ORIGINAL ARTICLE

Morphometric Anatomy of the Tibia Plateau in Nigerians

Dennis Erhisenebe O. Eboh

ABSTRACT

BACKGROUND: There are increasing cases of osteoarthritis and associated disabilities with age, hence the need for knee replacement to restore the anatomy and function of the knee. The objective of this study was to determine the dimensions of the tibial plateau in dry human tibias of Nigerians. This will serve as a guide for the tibia components during total knee replacement procedure.

METHODS: This study adopted the descriptive method of the quantitative design and utilized 133 dry tibias. Total transverse width, total anteroposterior length of intercondylar region, transverse widths of medial and lateral tibia plateaus, and anteroposterior length of the plateaus were measured in millimeter (mm). Statistical analysis of the data was done using mean (SD), t-test and correlation, with the aid of SPSS 23. Statistical significance was fixed at p<0.05.

RESULTS: Statistically, the differences between the right and left parameters were not significant. The mean total transverse width was longer than the total anteroposterior length. The mean anteroposterior length of the medial tibia plateau was significantly longer than that of the lateral tibia plateau. The difference between the transverse width of both the medial and lateral tibia plateau was not statistically significant.

CONCLUSION: This study showed that the tibial plateau dimensions can act as guiding tools to the orthopedic surgeon during a knee replacement procedure; and those involved in the fabrication of knee replacement prostheses for Nigerians. The physical anthropologists will also find the anthropometric data invaluable in population studies.

KEYWORDS: Arthroplasty, forensic anthropology, knee joint, orthopedics, Tibia, Nigeria

INTRODUCTION

The tibia plateau or condyle is the upper articular surface of the tibia. It slopes posteriorly and downwards which decreases with age from birth; and it is more prominent in people who are habitual squatters (1). The plateau is formed into a two concave particular area; the medial condyle which is oval anteroposteriorly and lateral condyle which is almost circular and slightly smaller than the former. They articulate with the corresponding femoral condyles to form part of the knee joint. An anteroposterior groove separates the
intercondylar eminence to form the medial and lateral intercondylar tubercles) (2).

In view of the increasing cases of osteoarthritis and the attendant disability (3) with age (4), and the need for knee replacement to restore the anatomy and function of the knee (5), a population-specific data of the proximal tibia become crucial. This is so because the dimensions of the superior articular surface of the tibia have been found to differ among populations (6,7). It has also been stated that variations in anthropometry exist among different populations of the world (8). These parameters have been well studied in Caucasian, Indian and East Asian subjects, but there is a dearth of information about the proximal tibia anthropometric parameters of the black African population. In a revision of 30 studies, only 3 of them, including 130 knees, belonged to black subjects of which none is African (9). Also, different anatomical profiles would not fit correctly with conventional components of knee prosthesis (10).

The linear dimensions of the tibia plateau had been done utilizing dry tibia bones (direct method) (8,11-13), computed tomography (CT) (14-16), and magnetic resonance imagining (MRI) (17,18). Despite the availability of studies on tibia plateau in the literature, there is a paucity of same in Nigerians. This study tends to fill the gap using the tibial plateau dimensions of Nigerians.

The basic morphometric data from this study will be very important to the orthopedic surgeons in planning for knee replacement procedures, and prosthetic industries involved in production of knee replacement prostheses. These primary data will also be of immense benefit to the anthropologist in comparing the tibia condyles with those of other ethnic groups or populations. The purpose of this study was to determine the dimensions of the tibia plateau in dry human tibias of Africans.

MATERIALS AND METHODS

The study used the descriptive method of the quantitative design. All dry human tibias in the anatomy museum of five Nigerian Universities: Ambrose Ali University, Delta State University, Nnamdi Azikiwe University and University of Benin, formed the study population. One hundred and thirty-three (133) tibias constituted the sample for the study, which amounted to all the available tibias in the bone collections. The Faculty Ethics Committee of the Delta State University, approved the research (REC/FBMS/DELSU/19/47), without any prejudice to the Declaration of Helsinki as revised (19).

