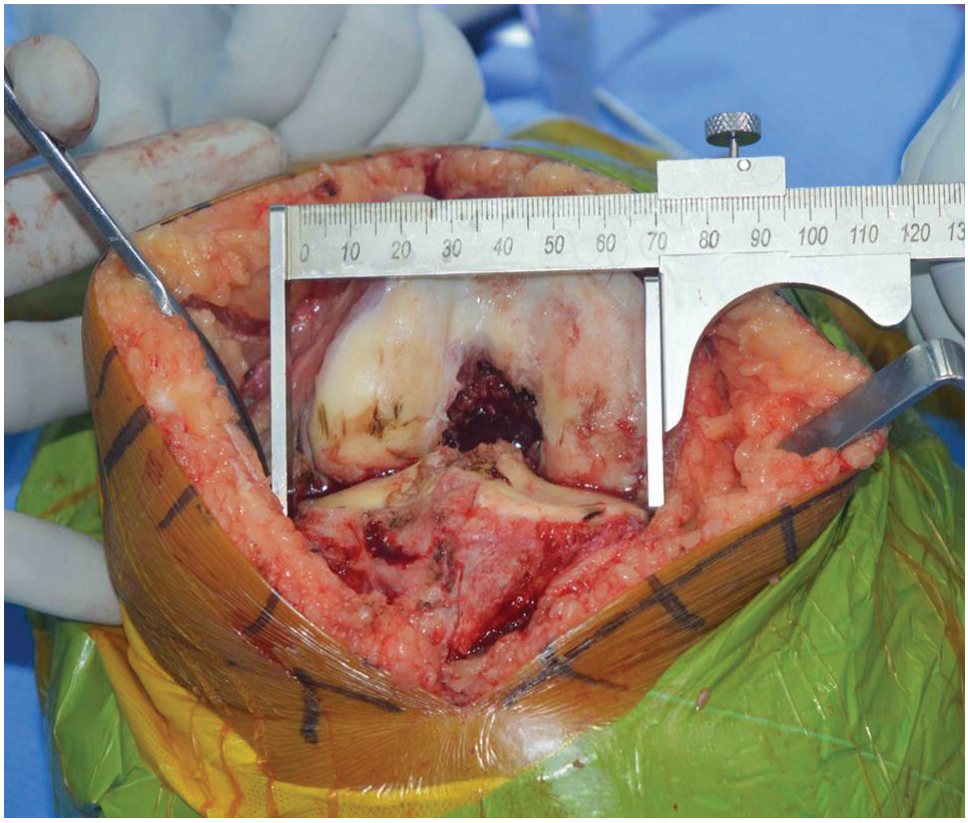

Fig. 3 Tibial mediolateral measurement.

