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Morphometry of the medial tibial plateau in Turkish knees: correlation to the current tibial components of unicompartmental knee arthroplasty

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Objective: The objective of this study was to measure the resected surfaces of the tibia in knees of Turkish patients and to compare these measurements with the dimensions of tibial implants in current use.

Methods: We made measurements of seven different dimensions of the medial tibial plateau at the virtual resection level for unicompartmental knee arthroplasty (UKA) on MRIs of 260 patients and the most commonly used four UKA implants in Turkey. Statistical analysis was performed by using Student's t-test, analysis of variance (ANOVA), chi-square test and Pearson's correlation coefficient by using SPSS software.

Results: The anteroposterior and widest mediolateral dimensions of the tibial plateau of Turkish knees were found relatively more approximate to the dimensions of Oxford and Zuk prostheses compared to that of Accuris and Mitus ($p<0.001$). The distance between the central mediolateral dimension and the widest mediolateral dimension was 2.4 (range: 0-6.3) mm in males and 2.6 (range: 0-6.2) mm in females. The maximum mediolateral dimension was found posterior to the central mediolateral dimension in the majority (202 out of 260) of cases. These findings point towards the asymmetry in the AP halves of the resected medial tibial condyle.

Conclusion: Tibial components designed according to anthropometric measurements based on both Western and Asian populations do not perfectly meet the requirements of Turkish population. Designing different UKA prostheses for different populations are required for best fit.

Key words: Prosthesis; tibial implant; Turkish population; unicondylar knee arthroplasty.

Appropriate sizing of the tibial component of the total knee arthroplasty (TKA) is essential for maximizing proximal tibial bone coverage and load transmission.[1,2] This provides the best stability and longevity for the implant.[3,4] If the tibial component in TKA is small, it-will be inadequately supported by the underlying bone and will subside and loosen.[5] Undersizing of the tibial component is even more critical for unicompartmental knee arthroplasty (UKA) than for TKA. The amount of bone support in UKA is less than half of that available for TKA, and there is insufficient room for a large stem. On the other hand, if the component is too large, the

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overhang may cause soft tissue irritation and pain. The problem is not only size but also the shape of the component. An optimally implanted UKA tibial component would be one that matches with all edges of the tibia.

Recent anthropometric studies have suggested that current designs of UKA do not address the racial anthropometric differences.[6,7] This leads to the problem of an implant size or shape mismatch with the resected bony surface in different populations.

In this study, we investigated the morphometric parameters of the tibial component regarding the UKA in the Turkish population. The objective of this study was to measure the resected surfaces of the tibia in knees of Turkish patients and to compare these measurements with the dimensions of tibial implants in current use.

Patients and methods

This study included 260 knees of 260 patients in the Turkish population. There were 150 women and 110 men, and the average age was 54.3±9.55 (range: 40 to 77) years. The exclusion criteria were patients with bone deformity, malalignment, or knees with any implants. Patients under the age of 40 and over 80 were also excluded.

Magnetic resonance imaging was performed using a 1.5 Tesla MRI system (Siemens MAGNETOM Avanto 1.5 T; Siemens AG, Munich, Germany). Axial, coronal and sagittal sections were obtained. The MRI sections were taken with a 7° posterior slope from 6 mm below the highest point of tibial plateau (Fig. 1).

Dimensions of the tibial cut surface was measured as described by Surendran et al.[7] and a line was drawn in the axial plane to the tibial cut surface, which was parallel to the intercondylar line of the femur. The length of this line is defined as the mediolateral (ML) dimension. An XY line was perpendicular to ML and passed through its mid-point. Line XZ was drawn medial to XY and made an angle of 6° anteriorly with XY. The anteroposterior (AP) line was 3 mm medial and parallel to line XZ. The widest mediolateral dimension of the medial tibial plateau (WD) was drawn perpendicular to the AP line (Fig. 2).

A line was drawn perpendicular to the AP line and its intersection with the medial tibial condyle at 25% was called (WA), 50% (WC) and 75% (WB). WD line was the maximum width of the medial tibial condyle. The distance between the WC line and the WD line was also measured and called as CD (Fig. 3).

