

Patellar Anthropometry in Sex Differentiation - A Study in the Southern Part of Andhra Pradesh, India

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Abstract

As in many cases, long bones get available in fragments, so gender determination from short as well as robust bones like patella is paid importance nowadays. So far, the literature reviewed show such records are found little in India, especially from the state of Andhra Pradesh. The present study is aimed to demonstrate the gender differentiability of different patellar anthropometric parameters viz, length, breadth, weight, thickness & patellar Index, etc., amongst the population of the southern part of Andhra Pradesh in India. A total of 50 intact patellae of which 25 belonging to males and 25 belonging to females, were taken out from human corpses of 20 to 50 years of age group, brought for postmortem to the Department of Forensic Medicine, Sri Venkateswara Medical College, Tirupati. Patellar vertical length, width, different measurements of the individual articular facet, patellar index, and surface area of the articular part, etc., were measured. In males, the mean of patellar length, Patellar index, Dry weight, Articular surface area were found to be 3.892 cm, 115.36, 20.06 gm, and 14.164 cm² respectively and in females, the mean of patellar length, Patellar index, Dry weight, Articular surface area were found to be 3.608 cm, 103.12, 15.16 gm and 9.664 cm² respectively. The values are found to be less in females than those found in males. The results of this study revealed that we can determine the sex of the southern Andhra Pradesh population, just by using the patellar measurements when other long bones, skull, and pelvis are not available or fragmented. But there remains scope for multicenter study throughout India to validate the fact.

Keywords: Patella, Sex determination, Morphometric parameters

Introduction

The diagnosis of sex from the adult human skeleton is important in the field of physical and forensic anthropology for the identification of a human body. There are many studies on the metric or non-metric diagnoses of sex from bones. The skull and pelvis have been the preferred elements by most forensic anthropologists¹. Recent research however has shown that the appendicular skeleton can achieve higher discrimination between sexes. As in many cases, long bones get available in fragments, so gender determination

from short as well as robust bones like patella is paid importance nowadays. Patella being a small but robust sesamoid bone, is often availed intact even after major accidental deaths where long bones easily get fragmented. As the patella develops within the quadriceps muscle, its size and shape are dependent upon the strength and size of the muscle mass. The patella is a small compact bone that does not undergo too many postmortem changes and therefore can be retrieved completely and used for such purposes. Tapan Kumar Jana et al² demonstrated sexual dimorphism in the northern part of the West Bengal population. Introna et al³ demonstrated gender differentiability of patella among the population of southern Italy. Mahfouz et al⁴ with three-dimensional CT guided research established gender differentiability of patellar anthropometric parameters. Dayal and Bidmos et al⁵ almost concurrently carried on similar

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researches in the population of South Africa and justified the reliability of the patella in this ground. Later Akhlagi et al⁶ endorsed such findings in the Iranian population. Veeramani et al⁷ carried on geometric analysis on the mediolateral placement of patella and tibial tuberosity in the population of Karnataka. Such an endeavor in the Indian population especially from Andhra Pradesh is little available in pertinent literature, searched for.

The aim and objective of the study were to demonstrate the gender-wise distribution of different anthropometric patellar parameters like maximum length, dry weight, the surface area of the articular part, patellar index, etc., in southern Andhra Pradesh population.

Materials and Method

For feasibility, the present study has been carried on under the purview of Sri Venkateswara medical college, Tirupati, over a period of one and a half years. Proper permission from the institutional ethics committee has been availed prior to the start of the study. With proper permission from the Head of the Department of Forensic Medicine and with informed consent from the near relatives of the deceased, patellae were collected for anthropometry from the cadavers brought for postmortem examination to the Department of Forensic Medicine, Sri Venkateswara Medical College, Tirupati. From these cadavers, those within the age group of 20 to 50 years were chosen to avoid age related underdevelopment or osteopenia of the bones. Kin of the deceased, whoever not consented to participate, the procedure was not performed on those cadavers. For uniformity of the result, patellae of the left side were taken out through a longitudinal incision in front of the knee. The bones were washed by brushing with Luke warm water and were placed under shelter to dry slowly. For the attachments of soft parts including tendons and ligaments, the bones were boiled for twelve hours or even more to strip off these soft parts easily with an ordinary brush. All these were done carefully to preserve original bone morphology. Only normal patellae were included in this study. Patellae with severe enthesophytes and other abnormalities were specifically excluded. Thus, a total of 50 patellae could be included in this study, out of which 25 were from males and 25 were from females.

