

Non-Invasive Gender Specific Morphometry of Congruent Surfaces of Knee Joint in North Indian Population

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ABSTRACT

Objective: Determine the sizes of distal femur and proximal tibia in north Indian population using magnetic resonance imaging technique. To analyses the morphometric differences in distal femur and proximal tibia in male and female.

Materials and Methods: Research work was carried out in Teerthanker Mahaveer Hospital, from December 2017 to January 2018. morphological analysis of proximal tibia and distal femur on 150 subjects (80 males, 70 females) using MRI to investigate a gender difference. Tibial mediolateral dimension (tML), tibial medial anteroposterior dimension (tMAP), tibial lateral anteroposterior dimension (tLAP) femoral mediolateral dimension (fML), femoral medial anteroposterior dimension (fMAP), and femoral lateral anteroposterior dimension (fLAP) were measured. The ratio of tMAP and tLAP to tML (plateau aspect ratio, tAP/tML×100%), and that of fMAP and fLAP to fML (condylar aspect ratio, fAP/fML×100%) were calculated.

Results: According to our study women were found to have more trapezoidal distal femurs with narrower ML dimensions and oval proximal tibia with a relatively long ML length.

Conclusion: The results suggested that in terms of prosthesis design, sex differences should be taken into account to design components that better match the natural geometry of knee joint.

Keywords: Total Knee Replacement (TKR), MRI, Knee Prosthesis, Aspect Ratio.

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INTRODUCTION

The knee joint is the most crucial and strongest joint in the human body. Total knee arthroplasty (TKA) or total knee replacement (TKR) is an orthopaedical surgical procedure where the joint surfaces of the knee, between femoral condyles and tibial plateau, are replaced.¹ To achieve a successful outcome throughout total knee arthroplasty (TKA) and to reduce complications, it is important that the size and shape of the knee prosthesis matches the morphology of the surgical operation of the knee.^{2,3} Specifically, Asian populations have totally different femoral dimensions and morphology than Western populations.^{4,5} However, presently the knee prostheses are designed based on anthropometrical information from Caucasian knees, and such prostheses do not necessarily provide the best fit in Asian populations. "One of the most important aspects of total knee replacement (TKR) surgery is to design better knee implants in the operation. In the traditional preparation for the surgery, surgeons

choose one from the available range of readymade implants by measuring patient's magnetic resonance images with morphological viewpoint. However, due to various size and shapes of human knee joint of every individual, the chosen readymade implant sometimes may not be proper to a patient or cannot be used for patients with a deformity or an abnormal anatomy. This is because available readymade implants just have a limited range of geometry for the mass manufacturing scheme. Therefore, in order to achieve higher implantation accuracy, a custom-made knee implant needs to be made for the patient with abnormal bone shapes. It is certain that the well-suitable implant may be the "best" from the viewpoint of morphological conformity. The sizes and the shapes of implants also play important roles, because prostheses that match patient morphotypes provide firmer fixation and better initial stability.^{6,7} It has been an issue of debate whether the knee joints of men and women differ

morphologically and whether gender specific prostheses are required.⁸⁻¹⁰ Morphological measurements revealed female knee joints have anterior condyles that are less prominent and diamond shaped. Furthermore, women with the same anteroposterior (AP) length have been reported to have a narrower mediolateral (ML) width than men.¹⁰

Given this finding, some have mention that gender-specific prostheses are needed". Therefore, with the expectation in mind of finding considerable variation associated with gender in the morphology of the knee joint, this study was carried out to determine the changes in morphometry of distal femur and proximal tibia in both sexes in North Indian population.

MATERIALS AND METHODS

This research was carried out in Teerthanker Mahaveer Hospital, from December 2017 to January 2018 and was approved by our Institutional ethical review board. A total of 150 subject (80 males and 70 female), were included in the study after signing the informed consent form. The subjects underwent magnetic resonance imaging (MRI) of knee joint.

