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Original Research Article

A Morphometric Study of the Proximal End of Tibia in Indian Population with Its Clinical Implication

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Abstract:

Background: The proximal end of the tibia plays a crucial role in the biomechanics of the knee joint, and its morphometric characteristics are essential for various clinical applications, including orthopedic surgeries and prosthesis design. There is limited data available on the morphometry of the proximal tibia in the Indian population.

Aim: This study aims to analyze the morphometric parameters of the proximal end of the tibia in the Indian population and to explore its clinical implications in orthopedic practices.

Methods: The study was a cross-sectional analysis conducted at Anugrah Narayan Magadh Medical College, Gaya, involving 90 participants. Inclusion criteria were adults of Indian origin, excluding those with proximal tibial fractures or congenital deformities. Morphometric measurements of the proximal tibia were obtained using digital calipers from radiographs. Data were analyzed using SPSS version 21.0, with statistical significance set at $p < 0.05$.

Result: The study found significant differences in proximal tibial measurements between males and females, with males having larger dimensions. No significant differences were observed between the right and left tibia. These findings highlight the importance of considering sex-specific anatomical variations in orthopedic procedures and implant design for the Indian population.

Conclusion: This study highlights significant sexual dimorphism and symmetrical characteristics in the proximal tibia of the Indian population. The findings underscore the need for sex-specific and population-specific knee prosthesis designs. Such tailored designs can improve surgical outcomes and reduce complications in knee arthroplasty.

Recommendations: Further studies with larger sample sizes and diverse populations are recommended to validate these findings. Additionally, incorporating these morphometric data into the design of knee implants could enhance their fit and function, potentially improving patient outcomes.

Keywords: Proximal Tibia, Morphometry, Indian Population, Orthopedic Surgery, Knee Prosthesis.

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Introduction

The proximal end of the tibia is a critical anatomical structure that significantly influences the function and biomechanics of the knee joint. Its morphometric characteristics are essential for various clinical applications, including the planning and execution of orthopedic surgeries, the design of knee prostheses, and the treatment of tibial fractures. Accurate knowledge of these anatomical parameters can enhance surgical outcomes and the efficacy of knee implants. Despite its importance, there is a paucity of detailed morphometric data on the proximal tibia in the Indian population [1].

Orthopedic surgeons often rely on morphometric data to plan surgical interventions such as total knee arthroplasty (TKA) and high tibial osteotomy (HTO). These procedures require precise measurements of the tibial plateau and other proximal tibial structures to ensure proper alignment and fit of implants. Inaccurate morphometric data can lead to complications such as implant loosening, malalignment, and poor functional outcomes. Therefore, region-specific morphometric studies are necessary to provide data that reflect the anatomical variations within different populations [2,3].

The Indian population, with its diverse genetic background and varying physical characteristics, may exhibit unique morphometric traits of the proximal tibia. Existing literature primarily focuses on Western populations, and the direct application

of these data to the Indian demographic may not be appropriate. This underscores the need for a dedicated morphometric study of the proximal tibia in the Indian context. Such a study would provide valuable insights and contribute to the optimization of surgical techniques and implant designs for Indian patients.

The aim of this study is to analyze the morphometric parameters of the proximal end of the tibia in the Indian population. By obtaining detailed measurements of the tibial plateau and associated structures, this research seeks to fill the gap in the existing literature and provide data that can be directly applied in clinical settings. The findings of this study are expected to enhance the accuracy of orthopedic procedures and improve the design of knee prostheses tailored to the Indian demographic.

Methodology

Study Design: This was a cross-sectional morphometric study conducted to analyze the proximal end of the tibia in the Indian population and assess its clinical implications.

Study Setting: The study was conducted at Anugrah Narayan Magadh Medical College, Gaya, over a period from December 2019 to November 2020.

Participants: The study included a total of 90 participants who were patients at Anugrah Narayan Magadh Medical College.

Inclusion Criteria:

- Participants aged 18 years and above.
- Individuals of Indian origin.
- Patients who consented to participate in the study.

Exclusion Criteria:

- Patients with a history of proximal tibial fractures.
- Individuals with congenital deformities affecting the tibia.
- Patients with any previous surgery involving the proximal tibia.

Bias: Efforts were made to minimize selection bias by consecutively enrolling eligible patients. Measurement bias was reduced by standardizing the measurement techniques and ensuring all measurements were taken by trained personnel.

Variables

Independent Variables: Age, sex, and side of the body (right or left tibia).

Dependent Variables: Morphometric measurements of the proximal tibia, including the dimensions of the medial and lateral condyles, intercondylar eminence, and tibial plateau.

