

Research article - Basic and applied anatomy

Anatomical morphometry of the tibial plateau in South Indian population

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Abstract

The objectives were to study the morphometry of lateral and medial tibial plateau in South Indian population. The study was performed using 73 dry cadaveric tibiae which were obtained from the gross anatomy laboratory of our institution. The antero-posterior length and medio-lateral breadth of the lateral and medial tibial condyles were measured. The data of the medial and lateral compartments, right and left sided tibiae were statistically analyzed and compared. The mean length and breadth of medial tibial plateau (\pm standard deviation) were 39.8 ± 3.8 mm and 26.7 ± 2.8 mm respectively. The same parameters for the lateral tibial plateau were 33.6 ± 3.7 mm and 26.1 ± 2.9 mm. For both length and breadth the dimensions were statistically lower for the lateral tibial condyle than the medial ($p < 0.05$). Differences were not statistically significant between right and left sides except for the length of lateral tibial plateau, which was longer on the right side ($p < 0.05$). The present study observed differences in the morphometric parameters between the lateral and medial tibial condyles and has provided additional information on the morphometric data of the tibial plateau which is important to the orthopedic surgeons.

Key words

Condyle, lateral, medial, meniscus, tibial plateau.

Introduction

Tibial condyles or the tibial plateau overhang the posterior surface of the proximal end of the tibia. The intercondylar eminence separates the medial and lateral articulating area of the tibia. The morphology of lateral tibial plateau differs from that of the medial one (Servien et al., 2008). Medial condyle is oval in shape and longer than the lateral condyle. The lateral condyle is about circular and correlated with its meniscus (Standring, 2005). The shape of the tibial plateau is important as it provides attachment to the lateral and medial menisci. It is reported that the menisci occupy 50% to 66.7% of the corresponding tibial condyle, with the lateral semilunar cartilage covering an area more extended than the medial one (Cohen et al., 1998). It was described that, during the 14th week of intrauterine life, the size of the tibial condyles and menisci are the same between the two sides. Later in development, the

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size of the menisci increases similarly in both medial and lateral compartments. However the tibial plateau area increases more rapidly in the medial than in the lateral compartment (Fukazawa et al., 2009). This is the reason for the smaller coverage of the medial meniscus in the medial tibial plateau (Fukazawa et al., 2009). The shape of medial tibial plateau was interestingly studied back in 19th century by German anatomists (Pinskerova et al., 2000).

The morphometric data of the tibial plateau are important to the orthopedic surgeon during meniscal allograft transplantation. It was described that in vivo dimensions of each tibial plateau are a key factor in planning unicompartmental knee arthroplasty (Servien et al., 2008). The optimization of coverage of resected tibial plateau is an important factor in the total knee arthroplasty procedure (Incavo et al., 1994; Servien et al., 2008). There are a few studies (Fitzpatrick et al., 2007; Surendran et al., 2007) available in the literature, which studied the compatibility of the anatomy of the tibial condyle with the size of the implant. There are some implants commercially available which appear similar to the anatomy of the lateral condyle rather than the medial one. So it has been reported that some implants are more suitable for the lateral condyle (Servien et al., 2008). In spite of these clinical interests, the anatomical studies about the tibial plateau are rarely reported and are not available from South Indian samples. This was the motivation to perform the present study using cadaver dry tibiae. Objectives of the present investigation were to figure out the morphometric dimensions of the medial and lateral tibial condyles in South Indian population. The clinical applications are discussed.

Materials and methods

The present study included 73 dry adult human cadaveric tibiae of South Indian population, which were obtained from the gross anatomy laboratory of our institution. Among them, 33 belonged to the right side and 40 to the left sides. The age and genders of the cadavers were not known. The tibiae which exhibited gross pathological changes and manual damages due to storage were excluded from the present investigation. The length and breadth of medial and lateral tibial plateaus were measured in each tibia (Fig. 1). The length was measured from the most anterior end to the most posterior end at the midpoint of each tibial plateau. The breadth was measured from the intercondylar eminence to the corresponding medial or lateral end at the midpoint (Fig. 1). All the measurements were performed by using a digital Vernier caliper. The tibiae were clamped to facilitate the measurements. The measurements were performed by the same person on three occasions and the average of the three values was taken as representative measure. The intra observer variation was minimized by taking the measurements three times. The data were tabulated and statistically analyzed. The data from medial and lateral tibial plateaus and the right and left knee joints were analyzed separately. The statistical analysis was performed between the right and left sides by the *t* test for unpaired samples and between medial and lateral compartments by *t*-test for paired samples. Differences were considered significant for *p*-value less than 0.05 ($\alpha=0.05$). The statistical package for the social sciences version 15 (IBM, Armonk, NY) was utilized for the comparisons and the data are recorded as mean \pm standard deviation.