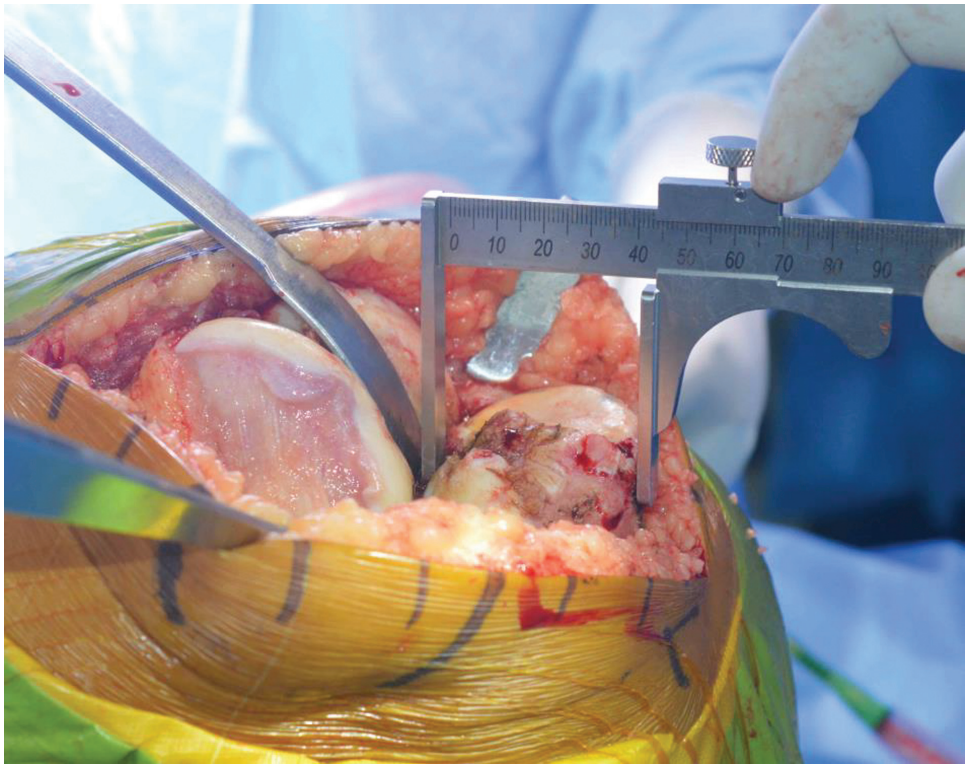

Fig. 4 Tibial anteroposterior measurement.

Table 1 Depiction of the morphology of knees between Arabian and Indian male and female patients

	n	t(AR)	*p*-Value	f(AR)	*p*-Value
Indian males	26	1.51 ± 0.13	0.102	1.27 ± 0.10	0.258
Arabian males	23	1.57 ± 0.12		1.26 ± 0.06	
Indian females	65	1.56 ± 0.12	0.711	1.23 ± 0.08	0.805
Arabian females	23	1.57 ± 0.18		1.23 ± 0.09	
Indian knees	91	1.55 ± 0.12	0.345	1.25 ± 0.09	0.821
Arabian knees	46	1.57 ± 0.15		1.25 ± 0.28	
Indian males	26	1.51 ± 0.13	0.049	1.27 ± 0.10	0.003
Indian females	65	1.56 ± 0.12		1.23 ± 0.08	

Abbreviations: f(AR), femoral aspect ratio; t(AR), tibial aspect ratio.

Arabian patients. Since the already mentioned consequences due to implant misfit apply to these two populations (Indian and Arabian), it is important to compare the knee anthropometry of these two populations and to find whether any significant difference in knee anthropometry exists so that these results can be applied in future implant designs. To the authors' knowledge, there are no studies in the literature analyzing the anthropometry of Indian and Arabian knees with respect to TKR. In our study, we compared the knee anthropometry of Indian and Arabian patients treated in our hospital in terms of proportional variation (AR) of the distal femur and proximal tibia.

In our study, we measured the tibial AP and ML measurements at the condyle level after removal of osteophytes. The tibial AP measurement was made at the intercondylar area where the dimension was maximum and the ML measurement was made at the condyle level just below the articular surface in the mediolateral direction. This method was similar to that of Uehera et al.[18] In some anthropometric studies, two different AP measurements were taken corresponding to the lateral and medial condyle and ML measurement was the same. Even though a few *in vitro* studies have mentioned better coverage of the resected surface with anatomical tibial component (different lateral and medial AP measurements),[19] there are no long-term studies reporting their clinical advantage. Lee et al[20] used three-dimensonal CT and a few others used MRI[20,21] for anthropometric knee measurements in their studies. In our study, the measurements were made intraoperatively using a Vernier caliper. The chances of error due to magnification associated with radiological modalities are minimized by such a direct measurement which is simple, cost-effective, and also avoids radiation exposure.

In many studies on knee anthropometry, the measurements were made on normal subjects.[22] But in clinical practice, measurement of arthritic knees would be more helpful because there would be associated dysplasia of the femoral and/or the tibial condyles. Since we measured the dimensions before any resections were made, the values correspond to the original anatomy of the knees and can be used diversely. Measurement on the resected bone may lead to differences in the measured dimensions due to variation in bone resection techniques and the choice of TKR system used.

In our study, we compared the ARs of tibiae and femurs in a subset of Indian and Arabian patients treated with TKR. The tibial and femoral ARs did not show a significant difference between the Indian and the Arabian population, both genderwise and in total (►**Table 1**). These results imply that there is no conspicuous difference in knee anthropometry with respect to AR between Indian and Arabian knees. This could be due to the reason that ethnically people of Malabar (northern part of Kerala state, India) had migrants from Syria and Oman (Arabian nations) as early as 6th century A.D., and our sample population belonging to these regions might have had genetic similarities.[23]

Another intriguing finding was obtained while comparing the ARs of Indian males and Indian females. Both the tibial and femoral ARs showed a statistically significant difference (p-value of t[AR] = 0.049 and f[AR] = 0.003) even though this comparison was not an objective of our study. However, the reason for this difference could not be substantiated. An overall comparison between the Indian and Arabian population demonstrated that the Arabs have the largest AP and ML measurements than the Indian population (►**Table 2**). These