Data Collection: Data were collected using digital calipers for precise measurements of the proximal tibial dimensions. Demographic information such as age and sex was recorded from patient medical records.

Procedure: Participants underwent imaging of the proximal tibia using standard radiographic techniques. Morphometric measurements were obtained directly from the radiographs. Each measurement was taken twice to ensure accuracy and the average was used for analysis.

Statistical Analysis: Data were analyzed using SPSS version 21.0.

Results

Participant Demographics: A total of 90 participants were included in the study. The mean age of the participants was 42.3 ± 12.5 years, with a range of 18 to 65 years. There were 50 males (55.6%) and 40 females (44.4%).

Morphometric Measurements

The morphometric measurements of the proximal tibia included the dimensions of the medial condyle, lateral condyle, intercondylar eminence, and tibial plateau. The results are summarized in Table 1.

Table 1: Morphometric Measurements of the Proximal Tibia

Measurement	Mean ± SD (mm)	Male (n=50)	Female (n=40)	p-value
Medial Condyle Width	47.2 ± 4.5	48.5 ± 3.9	45.5 ± 4.8	0.02
Lateral Condyle Width	45.1 ± 4.1	46.3 ± 3.7	43.5 ± 4.3	0.03
Intercondylar Eminence Height	12.8 ± 2.0	13.2 ± 1.8	12.3 ± 2.2	0.05
Tibial Plateau Width	71.4 ± 6.2	73.2 ± 5.8	69.1 ± 6.3	0.01

Side Differences: Measurements were compared between the right and left tibia. The results are summarized in Table 2.

Table 2: Comparison of Right and Left Tibia Measurements

Measurement	Right Tibia (n=45)	Left Tibia (n=45)	p-value
Medial Condyle Width	47.5 ± 4.3	46.9 ± 4.7	0.42
Lateral Condyle Width	45.4 ± 4.0	44.8 ± 4.3	0.34
Intercondylar Eminence Height	12.9 ± 2.1	12.7 ± 1.9	0.58
Tibial Plateau Width	71.8 ± 6.1	71.1 ± 6.3	0.47

Independent t-tests were used to compare the measurements between males and females, as well as between the right and left tibia. The results showed statistically significant differences between males and females for all measurements, with males having larger dimensions on average. No significant differences were found between the right and left tibia measurements.

The study found significant sexual dimorphism in the morphometric measurements of the proximal tibia, with males having larger dimensions compared to females. Specifically, the medial condyle width, lateral condyle width, intercondylar eminence height, and tibial plateau width were all significantly greater in males. This information is critical for orthopedic surgeons in planning reconstructive surgeries and designing implants that fit the anatomical variations in different populations.

There were no significant differences between the right and left tibia, indicating symmetrical morphometric characteristics in the studied population. This symmetry simplifies the clinical application of the findings, as measurements from one side can be reliably used as references for the other.

Discussion

Our study on the morphometric measurements of the proximal tibia in the Indian population revealed significant sexual dimorphism and symmetrical characteristics between the right and left tibiae. These findings align with previous research, contributing valuable data for clinical applications, especially in orthopedic surgery and prosthesis design.

Our study found that males had significantly larger dimensions for the medial condyle width, lateral condyle width, intercondylar eminence height, and tibial plateau width compared to females. This is consistent with findings from a study conducted in Eastern India, where male tibiae exhibited larger morphometric parameters compared to female tibiae [4]. No significant differences were found between the right and left tibiae in our study, indicating symmetrical morphometric characteristics. This observation was also reported in a study comparing right and left tibiae, where no significant differences were noted [5].

The significant differences in tibial dimensions between males and females underline the necessity of sex-specific designs for knee prostheses. Studies have shown that improper sizing of prostheses can lead to complications and poor outcomes in knee arthroplasty. For instance, a study on the North and East Indian populations highlighted the importance of tailored prosthetic designs to improve surgical outcomes [6]. Our findings are consistent with studies from different regions of India, showing regional variations in tibial dimensions. For example, a study in the Gujarat region also found larger dimensions in males compared to females, and variations in measurements compared to other Indian populations and Caucasians [7].

The need for accurate morphometric data is crucial for designing prostheses that fit well and provide better outcomes in knee arthroplasty. Studies emphasize that prostheses based on Western data may not fit well in Indian patients due to smaller dimensions in the Indian population [8].

Conclusion

This study provides essential morphometric data on the proximal tibia in the Indian population, highlighting significant sexual dimorphism and symmetrical characteristics between the right and left tibiae. These findings support the need for sex-specific and population-specific designs in knee prostheses to improve surgical outcomes and reduce complications in knee arthroplasty.

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