Method of measurements: Firstly, the bones were separated into right and left based on anatomical position. All bones with normal morphological features were involved in the study, while those with abnormal features and fractures were excluded. All the bones were adults of unknown gender. The following parameters were measured in millimeter according to Figure 1, using the digital sliding caliper (Mitutoyo, Japan): total transverse width (TTW) of the tibia plateau, total anteroposterior length (TAL) of the intercondylar region, the transverse width of the lateral tibia plateau (TWL), the anteroposterior length of the lateral plateau (ALL), the transverse width of the medial tibia plateau (TWM) and the anteroposterior length of the medial plateau (ALM).

Figure 1: Proximal tibia with all measurements taken.
AC: Length of medial tibial plateau; BD: Width of medial tibial plateau; GI: Length of lateral tibial plateau; JH: Width of lateral tibial plateau; DJ: intercondylar eminence; EF: Total anteroposterior length of tibia plateau; BH: Total transverse width of tibia plateau; MP: Medial tibial plateau; LP: Lateral tibial plateau; TT: Tibial tuberosity.

Data analysis: Analysis of the data was done with the aid of IBM SPSS statistic 23. Mean and standard deviation were used to summarize the
data, while independent (unpaired) samples t-test was used to test if there was a significant mean difference between data on the right and left sides, and paired samples t-test between the medial and lateral sides. All p-values <0.05 were regarded statistically significant.

RESULTS

Results showed that of the 133 dry tibias used for the study, 51.1% (68) were from the right and 48.9% (65) from the left. Table 1 showed results of independent samples t-tests that in all the parameters measured, the differences between the right and left sides were not significant statistically (p>0.05), as well as the mean dimensions of combined data on both sides. The mean total transverse width was greater when compared to the total anteroposterior length.

Results of paired samples t-test showed that the mean anteroposterior length of the medial plateau was longer than that of the lateral plateau and the difference was statistically significant (p<0.001; t=19.916). However, paired samples t-test also showed that the difference between the transverse width of the medial plateau and that of the lateral plateau was not statistically significant (p=0.067; t=-1.850).

Table 2 shows the comparison of the mean dimensions of the tibia plateaus in the present study and those of other populations. The mean total transverse width of the tibia plateau in the present study is greater than those of the Kenyan and Thai populations, but lower than those of South East Nigerian and Iranian populations. However, the mean total anteroposterior length of the tibia plateau in the present study is lower than those of the Kenyan, South East Nigerian and Iranian populations, but similar to that of the Thai population.

Table 1: Comparison of Tibia plateau parameters measured between right and left sides.

| Parameter                                | Data  | Range        | Mean (SD)    | t     | p-value |
|------------------------------------------|-------|--------------|--------------|-------|---------|
| Anteroposterior length of medial tibia   | Total | 28.36–53.79  | 44.36(4.96)  | -     | -       |
| plateau (mm)                             | Right | 29.27–52.46  | 45.03(4.23)  | 1.592 | 0.114   |
|                                          | Left  | 28.36–53.79  | 43.66(5.58)  |       |         |
| Transverse width of medial tibia plateau | Total | 21.86–41.36  | 30.93(3.40)  | -     | -       |
| plateau (mm)                             | Right | 21.86–41.36  | 31.38(3.12)  | 1.559 | 0.121   |
|                                          | Left  | 23.58–37.36  | 30.47(3.64)  |       |         |
| Anteroposterior length of lateral tibia  | Total | 22.06–48.37  | 39.4394(4.87)| -     | -       |
| plateau (mm)                             | Right | 22.06–48.15  | 40.1029(4.41)| 1.609 | 0.110   |
|                                          | Left  | 23.19–48.37  | 38.7452(5.26)|       |         |
| Transverse width of lateral tibia plateau| Total | 18.36–40.59  | 31.36(3.89)  | -     | -       |
| plateau (mm)                             | Right | 18.36–37.14  | 31.7372(3.70)| 1.150 | 0.252   |
|                                          | Left  | 21.44–40.59  | 30.9628(4.06)|       |         |
| Total transverse width of tibia plateau  | Total | 31.99–81.68  | 70.37(7.49)  | -     | -       |
| plateau (mm)                             | Right | 42.31–81.68  | 71.1569(6.76)| 1.244 | 0.216   |
|                                          | Left  | 31.99–79.90  | 69.5440(8.15)|       |         |
| Total anteroposterior length of tibia     | Total | 28.24–71.95  | 45.82(5.69)  | -     | -       |
| plateau (mm)                             | Right | 28.24–52.19  | 45.9824(4.51)| 0.328 | 0.743   |
|                                          | Left  | 28.56–71.95  | 45.6571(6.75)|       |         |