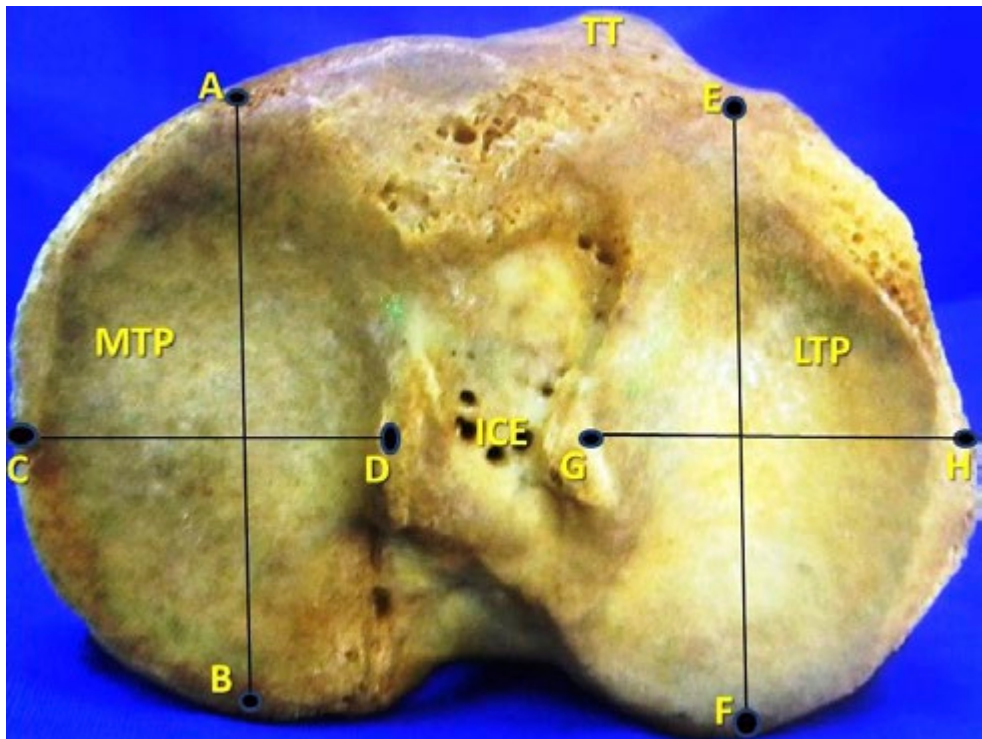


Figure 1. Proximal end of tibia showing the measurements performed in the present study. AB: length of medial tibial plateau; CD: width of medial tibial plateau; EF: length of lateral tibial plateau; GH: width of lateral tibial plateau; MTP: medial tibial plateau; LTP: lateral tibial plateau; ICE: intercondylar eminence; TT: tibial tuberosity.

Results

Analysis of differences between the medial (n=73) and lateral (n=73) compartments

The data showing the comparison of medial and lateral tibial plateau are represented in Table 1. The length of medial tibial plateau was greater ($p < 0.05$) than the lateral tibial plateau. The breadth was also greater for the medial tibial plateau than that for the lateral one ($p < 0.05$).

Analysis of differences between the right (n=33) and left (n=40) side tibiae

The comparison is represented in Table 2. It was observed that the differences were not statistically significant ($p > 0.05$) between the right and left sides with respect to any of the parameters of the medial tibial plateau. Among the parameters of lateral tibial plateau, the length was greater ($p < 0.05$) for the right side than the left, while there was no significant difference between sides for width.

Table 1. Morphometric data of medial and lateral tibial plateaus (n=146)

| Measures in mm | Medial tibial plateau | Lateral tibial plateau |
|----------------|-----------------------|------------------------|
| Length* | 39.8 ± 3.8 | 33.6 ± 3.7 |
| Breadth* | 26.7 ± 2.8 | 26.1 ± 2.9 |

Values are mean ± SD; *: p<0.05 (t-test for paired samples)

Table 2. Comparison of the tibial plateaus between sides (n=73)

| Measures in mm | Right side (n=33) | Left side (n=40) |
|------------------------|-------------------|------------------|
| Medial tibial plateau | | |
| Length | 40.6 ± 3.9 | 39.2 ± 3.6 |
| Breadth | 26.9 ± 2.9 | 26.6 ± 2.7 |
| Lateral tibial plateau | | |
| Length* | 34.8 ± 3.7 | 32.6 ± 3.4 |
| Breadth | 26.5 ± 3.4 | 25.7 ± 2.5 |

Values are mean ± SD, *: p<0.05 (t-test for unpaired samples).

Discussion

The tibial plateau plays an important role in the function of the knee. The plateau of the medial and lateral condyle of tibia articulates with the corresponding femoral condyle. The two intercondylar tubercles form the intercondylar eminence, which separates the lateral and medial condyles (Moore and Dalley, 2006). It is known that there is a significant variability in the anthropometry of different populations across the world. Asians have a smaller stature in comparison to the tall and robust Caucasians. Unfortunately, most of the prostheses which are available commercially and are currently in use for surgery are designed for the Western population while Indians have a smaller skeletal profile. Indians will need smaller sized knee prosthesis. Indian patients are at the risk of getting a prosthesis which is oversized in procedures like unicompartmental knee arthroplasty and total knee arthroplasty (Vaidya et al., 2000). Implantation of the oversized prosthesis can lead to incompatibility with the resected bones (Surendran et al., 2007).

