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## Research paper

# Anthropometric assessment of tibial resection surface morphology in total knee arthroplasty for tibial component design in Indian population

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## ABSTRACT

**Introduction:** An anthropometrically well designed knee prosthesis that matches properly to the resected surface of the bone is key for long term survivorship in TKA.

**Aim:** The aim of the study was to make an anthropometric analysis at resected surfaces of proximal tibia in Indian population and to compare it with the available data of other ethnicities. **Methods:** CT scans of 50 subjects were used to select the tibial resection surface. The surface selection was virtually done on each tibia at 8 mm off the lateral plateau using Micro Dicom system (reflecting a 10-mm surgical cut assuming a cartilage thickness of 2 mm). We measured the mediolateral, middle anteroposterior, medial and lateral anteroposterior dimensions, the aspect ratio and asymmetry metrics of the resected proximal tibial surface.

**Results:** The dimensions of the tibial plateau of Indian knees demonstrated significant differences according to gender ( $P < 0.05$ ) in terms of size. The shape parameters are not different significantly. When compared to all other ethnicities the Indian knee differs in size as well as the shape parameters i.e. Aspect ratio.

**Conclusion:** Clinically relevant differences in proximal tibia morphology at the level of proximal TKA resections across ethnicities can lead to mismatch of sizes of Western TKA implants in Indian patients. Tibial component designs should be done by considering the morphometry of knee in Indian population. Indian females were found to have significant smaller dimension of tibia in terms of size than. But the impact of small sample size and single centre on study warrant a multicentric study with large sample size.

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## 1. Introduction

Total Knee Arthroplasties (TKAs) has been reported to have unsatisfactory results in upto one-third of patients.<sup>1</sup> Beside accurate bone cutting and adequate balancing of the soft tissues, the successful outcome of TKA depends on, maximizing tibial coverage with the correct component size. This is mandatory for minimizing the stress applied to the bone–implant interface and ensuring an appropriate load transmission.<sup>1–2</sup> Several studies assessed knee morphology, focusing on qualitative description of

or basic dimensional measurements at the TKA resection level (such as anterior–posterior and medial–lateral dimensions).<sup>3–6</sup>

As compared to western counterparts Asian subpopulations are known to have a smaller build and stature.<sup>7</sup> This results in implant size mismatch with the resected bony surface in the Asian patients. Compared to the femoral side, the tibial component is more prone to complications in TKA.<sup>8</sup> In case tibial component does not match accurately to the resected proximal part of the tibia, the surgeon may have to choose either a larger, overhanging component or a smaller, underhanging one.<sup>9</sup>

To fully characterize the asymmetric and irregular shape at the Tibial resection level, however, morphological quantification beyond qualitative or basic dimensional measurements is needed, with the potential to reveal ethnic- and gender-based morphological differences relevant to TKA design.

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In respect to the above facts and paucity of anthropometric data in the literature on the proximal tibia in the Indian population, we evaluated the anthropometric data on the proximal tibia that was obtained by using computer tomography. Furthermore, the pattern of change of the mediolateral dimensions in relation to the anteroposterior dimensions was compared between the study population and the available data of other ethnicities.

## 2. Materials and methods

The prospective analysis was done in a tertiary care center in New Delhi in total 50 subjects from Jan 2016 till July 2017. Morphologic data from the proximal tibia of 50 normal knees in 50 subjects were analyzed, wherein one knee of each subject was studied. Subjects with normal lower limb appearance, normal alignment, no prior trauma or congenital deformities were included in the study. Patients with any deformity in the coronal or sagittal plane, lower extremity malalignment (metaphyseal varus/valgus  $>10^\circ$ ), knee flexion deformities  $>10^\circ$ , substantial bone loss, history of previous surgery, proximal tibial fracture or knees with any implants were excluded from the study.