SD: Standard deviation
Table 2: Comparison of mean dimensions of tibia plateau of present study and those of other populations

| Dimension (mm)                      | Data               | South Indian (8) | Kenyan (11) | South East Nigerian (13) | Iranian (14) | Thai (18) | North Indian (22) | French (23) | Present study (Nigerian) |
|------------------------------------|--------------------|------------------|-------------|--------------------------|--------------|-----------|-------------------|-------------|-------------------------|
| Anteroposterior length of medial tibia plateau | Total              | 39.80(3.38)      | 42.06       | -                        | 50.50(4.39)  | -         | -                 | 50.80       | 44.36(4.96)              |
|                                    | Right              | 40.60(3.90)      | 42.28       | -                        | -            | 45.42(4.17)*| -                 | 44.03       | 43.66(5.58)              |
|                                    | Left               | 39.20(3.60)      | 41.83       | -                        | -            | 45.05(4.51)*| -                 | -           | 30.93(3.40)              |
| Transverse total width of medial tibia plateau | Total              | 26.70(2.80)      | 27.21       | -                        | -            | 28.72(2.94)*| -                 | -           | 31.38(3.12)              |
|                                    | Right              | 26.90(2.90)      | 27.13       | -                        | -            | 28.17(2.66)*| -                 | -           | 30.47(3.64)              |
|                                    | Left               | 26.60(2.70)      | 27.29       | -                        | -            | -         | -                 | -           | -                       |
| Anteroposterior length of lateral tibia plateau | Total              | 33.60(3.70)      | 37.43       | -                        | 48.90(5.00)  | -         | 47.20(3.30)       | 39.44       | 47.20(3.30)              |
|                                    | Right              | 34.80(3.70)      | 38.17       | -                        | -            | 38.82(2.81)*| -                 | 40.10       | 47.20(3.30)              |
|                                    | Left               | 32.60(3.40)      | 38.68       | -                        | -            | 39.00(3.97)*| -                 | 38.75       | 31.36(3.89)              |
| Transverse total width of lateral tibia plateau | Total              | 26.10(2.90)      | 26.78       | -                        | -            | 27.33(2.81)*| -                 | -           | 31.74(3.70)              |
|                                    | Right              | 26.50(3.4)       | 26.96       | -                        | -            | 27.41(3.09)*| -                 | -           | 30.96(4.06)              |
|                                    | Left               | 25.70(2.50)      | 26.61       | -                        | -            | -         | -                 | -           | -                       |
| Total transverse width of tibia plateau | Total              | -                | 69.38       | 75.30(0.67)              | 74.60(5.9)   | 68.80(5.80)| -                 | 70.37       | 71.46(6.76)              |
|                                    | Right              | -                | 70.09       | -                        | -            | -         | -                 | -           | 69.54(8.15)              |
|                                    | Left               | -                | 68.66       | -                        | -            | -         | -                 | -           | -                       |
| Total anteroposterior length of tibia plateau | Total              | -                | 49.38       | 55.00(5.56)              | 48.60(4.5)   | 46.04(4.40)| -                 | 45.82       | 45.98(4.51)              |
|                                    | Right              | -                | 49.99       | -                        | -            | -         | -                 | -           | 45.98(4.51)              |
|                                    | Left               | -                | 48.77       | -                        | -            | -         | -                 | -           | 45.66(6.75)              |
| Method used                        | Direct             | Direct           | Direct      | MRI                      | MRI          | Direct     | CT scan           | Direct      |                        |

*Average of mean values for male and female

**DISCUSSION**

In this study, the mean total transverse width was almost similar to that of Lakati and Ndeleva (11) in Kenya, but greater than that of Gupta et al. (10) in South India. The mean total transverse width in the current study was also similar to the average of the combined male and female data on both sides in a study conducted in Bihar region, India, by Sinha and Prasad (20). Moghtadaei et al. (14) in Iran also conducted a similar study and the mean total transverse width was greater than that of the present study. The reason for this difference could be because the former used CT scan as against the direct method used in this study. Previous studies have shown that the direct method was more accurate than the radiological methods (8, 21).