The study from Servien et al. (2008) showed that antero posterior length was higher for the medial condyle (50.8 ± 3.3 mm) than for the lateral one (47.2 ± 3.3 mm). Our results are similar to Servien et al. (2008), as also in the present study it was observed that the anteroposterior dimension was significantly longer for the medial (39.8 ± 3.8 mm) than the lateral plateau (33.6 ± 3.7 mm). The difference from the data of Servien et al. (2008) may be because of the materials we used. We examined the anatomical cadaveric tibiae while in Servien's et al. (2008) study radiological computed tomogram films were used and it is believed that anatomical data are more accurate than the radiological (Jaffar et al., 2012). Ethnic factors may also be relevant,

as we examined South Indian samples and Servien et al. (2008) French patients. Some of the dried bone specimens in the present study had erosions due to the prolonged storage. This is the reason why some researchers go in search of *in vivo* morphometry, which may be accurate as well. Radiological data are used more often for the clinical purpose, however anatomical data are still referred and cited in clinical medical research and are used in the clinical setup on many occasions.

Kwak et al. (2007) using 3D computerized tomography scans of the upper tibia from Korean cadavers reported that the anteroposterior length was 47.3 ± 3.8 mm. In their samples, the mediolateral tibial plateau breadth was 73.5 ± 5.6 mm. They reported that the parameters observed were lower than the size of commercially available knee implants. They also described that the smaller implants could lead to mediolateral undersizing and the larger ones could cause mediolateral overhang. Kwak et al. (2007) believed that their data may offer a guideline for preparing total knee prostheses among Koreans. Srivastava et al. (2014) conducted a morphometric study of the tibial condyles in the North Indians. In their study the average antero-posterior diameter of the medial and lateral tibial condyles of the right tibia were 38.63 mm and 36.47 mm respectively. For the left side specimens, the same parameters were 39.94 mm and 36.94 mm respectively. The data of the present study are almost similar to those for North Indian population by Srivastava et al. (2014). However Srivastava et al. (2014) study did not compare the medial and lateral tibial condyles statistically. In their study the average transverse diameter of the medial and lateral tibial condyles of the right tibia were 29.73 mm and 29.21 mm respectively. For the left side specimens, the same parameters were 27.5 mm and 29.77 mm respectively. These data are almost similar to the data obtained in our present study. We can speculate that there is no significant difference in the morphometric parameters of the tibial plateau among the North and South Indian populations. This information may be useful for managing implants for patients from Northern and Southern India.

In another study performed from 100 total arthroplasty knees by using the radiographic films, medial and lateral tibial condyles were evaluated and it was shown that the lateral tibial plateau is smaller than the medial one; therefore the need was highlighted for a knee arthroplasty procedure which takes into account the difference between the lateral and medial tibial condyles to ensure complete tibial coverage (Westrich et al., 1995). Fitz et al. (2013) reported that the lateral tibial plateau would need a different tibial implant, round in shape and with a smaller antero-posterior length/transverse width ratio. In the surgical practice, the orthopedists avoid implants with incomplete coverage of the tibia as this may induce the collapse of the implant (Bohm and Landsiedl, 2000; McAuley et al., 2001). It is understood that the implant design needs knowledge of the size of the tibial plateau. The morphology of the tibial component should match the resected surface in order to restore the stability and load transmission after knee replacement (Surendran et al., 2007). Total knee arthroplasty and unicompartmental knee arthroplasty are both accurate surgeries which require optimum prosthesis sizing. This is important to ensure a better prognosis and prosthesis long term survival, which would lead to normal function post operatively (Chaichankul et al., 2011). The present study has reported the morphometric data of the tibial plateau from the South Indian population and compared the data statistically. It has been observed that the parameters differ among the medial and lateral compartments. The data may assist the orthopedists and arthroscopy sur-

geons in preparing a manual on how to make meniscal implants and artificial prostheses. The findings also enlighten morphologists, anthropologists and clinical anatomists. We believe that the data of the present study will be of use while manufacturing tibial knee prostheses for the South Indian population in order to provide optimum tibial implant coverage. The data are also essential to the forensic and physical anthropologists.

A limitation of the present study is the lack of parameter comparison between genders. Future implications of this subject include determining the morphometric data from the radiographic films with Scion image analyzer software (Scion Corp., Frederick, MD). In vivo morphometry of the tibial plateau can be done using nuclear magnetic resonance imaging of the knee joint, three dimensional computed tomogram pictures and intra operative measurement of the resected tibial surfaces. Correlation can also be done with bony measurements on the X ray films. In a clinical perspective, the size of the tibial plateau can be estimated by the body weight/height or standardized measurements from computerized tomography scan, X-ray or magnetic resonance imaging, which will be useful in the preoperative planning of the substitution.

Conflict of interest

The authors declare that they have no conflict of interest.

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