The Morphometric Analysis of Adult Dry Patellae: A Cross-sectional Study

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ABSTRACT

Introduction: The patella is the largest sesamoid bone in the body, which develops within the tendon of the quadriceps femoris muscle. It is a flat, distally tapered, and proximally curved bone. The morphometric study of the patella is important for orthopaedic surgeries.

Aim: To conduct a morphometric analysis of the adult dry patella.

Materials and Methods: A cross-sectional observational study was conducted on 50 dry human patellae from both the right and left sides of unknown gender. These specimens were obtained from the "Bone Library" of the Department of Anatomy, TN Medical College, and Nair Hospital, Mumbai, Maharashtra, India, during the period from December 2022 to February 2023. Patellar length, width, thickness, as well as the width of the articular facet, were measured using an electronic digital vernier caliper. Mean, standard deviations, and p-value were calculated using the Statistical Package for Social Sciences (SPSS) version 26.0. Patellar parameters between the right and left sides were compared, and an unpaired student's t-test was applied.

Results: The mean height, width, and thickness of the right patellae were 42.08±3.44 mm, 45.20±4.35 mm, and 18.85±2.16 mm, respectively, while those of the left patellae were 42.68±3.52 mm, 45.00±2.57 mm, and 19.56±1.62 mm, respectively. The mean width of the medial and lateral articular facets of the right patellae were 18.65±2.65 mm and 23.20±2.20 mm, respectively, while those of the left patellae were 19.10±2.25 mm and 22.61±1.69 mm, respectively.

Conclusion: The present study evaluates different dimensions such as length, width, thickness, and the articular facet of the patella. These findings will be helpful in designing knee implants and during reconstructive surgeries related to the knee.

INTRODUCTION

The patella, embedded in the tendon of the quadriceps femoris muscle, is the largest sesamoid bone [1]. It is a flat, distally tapered, and proximally curved bone. Anthropometric measurements of the patella's dimensions are significant for stability, both normally and postoperatively. Establishing the appropriate size of the patellar implant-bone composite is crucial in ensuring functional stress in arthroplasty [2]. An imbalanced patellofemoral joint implant could lead to ineffective lever support and limited range of motion [3]. The importance of the patella for the knee, in addition to its protective and aesthetic characteristics, lies primarily in how it increases the lever arm of the extensor apparatus, thereby enhancing quadriceps strength by up to 50% [4]. A high patella (patella alta) is associated with a greater risk of chondromalacia and patellofemoral dislocation [5], while a low patella (patella baja) is correlated with a higher risk of patellofemoral osteoarthritis, Osgood-Schlatter disease, and limited knee motion.

Wiberg G proposed three shapes based on the position of the vertical ridge [6]:

Type I: There are roughly equal medial and lateral facets.

Type II: The most common type, where the medial facet is only half the size of the lateral facet.

Type III: The medial facet is positioned so far medially that the central ridge is barely noticeable.

In India, only a few studies have been conducted on patella dimensions [7,8]. The present study aimed to perform a morphometric analysis of the adult dry patella.

MATERIALS AND METHODS

The study was a cross-sectional observational study performed on 50 human adult patellae, with 25 from the left side and 25 from the right side. The bones were obtained from the 'Bone Library' of the Department of Anatomy at TN Medical College and Nair Hospital, Mumbai, Maharashtra, India. The study was conducted from December 2022 to February 2023, spanning three months. A waiver of consent was obtained since it was a cadaveric bone study.

Inclusion criteria: Patellae with intact borders and articular facets, without any osteoporotic changes or physical damage were included in the study.

Exclusion criteria: Damaged, decalcified, and osteoporosed bones, were excluded from the study.

Study Procedure

Morphometric dimensions of the patella were measured using well-calibrated vernier calipers (Yamano, Japan) with an accuracy of 0.5 mm. The measurements are presented in [Table/Fig-1]. Patellar height was measured from the highest point of the base to the apex of the patella, while patellar width was determined as the maximum horizontal distance between the medial and lateral borders of the patella, as shown in [Table/Fig-2-4]. Patellar thickness was measured as the distance between the anterior surface and the median ridge on the posterior surface [Table/Fig-5]. The medial articular facet width was defined as the maximum distance between the medial borders to the median ridge, and the lateral articular facet width was measured from the lateral border to the median ridge [Table/Fig-2].

Parameters	Measurement
Patellar height	Highest point of the base to the apex of patella
Patellar width	Maximum horizontal distance between the medial and lateral borders of patella
Patellar thickness	Distance between the anterior surface and the median ridge on the posterior surface
Width of the lateral articular facet	Maximum distance between the lateral border to the median ridge
Width of the medial articular facet	Maximum distance between the medial border to the median ridge

[Table/Fig-1]: Parameters and their measurement points.

[Table/Fig-2]: Morphometric parameters of patella (showing the patellar height and width along with medial and lateral articular facets).

[Table/Fig-3]: Measurement of patellar height (highest point of the base to the apex of patella).

[Table/Fig-4]: Measurement of patellar width (maximum horizontal distance between the medial and lateral borders of patella).

[Table/Fig-5]: Measurement of patellar thickness (distance between the anterior surface and the median ridge on the posterior surface).

STATISTICAL ANALYSIS

The mean, standard deviations, and p-value were calculated using SPSS version 26.0. Patellar parameters between the right and left sides were compared, and an unpaired Student's t-test was applied. The level of significance was considered to be less than 0.05.