The mean total transverse width of the present study is slightly lower than the average of the mean total transverse width of males and females in a study by Fan et al. (17) who studied the tibia plateau in Southeastern China, using the Magnetic Resonance Imaging scans (MRI). A similar study in South-East Nigeria (13) reported a mean total transverse width which is greater than that of the present study; and this can be attributed to differences in sample size.

The anteroposterior length of the tibia plateau in the current study was similar in dimension to that of Gupta et al. (10) in South India. It is, however, lower than those reported by Fan et al. (17), Moghtadaei et al. (14) and Lakati and Ndeleva (11) and Katchy et al (13). This may be due to factors such as error of measurements, different methods adopted which affect anthropometric measurements, ethnic differences due to geographic locations and differences in sample size.

Comparing the anteroposterior and transverse dimensions of medial and lateral plateaus, the results of the present study showed that the anteroposterior length of the medial plateau was greater than that of the lateral one. This is important, especially for prosthetic designs that puts into consideration the difference in medial and lateral plateau in order to eliminate the problem of asymmetric design. A similar report on the difference in anteroposterior dimension between medial and lateral plateaus had been made in previous studies (22, 23). Nonetheless, the transverse...
The width of both plateaus was approximately equal in dimension in the present study.

The observation on anteroposterior and transverse dimensions of the plateaus was similar to that of Gupta et al. (10) in a study of 50 dry tibias in South India population. Similarly, another study that utilized 52 dry tibia bones in Kenya, by Lakati and Ndeleva (11), showed that the mean combined anteroposterior dimension was higher in medial plateau than the lateral plateau, while the mean transverse dimension was equal in both plateaus. Srivastava et al. (24) also studied 150 dry tibias of North Indian subjects and the result showed that the anteroposterior dimension was higher in the medial plateau than the lateral plateau, while the transverse dimension was equal in both plateaus. Sinha and Prasad (20) conducted a study using 50 dry bones in Patna, Bihar, India, and the results revealed that both the anteroposterior and transverse dimensions were higher in the medial than the lateral plateau. Gandhi et al. (22) conducted a similar study using 100 dry tibia bones in North India, and the analysis of the result revealed that the average of the mean combined anteroposterior length and transverse width of males and females were higher in medial plateau than in lateral plateau. Shree et al. (12), conducted a study using 50 dry tibia bones in Chennai, and the analysis of the result revealed that the average of the mean combined anteroposterior length and transverse width of both plateaus and also between corresponding dimensions on both sides. The data documented in the present study will be useful to the orthopedic surgeon in selecting prostheses of suitable sizes, and the manufacturing industry of tibia prostheses for the Nigeria population. They will also be useful to the physical anthropologists in population studies.

REFERENCES

1. Benninger B. Knee. In: Standring S, ed. Gray’s anatomy. The anatomical basis of clinical practice. 41st ed. London, UK, Elsevier, 2016: 1383-1399.
2. Sinnatamby CS. Last Anatomy. Regional and applied. 12th ed. St Louis: Elsevier; 2011: 171-174.
Iranian population and its correlation with Jahansouz A. Morphology of proximal tibia in Moghtadaei M, Moghimi J, Farahini H, Clin Pract implication in tota amongst the Igbos of South East Nigeria and its The morphology of proximal tibia geometry Katchy AU, Agu AU, Ikele IT, Esom E, Nto NJ. Morphological and morphometric study Shree PC, Babu KY, Mohanraj KG. implants.
correlation with total Knee replacement Lakati KC, Ndeleva BM. Wider femoral and mediolaterally narrower tibial components are required for total knee arthroplasty in Turkish patients. Knee Surg sports Traumahtol Arthrosc, 2019; 27:215521-66.