The term aspect ratio (AR), defines the ratio of the WD to the AP dimension of the medial tibial condyle as

Fig. 1. The MRI sections in the sagittal plane used for drawing a 7° posterior slope from 6 mm below the highest point of the tibial plateau. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

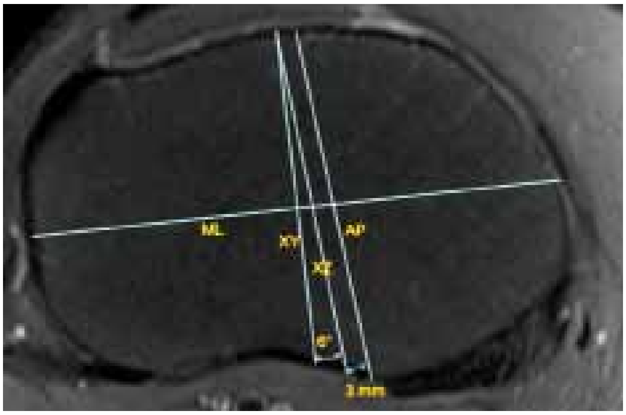

Fig. 2. View of the medial tibial condyle at resection level. Lateral border of the resection was 3 mm medial to XZ line with 6° of external rotation (alignment of the center of the femoral head). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

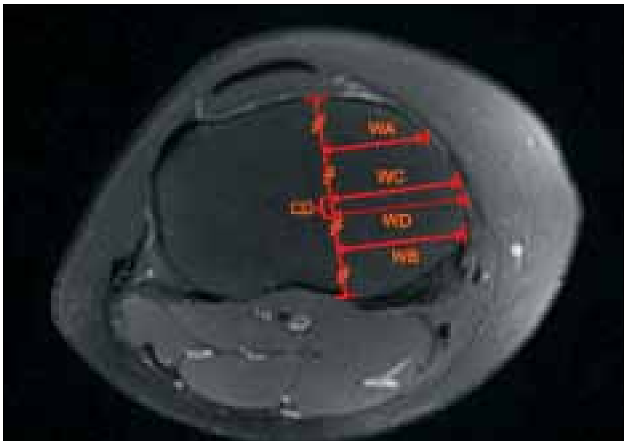

Fig. 3. WD line shows the widest length of the resection at the medial plateau. WA, WB, WC lines intersect the AP line at 25%, 50% and 75%, respectively. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

described by Hitt et al., and it is expressed as a percentage (WD/AP x 100).[8]

A digital radiological system, NovaPACs Diagnostic Viewer, was used for all radiological evaluation and all data was evaluated by two orthopedic surgeons and one radiologist.

Statistical analysis was performed by using analysis of variance (ANOVA) in comparing implants and patients. Dunnet's post hoc test and Spearman's correlation were used for comparing patients and implant series by using SPSS v19.0 (SPSS Inc., Chicago, IL, USA). The dimensions were expressed as mean±standard deviation. The significance level was set at $p<0.05$ in all tests.

Results

The comparison of WD and AP dimensions of the implants in males and females are shown in Figure 4. The AP and WD dimensions of the study population were found relatively more approximate to the knee dimensions of Oxford and Zuk prostheses compared to that of Accuris and Mitus ($p<0.001$). Although, the ratios of all implant brands involved in this study were found almost