RESULTS

The results of the descriptive statistical analysis, including the mean and standard deviation of the right and left patellae, as well as the medial and lateral articular facet widths, are shown in [Table/Fig-6]. The mean height, width, and thickness values in this study were 42.08±3.44 mm, 45.2±4.35 mm, and 18.85±2.16 mm for the right patella, while they were 42.68±3.52 mm, 45±2.57 mm, and 19.56±1.62 mm for the left patella. The width of the medial and lateral articular facets was 18.65±2.65 mm and 23.2±2.2 mm for the right side, and 19.1±2.25 mm and 22.61±1.69 mm for the left patella, as shown in [Table/Fig-6].

Measurement (mm)	Right	Left	p-value
Patellar height	42.08±3.44	42.68±3.52	0.379
Patella width	45.2±4.35	45±2.57	0.541
Patella thickness	18.85±2.16	19.56±1.62	0.245
Width of medial articular facet	18.65±2.65	19.1±2.25	0.129
Width of lateral articular facet	23.2±2.2	22.61±1.69	0.154

[Table/Fig-6]: Measurement of different parameters of patella with mean and standard deviation.
Unpaired t-test; level of significance: p-value of <0.05

Considering a p-value of <0.05 as statistically significant, it is clear from the table that there are some differences in the comparison of parameters between the left and right sides, but these differences are not statistically significant.

DISCUSSION

The patellar morphometry plays an important role in the mechanical design of patellofemoral implants. The results obtained from the present study were tabulated and compared with other available studies [Table/Fig-7] [2,7-12]. The present study did not show a significant difference between the measurements of the right and left limbs (p>0.005). The mean patellar height, thickness, and width were 42.38, 19.21, and 45.1 mm, respectively. [Table/Fig-2] shows that the measurements obtained from the Indian population were lower compared to those obtained from other populations.

Study	Sample and subjects	Patella height (mm)		Patella thickness (mm)		Patella width (mm)	
		Mean	SD	Mean	SD	Mean	SD
Baldwin JH and House CK 2005 Western population [2]	92 adult patellae during Total Knee Arthroplasty (TKA)	-	-	22.6	-	49.5	-
Yoo JH et al., 2007 Korean population [8]	Magnetic resonance imaging measurements of 163 adults	44.6	3.7	22.3	1.9		
Iranpour F et al., 2008 United Kingdom [9]	3D reconstructed CT scans from 37 adults	34.3	4.8	22.4	2.3	44.8	-
Agnihotri G et al., 2013 [10]	200 cadaveric patellae	35.8	-	16.95	-	37	4.1
Oladiran I et al., 2013 [11]	-	43.7	3.6	23.9	2.1		
Murugan M et al., 2016 [12]	65 adult dry patellae	38.07	3.7	18.29	1.73		

| Taj S et al., 2022 [7] | 50 human dry patellae | 40.7 | 3.4 | 20.3 | 1.6 | 41.2 | 3.7 |
| Present study | 50 adult dry patellae | 42.38 | 3.5 | 19.21 | 2.2 | 45.1 | 3.8 |

[Table/Fig-7]: Comparison of the parameters with the available studies [2,7-12].

In [Table/Fig-7], the patellar height obtained from the present study was calculated as 42.38±3.5 mm, which was comparable to the study conducted by Taj S et al., with a value of 40.7±3.5 mm [7]. The patellar thickness in the present study was 19.21±2.2 mm, which was again similar to the study performed by Taj S et al., on the South Indian population [7].

The comparison of the Medial and Lateral Articular Facets (MAF, LAF) of the patella between the present study and other past studies is presented in [Table/Fig-8] [7,10,12,13]. The width of the medial and lateral articular facets calculated in the present study was 17.87±2.4 mm and 22.91±1.9 mm, respectively, which was similar to the findings obtained by Biswas S and Sharma S, with values of 15.1 mm and 22.5 mm, respectively [13].

| Study | Sample and subjects | Width of median articular facet (mm) | | Width of lateral articular facet (mm) | |
		Mean	SD	Mean	SD
Agnihotri G et al., 2013 [10]	200 cadaveric patellae	13.7	1.9	17.7	2.7
Murugan N et al., 2016 [12]	65 adult dry patellae	18.78	-	22.75	-
Taj S et al., 2022 [7]	50 human dry patellae	21.0	-	24.6	-
Biswas S and Sharma S, 2019 [13]	89 human dry patellae	15.1	-	22.5	-
Present study	50 adult dry	17.87	2.4	22.91	1.9

[Table/Fig-8]: Comparison of the medial and lateral articular facet (MAF, LAF) of patella [7,10,12,13].

Limitation(s)

The study was conducted on adult dry patellae; however, the age and gender were not taken into consideration, and the sample size was also limited to 50.

CONCLUSION(S)

The present morphometric study provides records of various dimensions of the patella, which can contribute to the design of patellar implants. Most of the existing Total Knee Arthroplasty (TKA) implants are designed to suit the knee anatomy of the Western population. The data obtained from present study will be helpful in designing implants for the Indian population. By increasing the sample size and including specimens of diverse ethnicities, the study can be made more significant and useful. The data obtained from present study can also be useful for clinicians in planning the treatment for knee pain, as well as other patellofemoral-related problems.

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