Table 2 Depiction of the mean and standard deviation of each subgroups of the Indian and the Arabian population

			n	Minimum	Maximum	Mean	SD
Indian population	Indian males	t(AR)	26	1.18	1.80	1.5192	0.13453
		f(AR)	26	0.97	1.49	1.2764	0.10958
	Indian females	t(AR)	65	1.15	1.86	1.5699	0.12468
		f(AR)	65	1.06	1.44	1.2396	0.08381
Arabian population	Arabian males	t(AR)	23	1.33	1.79	1.5729	0.12717
		f(AR)	23	1.16	1.39	1.2638	0.06222
	Arabian females	t(AR)	23	1.31	1.89	1.5794	0.18423
		f(AR)	23	1.05	1.40	1.2385	0.09683

Abbreviations: f(AR), femoral aspect ratio; *n*, total number; SD, standard deviation; t(AR), tibial aspect ratio.

findings can make great strides into gender-specific and ethnic-specific newer implant designs.

Some studies have measured the femoral AR (fML/fAP) of TKR patients intraoperatively. Poilvache et al reported that the femoral AR was 1.333 for White males and 1.299 for White females.[24] Lonner et al found this value to be 1.235 and 1.19 for white males and females, respectively.[25] Chin et al reported similar results, with a femoral AR of 1.266 for White men and 1.22 for White women.[26] In our study, the mean ARs of tibia and femur were 1.555 and 1.250 respectively for the Indian population. For the Arabian population, the mean ARs of tibia and femur were 1.576 and 1.251, respectively. It should be noted that in our study the measurements were made intraoperatively before making any bone cuts, whereas in others the measurements were made after making the bone cuts.

Recently, several designs have come up with intermediate sizes, and with narrow and standard ML dimensions for the same AP dimensions that can address the misfit to a certain extent. In our opinion, however, such designs are available only with a few manufacturers and not yet been made widely available. Also, the availability of intermediate sizes and two different ML sizes for the same AP dimension only partially addresses the anatomical misfit problem. Therefore, the concept of ethnic-specific designs needs more emphasis.

Our study had a few limitations. First, the measurements obtained were not normally distributed, which could be due to the limited number of cases. Second, the male-to-female ratio had a predominance of female patients in the Indian population. However, this ratio reflects the actual ratio seen in clinical practice representing the actual incidence of knee osteoarthritis.[27] Studies in the literature that quote an equal male-to-female ratios were either cadaveric studies[24] or those with recruited healthy volunteers with nonarthritic knees.[11,28–30] Third, the participants enrolled in our study was limited to a single orthopedic center which may not sufficiently represent the whole Indian or Arabian population. Lastly, we measured the dimensions from arthritic knees. For developing ethnic-specific TKR implants, the answer to whether we should consider arthritic knees or normal knees for measurement remains unclear and needs further research. Contemporary implant designs are made based on the evaluation of hundreds of CT scans obtained on patients. This study is evaluating less than 100 in each group. The study is providing a good basis for the ARs. Some caution may be needed to extrapolate that these are the correct sizes to consider for TKR design (a larger sample is likely needed).

Conclusion

The above results would suggest that TKR implants designed anatomically to suit the Indian population can also suit the Arabian population and vice versa. The data from our study can be used by implant designers to come up with ethnic-specific TKR implants.

Conflict of Interest

None declared.