MRI Technique: Images were obtained with the help of, 1.5 TESLA MRI unit (Avanto magnetomtim + dot system simmens. Erlangen Germany) at 3 mm thick with an intervening interval of 0.3 mm. To obtain an axial image which runs parallel to knee joints, the subjects were asked to lie down in the supine position with their knee joints at 0°angle with patella facing forward for the imaging.¹¹ NUMARIS/4 synngo MR D13 system was used to measure the morphometric parameters in the axial image of proximal tibia and distal femur.

Measurement of Proximal Tibia. "The mediolateral length of tibia (tML) was the length of the longest ML line in axial images of the

proximal tibia. Anteroposterior length of tibia (tAP) was taken as the line drawn perpendicular to the tML line while passing through the midpoint of the resected surface. Medial anteroposterior length (tMAP) and lateral anteroposterior length (tLAP) were defined as the longest lines drawn parallel to the tAP line and perpendicular to the tML line, to the medial and the lateral condyles of tibia respectively from the resected surface".¹² (Fig 1)

Measurement of Distal Femur. Measurements of the transepicondylar axis connecting the medial and lateral epicondyles (to determine ML length) might have larger values than replacements. Instead of defining transepicondylar axis as ML length, we decided to take measurement at the distal femur where the femoral component is inserted during TKA. The measurement was made in the axial MR image which is 9–10 mm above the lowest point of the medial femoral condyle (one to two slice(s) more distal to axial image showing the transepicondylar axis). Medioloateral length of distal femur (fML) was taken to be that of the longest line connecting the medial and the lateral dimensions while medial anteroposterior length (fMAP) and the lateral anteroposterior length (fLAP) of distal femur were defined as the longest line drawn perpendicular to the fML line, reaching the medial and the lateral condyles of femur respectively from the resected surface. (Fig 2)

Ratio of ML to AP: Based on definition of Hitt et al.¹³, the ratios of tMAP and tLAP to tML (plateau aspect ratio, tAP/tML×100%), and that of fMAP and fLAP to fML (condylar aspect ratio, fAP/fML×100%) were calculated.

Statistical Analysis: Student t-test was performed to determine the significances of gender differences. Statistical significance was accepted for p values of <0.05. The data were analysed by using SPSS (version 16.0).



Fig 1: Axial MRI image of the proximal tibia showing the mediolateral length of tibia (tML), the anteroposterior length of tibia (tAP), the medial anteroposterior length (tMAP), the lateral anteroposterior length (tLAP).



Fig 2: Axial MRI image of the distal femur showing the mediolateral length of distal femur (fML), the medial anteroposterior length (fMAP), the lateral anteroposterior length (fLAP).

RESULTS

Morphotype of Proximal Tibia

There is a significant gender difference in tML and tAP length with $p < 0.001$. The proximal tibia of women was observed to be diamond shaped with ML length longer than AP length. There is no significant difference males and females tMAP/tML with p value 0.71 and tLAP/tML with p value 0.81.

Morphotype of Distal Femur

It was observed that there was a significant increase in dimension of males as compared to females with p value < 0.001 . Aspect ratio of females fMAP/fML and fLAP/fML were significantly larger in females with p value < 0.001 .

DISCUSSION

Dimensions of distal femur and proximal tibia, of females were found to be significantly smaller than those of males. In addition, there is a difference in the aspect ratio of distal femur and proximal tibia between male and female knees. Women were found to have more trapezoidal distal femurs with narrower ML dimensions and oval proximal tibia with a relatively long ML length.

Morphometry of Proximal Tibia

The mediolateral length of tibia was taken in both male and female subjects and the dimension of tML in females is found to be narrower than the male. The Medial anteroposterior condyle length of tibia was taken in both male and female subjects and the dimension of tMAP female is found to be narrower than the male.

The lateral anteroposterior condyle length of tibia was taken in both male and female subjects and the dimension of tLAP in female was found to be narrower than the male.