CT scans of 50 subjects were used to select the tibial resection surface. The surface selection was virtually done on each tibia at 8 mm off the lateral plateau using *Micro Dicom system* (reflecting a 10-mm surgical cut assuming a cartilage thickness of 2 mm). We measured the mediolateral, middle anteroposterior, medial and lateral anteroposterior dimensions, the aspect ratio and asymmetry metrics of the resected proximal tibial surface. The system of measurements was adopted from the work of Dai and Bischoff published in 2013 (Figs. 1–6).<sup>10</sup>

The neutral rotational axis (Y) was defined as the line connecting the medial third of the tubercle and center of the PCL attachment site, projected onto the resection plane (Fig. 3). The origin of the coordinate system was placed at the midpoint between the anterior and posterior intersecting points of the tibial contour with the Y&HIPHEN;axis (Fig. 4). A bounding box was constructed in this coordinate system (Fig. 5). The medial and lateral compartments of the resection contours were identified as the regions separated by the neutral rotational axis. A series of morphological metrics was then computed for each contour:

## 3. Dimensions

ML width; medial and lateral AP dimensions (Fig. 1A).



Fig. 1. Tibial Resection Surface reflecting 10 mm surgical cut.

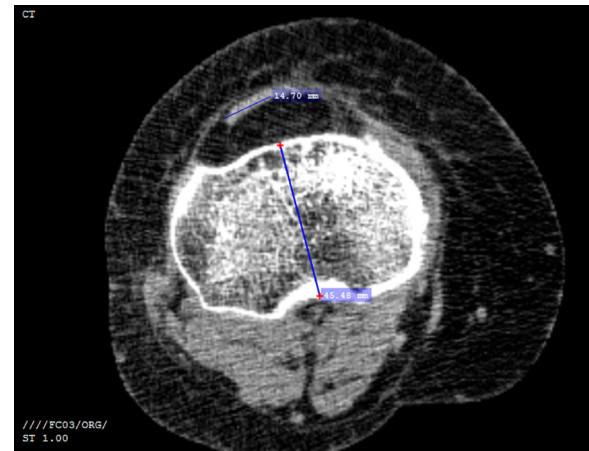


Fig. 2. Measurements performed on resected surface of Proximal tibia showing Y rotational axis.

### 3.1. Radii

The medial curve was identified as the portion of the resection contour from the medial 25% (0–25%) of the ML dimension; the anterior medial curve was identified as the anterior 50% of this medial curve (Fig. 1B). The medial anterior radius was then defined as the radius of the least squares best-fit circle to the anterior medial curve. The lateral anterior radius was defined similarly (Fig. 1B).

### 3.2. Areas

Bounding box area (overall).

### 3.3. Aspect ratios

For overall resected plateau (Plateau aspect ratio), the ratio was defined as the ML/AP ratio of the bounding box. For each individual compartment (compartment aspect ratio), the ratio was defined as the ML/AP ratios for the medial and lateral bounding boxes. This convention was chosen to ensure that aspect ratio values generally ranged from 0 to 1, with closer to unity representing a more square-like geometry.

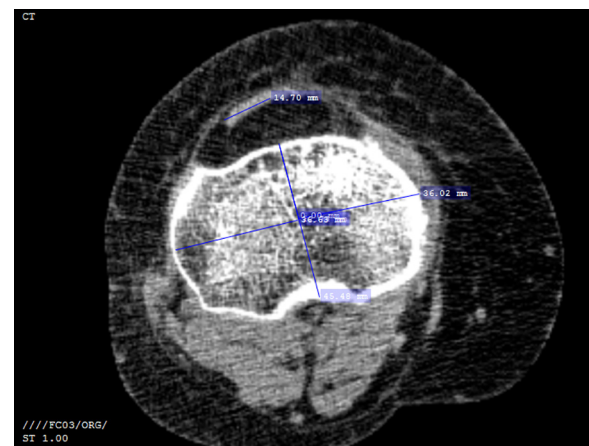


Fig. 3. Measurements performed on resected surface of Proximal tibia showing Medioloateral and Anterio-posterior dimensions.

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