References

1 Cheng C-K, Lung C-Y, Lee Y-M, Huang C-H. A new approach of designing the tibial baseplate of total knee prostheses. Clin Biomech (Bristol, Avon) 1999;14(02):112–117
2 Mahoney OM, Kinsey T. Overhang of the femoral component in total knee arthroplasty: risk factors and clinical consequences. J Bone Joint Surg Am 2010;92(05):1115–1121
3 Ranawat CS. The patellofemoral joint in total condylar knee arthroplasty. Pros and cons based on five- to ten-year follow-up observations. Clin Orthop Relat Res 1986;(205):93–99
4 Dennis DA. Evaluation of painful total knee arthroplasty. J Arthroplasty 2004;19(04, Suppl 1):35–40
5 Culp RW, Schmidt RG, Hanks G, Mak A, Esterhai JL Jr, Heppenstall RB. Supracondylar fracture of the femur following prosthetic knee arthroplasty. Clin Orthop Relat Res 1987;(222):212–222
6 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(01):124–130
7 Ha CW, Na SE. The correctness of fit of current total knee prostheses compared with intra-operative anthropometric measurements in Korean knees. J Bone Joint Surg Br 2012;94(05): 638–641
8 Jain JP. Knee prosthesis sizes in Indian patients undergoing total knee replacement. Int Surg J 2016;2(03):348–351
9 Vaidya SV, Ranawat CS, Aroojis A, Laud NS. Anthropometric measurements to design total knee prostheses for the Indian population. J Arthroplasty 2000;15(01):79–85
10 Cheng FB, Ji XF, Lai Y, et al. Three dimensional morphometry of the knee to design the total knee arthroplasty for Chinese population. Knee 2009;16(05):341–347
11 Ho W-P, Cheng C-K, Liau J-J. Morphometrical measurements of resected surface of femurs in Chinese knees: correlation to the sizing of current femoral implants. Knee 2006;13(01):12–14
12 Urabe K, Miura H, Kuwano T, et al. Comparison between the shape of resected femoral sections and femoral prostheses used in total knee arthroplasty in Japanese patients: simulation using three-dimensional computed tomography. J Knee Surg 2003;16(01): 27–33
13 Yip DK, Zhu YH, Chiu KY, Ng TP. Distal rotational alignment of the Chinese femur and its relevance in total knee arthroplasty. J Arthroplasty 2004;19(05):613–619
14 Tria AJ Jr. Minimally invasive total knee arthroplasty: the importance of instrumentation. Orthop Clin North Am 2004;35(02): 227–234
15 Kim H-A, Kim S, Seo YI, et al. The epidemiology of total knee replacement in South Korea: national registry data. Rheumatology (Oxford) 2008;47(01):88–91
16 Scuderi GR, Tenholder M, Capeci C. Surgical approaches in mini-incision total knee arthroplasty. Clin Orthop Relat Res 2004; (428):61–67
17 Hafez MA, Sheikhedrees SM, Saweeres ES. Anthropometry of Arabian arthritic knees: comparison to other ethnic groups and implant dimensions. J Arthroplasty 2016;31(05):1109–1116
18 Uehara K, Kadoya Y, Kobayashi A, Ohashi H, Yamano Y. Anthropometry of the proximal tibia to design a total knee prosthesis for the Japanese population. J Arthroplasty 2002;17(08):1028–1032
19 Bloebaum RD, Bachus KN, Mitchell W, Hoffman G, Hofmann AA. Analysis of the bone surface area in resected tibia. Implications in tibial component subsidence and fixation. Clin Orthop Relat Res 1994;(309):2–10
20 Howell SM, Kuznik K, Hull ML, Siston RA. Results of an initial experience with custom-fit positioning total knee arthroplasty in a series of 48 patients. Orthopedics 2008;31(09):857–863
21 Thienpont E, Paternostre F, Pietsch M, Hafez M, Howell S. Total knee arthroplasty with patient-specific instruments improves function and restores limb alignment in patients with extra-articular deformity. Knee 2013;20(06):407–411

22 Surendran S, Kwak DS, Lee UY, et al. Anthropometry of the medial tibial condyle to design the tibial component for unicondylar knee arthroplasty for the Korean population. Knee Surg Sports Traumatol Arthrosc 2007;15(04):436–442
23 Elias T. East Syrian missions to Asia with special reference to Malabar coast from sixth century to sixteenth century AD and its influence on Indian religion, society and culture. Available at: https://shodhganga.inflibnet.ac.in/handle/10603/6356?mode=full. Accessed March 18, 2004
24 Poilvache PL, Insall JN, Scuderi GR, Font-Rodriguez DE. Rotational landmarks and sizing of the distal femur in total knee arthroplasty. Clin Orthop Relat Res 1996;(331):35–46
25 Lonner JH, Jasko JG, Thomas BS. Anthropomorphic differences between the distal femora of men and women. Clin Orthop Relat Res 2008;466(11):2724–2729
26 Chin KR, Dalury DF, Zurakowski D, Scott RD. Intraoperative measurements of male and female distal femurs during primary total knee arthroplasty. J Knee Surg 2002;15(04):213–217
27 UNICEF Egypt. Children in Egypt: a statistical digest. Available at: https://www.unicef.org/eg_UNICEF-2015-Children-in-Egypt-Statistical-Digest(3).pdf. Accessed June, 2015
28 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(01):26–30
29 Hovinga KR, Lerner AL. Anatomic variations between Japanese and Caucasian populations in the healthy young adult knee joint. J Orthop Res 2009;27(09):1191–1196
30 Hussain F, Abdul Kadir MR, Zulkifly AH, et al. Anthropometric measurements of the human distal femur: a study of the adult Malay population. BioMed Res Int 2013;2013:175056