The aspect ratio of tMAP/tML length of tibia was calculated in both male and female subjects and the result shows minor difference in the aspect ratio between male and female. Mean difference

tMAP/tML of aspect ratio in male and female was 0.01. The aspect ratio of tLAP/tML length of tibia was calculated in both male and female subjects and the result shows similar difference in the aspect ratio between male and female. Mean difference tLAP/tML of aspect ratio in male and female is 0.00. In the present study, tML length was found to be greater in women when same AP length was compared in between males and females. The results of our study support the research conducted by Hong-Chul Lim et al.¹⁴ who had done morphological study of distal femur and proximal tibia in Korean population and he found that tML and tAP length showed significant gender difference and different plateau aspect ratio. The result of morphotype of distal femur and its mean show significantly larger value in dimension. The aspect ratio tLAP/tML was found to be similar in males and females with ($p < 0.8$) showing insignificant. These findings again is consistent with the finding of Hong-Chul Lim et al. aspect ratio (tLAP/tML) was found also found to be insignificant in his study. In our study the mean value of tMAP in males was 4.80 and that of female it was 4.14 and of tLAP in male 4.48 and of female it is 3.87. These findings was in accordance with the results of study of Swati Gandhi et al.¹⁵ who conducted morphometric analysis of upper end of tibia in Indian population in which the tMAP of male 4.85 and that of female was 4.23 and tLAP of male 4.08 and female 3.67. The results of our study was in conformity with the findings of Kwak et al.¹² who reported the ML length of the female proximal tibial surface is smaller than that of the male after adjusting for AP length. Cheng et al.¹⁶ also reported proximal tibia in males had larger values in ML dimension and aspect ratio than female under a given same AP dimension in a Chinese population. All parameter of distal femur was observed and values were compared between males and females.

Morphometry of Distal Femur

The mediolateral length of femur was taken in both male and female subjects and the dimension of fML female is found to be narrower than the male. The medial anteroposterior condyle length of femur was taken in both male and female subjects and the dimension of fMAP female is found to be narrower than the male. The lateral anteroposterior condyle length of femur was taken in both male and female subjects and the dimension of fLAP female is found to be narrower than the male. The aspect ratio of fMAP/fML length of tibia was calculated in both male and female subjects and the aspect ratio of fMAP/fML male is found to be narrower than the female. The aspect ratio of fLAP/fML length of tibia was calculated in both male and female subjects and the aspect ratio of fLAP/fML in male is found to be narrower than the female. Regarding the morphology of distal femurs, our data showed that men have significantly larger dimensions than women for all measurements, the aspect ratio in women is greater than that in male. The females were found to have a narrower ML dimension compared with a male distal femur of the same AP dimension and less prominent anteromedial femoral condyle. These results are similar with those of Caucasian studies.¹⁶

The results of our study support the research conducted by Hong-Chul Lim¹⁴ who had done morphological study of distal femur and proximal tibia in Korean population and he found that fML and fAP length showed significant gender difference and different plateau aspect ratio. The result of morphotype of distal femur and its mean show significantly larger value in dimension. The results of our study on morphometry of distal femur supports the research conducted by Tw Ewe et al.¹⁷ who had done morphological study of distal femur in Malaysia population and he found that fML and fAP length showed significant gender difference. According to our study the mean difference in the morphometry of distal femur showed significantly larger value in dimension which is in accordance with the findings of Bo Yang et al.¹⁸ who studied comparison of sex difference in distal femur in Chinese population and found that fML and fAP length showed significance difference.

CONCLUSION

On the basis of our study we can conclude that there is a significant gender differences in the tML and tAP length of proximal tibia in North Indian population. In females the values are less as compared to males. The aspect ratio of males and females are similar in tibia. Moreover, there is a significant gender differences in the morphometry of femur. fML and fAP length of distal femur in males is greater than females. The aspect ratio of femur is also higher in females. These finding may provide guidance for designing suitable total knee prosthesis for the Indian population, especially for design of gender specific prosthesis.

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