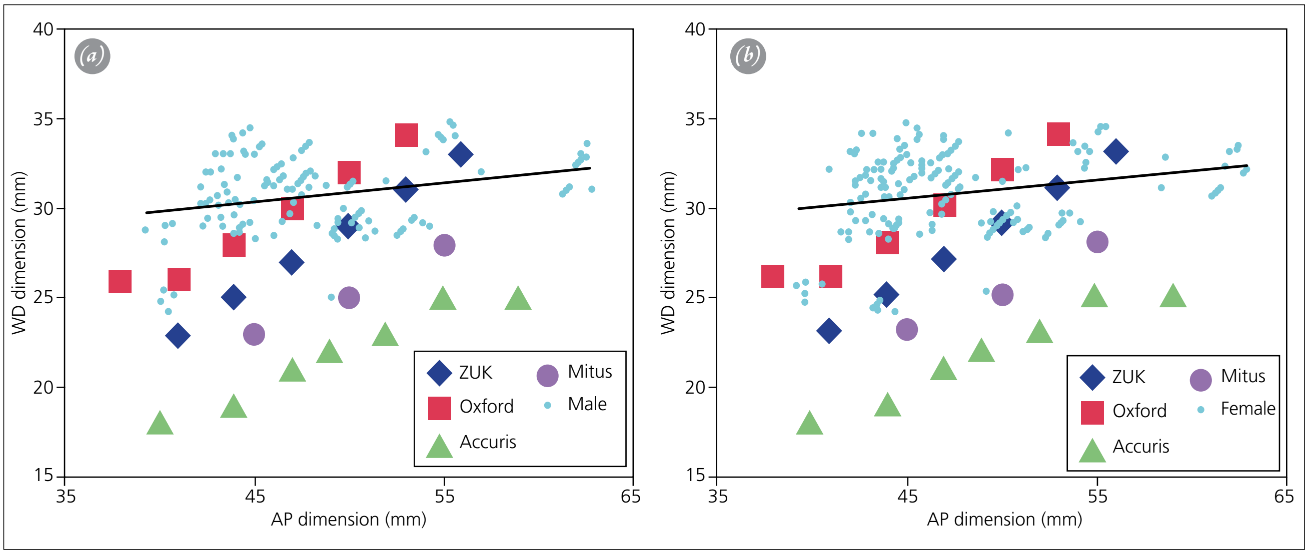

Fig. 4. Measurements of the AP and WD dimensions of Turkish knees of **(a)** males and **(b)** females are compared to the dimensions of the four currently used UKA implants in Turkey. The line represents the average values for the population data. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

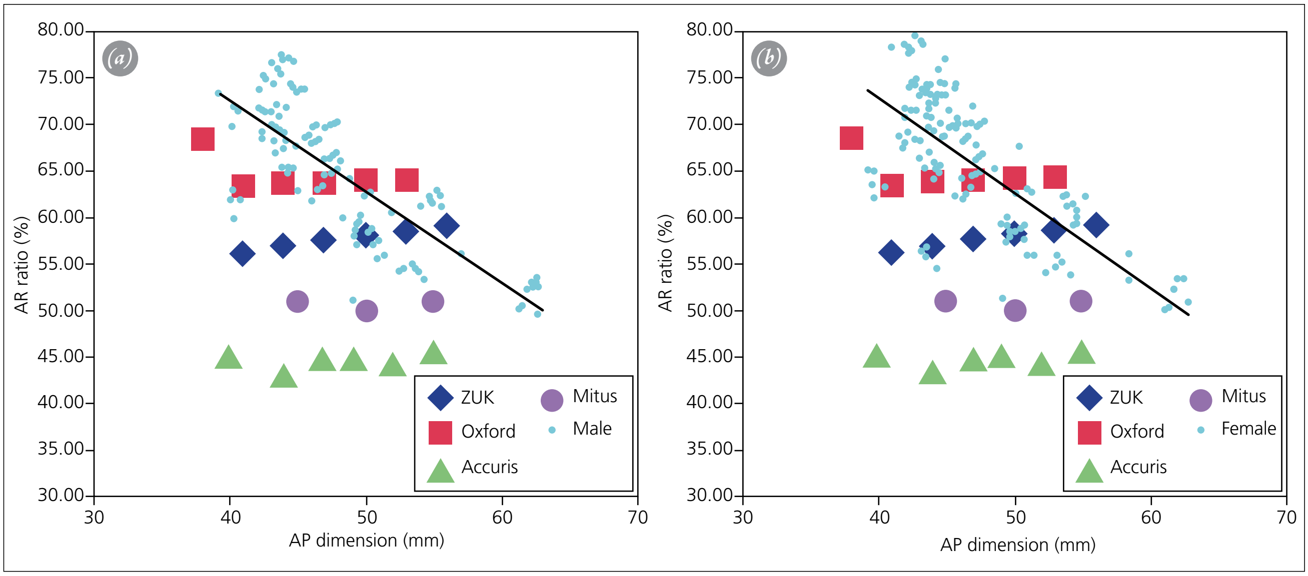

Fig. 5. The measurements of the UDA implants demonstrated progressive decline in the AR with the increase in the AP dimension in **(a)** males and **(b)** females. The line represents the average values for the population data. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

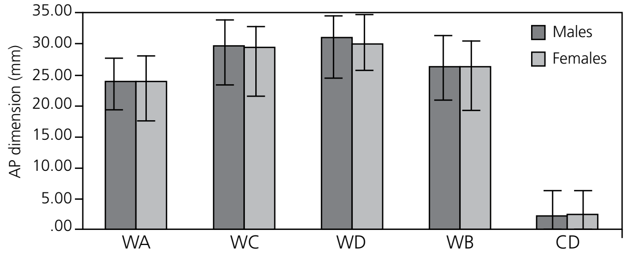

Fig. 6. The mediolateral dimensions (WA, WC, WB and WD) of the medial tibial condyle and CD along the AP dimension.