Li P, Tsai T-Y, Li J-S, Li J-S, Zhang Y, Kwon Y-M, Rubash HE, Li G. Morphological measurement of the knee: race and sex effects. Acta Orthop (Begl), 2014; 80:260-268.

Murlimanju BV, Purushothama C, Srivastava A, Kumar CG, Krishnamurthy A, Blossom V, Prabhu LV, Saralaya VV, Pai MM. Anatomical morphometry of the tibial plateau in South Indian population. Ital J Anat Embryol, 2016; 121(3):258-264.

Kim TK, Philips M, Bhandari M, Watson J, Malhotra R. What differences in morphologic features of the knee exist among patients of different races? A systematic review. Clin Orthop Related Research, 2017; 475:170-182.

Gupta C, Kumar J, Kalthur SG, D’souza AS. A morphometric study of the proximal end of theibia in South Indian population with its clinical implications. Saudi J Sports Med, 2015; 15:166-169.

Lakati KC, Ndeleva BM. Anthropometry of the proximal tibia in a Kenyan population and its correlation with total Knee replacement implants. East Afr Orthop J, 2018; 12 (1): 3-8.

Shree PC, Babu KY, Mohanraj KG. Morphological and morphometric study of tibial condylar area and its clinical significance. Drug Invention Today, 2018; 10(10): 1892-1895.

Katchy AU, Agu AU, Ikele IT, Esom E, Nto NJ. The morphology of proximal tibia geometry amongst the Igbo of South East Nigeria and its implication in total knee replacement. Noger J Clin Pract, 2019; 22:1423-1429.

Moghtadaei M, Moghimi J, Farahini H, Jahansouz A. Morphology of proximal tibia in Iranian population and its correlation with available prostheses. Med J Islam Repub Iran, 2015; 29:225.

Shah DS, Ghayr R, Ravi B, Hegde C, Shetty V. Morphological Measurements of Knee Joints in Indian Population: Comparison to Current Knee Prostheses. Open J Rheumatol Autoimmune Dis, 2014; 4:75-85.

Dai Y, Bischoff JE. Comprehensive Assessment of Tibial Plateau Morphology in Total Knee Arthroplasty: Influence of Shape and Size on Anthropometric Variability. J Orthop Res, 2013; 31:1643–1652.

Fan L, Xu T, Li X, Zan P, Li G. Morphologic features of the distal femur and tibia plateau in Southeastern Chinese population: A cross-sectional study. Medicine, 2017; 96(46):1-5.

Chaichankul C, Tanavalee A, Itiravivong P. Anthropometric measurements of knee joints in Thai population: Correlation to the sizing of current knee prostheses. Knee, 2011; 18 (1):5-10.

World Medical Association. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bull World Health Organ, 2001; 79:373-374.

Sinha BK, Prasad R. Morphometric study of upper end of tibia in Bihar region and its clinical implication in knee arthroplasty. Int J Med Health Res, 2018; 4(5):120-122.

Jaffar M, Murlimanju BV, Saralaya VV, Prabhu LV, Prashanth KU, Krishnamurthy A. Bone morphometry. Bratisl Med J, 2012; 113: 673-675.

Gandhi S, Singla RK, Kullar JS, Suri RK, Mehta V. Morphometric Analysis of Upper End of Tibia. J Clin Diagn Res, 2014; 8(8):AC10-AC13.

Servien E, Saffarini M, Lustig S, Chomel S, Neyret P. Lateral versus medial tibial plateau: Morphometric analysis and adaptability with current tibial component design. Knee Surg Sports Traumahtol Arthrosc, 2008; 16:1141-1145.

Srivastava A, Yadav A, Thomas RJ, Gupta N. Morphometric study of tibial condylar area in the North Indian population. J Med Sci Clin Res, 2014; 2:515-519.

Prasanna VKA, Ravindranadh GA, Deena UKK. Tibial Plateau Morphometry in South Indian Population. Int J Anat Radiol Surg, 2018; 7(3):18-22.

Lucena DOS, Santos ERS, Albuquerque PPF, Albuquerque PV, Oliveira BDR, Ciaffo V. Determination of sex based on the morphometric evaluation of the proximal tibia. Int J Morphol, 2018; 36(1):104-108.