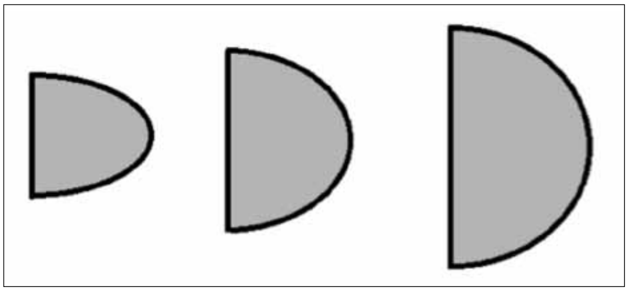

Fig. 7. For a given increase in the AP dimension of the resected medial tibial condyle, the corresponding increase in the mediolateral dimension is of lesser magnitude.

similar, the measurements demonstrated a progressive decline in the AR with an increase in the AP dimension for both males and females (Fig. 5) ($p<0.001$). The AR of the Accuris and the Mitus implants was found to be lower than the whole range of AP dimensions measured in our population.

We measured the mediolateral dimensions (WA, WC, WB and WD) of the medial tibial condyle at specific points along the AP dimension (Fig. 6). The mean CD length was found to be 2.4 (range: 0-6.3) mm in males and 2.6 (range: 0-6.2) mm in females. The maximum mediolateral dimension was located posterior to the central mediolateral dimension (WC) in the majority (202 out of 260) of cases. These findings point towards the asymmetry in the AP halves of the resected medial tibial condyle.

Discussion

The success of a knee replacement depends on the surgical technique, the rehabilitation, and the implant design.[9,10] The ideal implant design should aim the restoration of normal knee mechanics by preserving the tissues and providing surfaces that recover function.[11] The best stability can be achieved by optimizing the load transfer by matching the geometry of the implant to the resected surface as much as possible.[12]

The mismatch of the resected surface and tibial component may cause problems. If the component is too large, it will overhang the bone and impinge on the surrounding soft tissues; if it is too small, there will be increased contact stress and poorer load transfer across its surface, and may also result in subsidence if the implant is not resting on the harder cortical bone rim. Therefore, a proper fit between the component and the resected surface is a critical factor in survivorship for UKA.[13]

Most of the prostheses currently available in the market are produced to fit with the anatomical features of the European and North American populations. The anthropometric differences in the dimensions of the knee have to be considered as a reason for the mismatch between the component and the resected surface. However, there is not much information regarding the anthropometry of the knee joint in order to design UKA implants that are suitable for different populations. There are limited studies that show the significant differences between these component sizes and cut surface sizes of the Asian populations.[6-8] The Turkish population, however, show differences with respect to Asian, European and North American populations, as demonstrated in anthropometric studies.[14]

The shape of the components are as important as the linear dimension of WD and AP size to best fit the resected area.[13,15] That is why we calculated not only the AP and lateral dimensions but also the WA, WB, WC and the AR. The measurement of the WA, WC, WD, WB and AP dimensions gave a rough estimate of the gross size of the resected medial tibial condyle. An AR of less than 100% predicts an AP oblong shape for the prosthesis. Surendran et al.[7] found the WD was located behind the WC in a majority of the Korean population, with a more posterior location in the female gender. The authors think that, this could be due to the prolonged flexed knee posture maintained during daily activities, which might lead to hypertrophy in the mediolateral dimension at a more posterior location of the tibial condyle. In the Turkish population, the prolonged flexed knee posture is more common than in Western populations and less than Asian populations. Our measurements support this, which show a smaller length of CD compared to the Korean population, irrespective of gender. However, all of the dimensions of Turkish knees are smaller in females, meaning the CD measured in females is bigger than that of males.

The morphological data showed a progressive decrease in the AR with an increase in the AP dimension of the condyle, irrespective of the gender (Fig. 5). This implies that for a given increase in the AP dimension of the resected medial tibial condyle, the corresponding increase in the mediolateral dimension is of lesser magnitude (Fig. 7). This situation leads to a mismatch with the conventional UKA tibial component designs. As the size of the implants got bigger, the Accuris and Oxford tibial prostheses showed a relatively decreasing AR, the Mitus showed a relatively constant AR, and the Zuk and Osteonics showed an increasing AR. Tibial components that have an AR matching that of Turkish population are expected to provide better coverage for the resected medial tibial condyle.

When the population data was compared with the designs of the conventionally used tibial components, we found that two designs (Accuris and Mitus) showed mediolateral undersizing for all the comparative AP dimensions. The three designs (Zuk, Oxford, and Osteonics) had better AR measurements matching with those of the Turkish population. However, they also demonstrated mediolateral undersizing for the smaller AP dimensions and oversizing for the larger AP dimensions.

We realize that, the AP and WD dimensions of Turkish knees show a more widespread graphical distribution compared to Asian populations. The explanation of this may be the genetic variety of the population living in Turkey. These genetic variations of the population may bring anthropometric differences within the Turkish population itself.

In conclusion, our results confirm the differences between the Turkish population and the tibial components designed according to anthropometric measurements based on both Western and Asian populations. We believe that the results found in this study will not only be helpful in designing UKA implants that is more appropriate for the Turkish population, but also will be evidence for the requirement of different designs for different populations.

Conflicts of Interest: No conflicts declared.

References

1. Berend ME, Small SR, Ritter MA, Buckley CA. The effects of bone resection depth and malalignment on strain in the proximal tibia after total knee arthroplasty. J Arthroplasty 2010;25:314-8. CrossRef
2. Innocenti B, Truyens E, Labey L, Wong P, Victor J, Bellemans J. Can medio-lateral baseplate position and load sharing induce asymptomatic local bone resorption of the proximal tibia? A finite element study. J Orthop Surg Res 2009;4:26. CrossRef
3. D'Lima DD, Patil S, Steklov N, Slamin JE, Colwell CW Jr. Tibial forces measured in vivo after total knee arthroplasty. J Arthroplasty 2006;21:255-62. CrossRef
4. Chau R, Gulati A, Pandit H, Beard DJ, Price AJ, Dodd CA, et al. Tibial component overhang following unicompartmental knee replacement-does it matter? Knee 2009;16:310-3. CrossRef
5. Nielsen PT, Hansen EB, Rechnagel K. Cementless total knee arthroplasty in unselected cases of osteoarthritis and rheumatoid arthritis. A 3-year follow-up study of 103 cases. J Arthroplasty 1992;7:137-43. CrossRef
6. Cheng FB, Ji XF, Zheng WX, Lai Y, Cheng KL, Feng JC, Li YQ. Use of anthropometric data from the medial tibial and femoral condyles to design unicondylar knee prostheses in the Chinese population. Knee Surg Sports Traumatol Arthrosc 2010;18:352-8. CrossRef
7. Surendran S, Kwak DS, Lee UY, Park SE, Gopinathan P, Han SH, 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;15:436-42. CrossRef
8. Hitt K, Shurman JR 2nd, Greene K, McCarthy J, Moskal J, Hoeman T, et al. Anthropometric measurements of the human knee: correlation to the sizing of current knee arthroplasty systems. J Bone Joint Surg Am 2003;85-A Suppl 4:115-22.
9. NIH Consensus Statement on total knee replacement. NIH Consens State Sci Statements 2003;20:1-34.
10. Choong PF, Dowsey MM. Update in surgery for osteoarthritis of the knee. Int J Rheum Dis 2011;14:167-74. CrossRef
11. Walker PS, Yildirim G, Arno S, Heller Y. Future directions in knee replacement. Proc Inst Mech Eng H 2010;224:393-414. CrossRef
12. Incavo SJ, Ronchetti PJ, Howe JG, Tranowski JP. Tibial plateau coverage in total knee arthroplasty. Clin Orthop Relat Res 1994;299:81-5.
13. Fitzpatrick C, FitzPatrick D, Lee J, Auger D. Statistical design of unicompartmental tibial implants and comparison with current devices. Knee 2007;14:138-44. CrossRef
14. Güleç E, Akın G, Sagir M, Koca Özer B, Gültekin T, Bektaş Y. Anthropometric dimensions of Anatolian people: results of 2005 Turkish Anthropometric Survey. [Article in Turkish] Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi 2009;49:187-201.
15. Fitzpatrick CK, FitzPatrick DP, Auger DD. Size and shape of the resection surface geometry of the osteoarthritic knee in relation to total knee replacement design. Proc Inst Mech Eng H 2008;222:923-32. CrossRef