Different parameters were recorded using the same weighing machine and Vernier calipers. In every case, three records were taken and the average of all was noted, to minimize the intra-observer variation. All measurements were adapted from **Martin and Knussmann's definitions**⁸.

Parameters taken for metric sexing of the patella:

Dry weight of the bone (DW): Noted with digital weighing machine, Maximum Length (ML) = greatest distance between the base and apex, Maximum breadth (MB) = greatest distance between the medial and lateral sides, Maximum thickness (MT) = Distance between anterior and posterior surfaces, Vertical diameter of the articular part. (VDA), Transverse diameter of the articular part. (TDA), Breadth of the medial articular facet (BMAF) = distance between the medial edge of the patella and median ridge of the articular facet, Breadth of the lateral articular facet (BLAF) = distance between the lateral edge of the patella and median ridge of the articular facet. For estimation of breadth of the articular facets, the respected articular facet was colored by ink and the impression was taken on centimeter calibrated graph paper, Surface area of the articular part (SAP) = VDA X TDA, Patellar index: (PI) patellar index was calculated by using the formula: maximum breadth/maximum length x100. All these anthropometric parameters were analyzed and sex differences were observed.

Observations

The statistical product and service solutions version (12) program was used to analyze all the data. Descriptive statistics, which included means and standard deviations, were obtained for all measurements. Subsequent independent 't' test was carried out on each variable in both the sexes to find out the significant differences ($p < 0.005$) in the male and female mean measurements. The average of the two means (mean of males and that of females) used as the demarcating points as per the previous studies.

The main findings can be highlighted as:

The gross appearance of the patellae of both the sexes was observed carefully. It was seen that in males the patellae were heavier, larger, and more marked with muscular and ligamentous impressions than in females.

Dry weight of the bone (DW) was recorded using the digital weighing machine and arranged according to the sex they belong to. The male patellae varied from 12.6 gm to 25.6 gm in weight with an average of 20.6 gm. The female patellae varied from 11.4 gm to 19.5 gm with an average of 15.16 gm (**Table no.1**). **Maximum Length (ML)** of the male patellae was 3.7 cm to 4.1 cm with an average of 3.8 cm while that of the female patellae was 3.4 cm to 3.8 cm with an average of 3.6 cm. **Maximum breadth (MB)** of the male patellae was 4.0 cm to 4.8 cm with an average of 4.5 cm and that of the female patellae was 3.6 cm to 4.2 cm, with an average of 3.7 cm. **Maximum thickness (MT)** of the male patellae was 1.9 cm to 2.4 cm with an average of 2.06 cm and that of the female patellae was 1.5 cm to 1.9 cm, with an average of 1.68 cm. **Vertical Diameter of the Articular part (VDA)** of the male patellae was 3.2 cm to 3.7 cm with an average of 3.3 cm and that of the female patellae was 2.9 cm to 3.5 cm, with an average of 3.2 cm. **Transverse Diameter of the Articular part (VDA)** of the male patellae was 4.3 cm to 4.7 cm with an average of 4.4 cm and that of the female patellae was 4.0 cm to 4.3 cm, with an average of 4.1 cm. **Breadth of the medial articular facet (BMAF)** of the male patellae was 1.7 cm to 2.0 cm with an average of 1.9 cm and that

of the female patellae was 1.5 cm to 1.7 cm, with an average of 1.63 cm. **Breadth of the lateral articular facet (BLAF)** of the male patellae was 2.4 cm to 2.8 cm with an average of 2.5 cm and that of the female patellae was 2.0 cm to 2.4 cm, with an average of 2.2 cm. **Surface area of the articular part (SAP)** of the male patellae was 12 cm² to 16.2 cm² with an average of 14.1 cm² and that of the female patellae was 9.3 cm² to 10.0 cm², with an average of 9.6 cm². **Patellar Index (PI)** was calculated in both and it was higher in the male patellae ranging from 100 to 129 with an average of 115.3 and low in female patellae ranging from 92 to 120, with an average of 103.1.

Demarcating values are calculated by taking the average of the means of all parameters of both male and female patellae (**Table no 2**). The values reveal that in males all the parameters Viz, DW, ML, MB, MT, VDA, TDA, BMAF, BLAF, SAP & PI are more than 17.38, 3.73, 4.15, 1.54, 3.26, 4.35, 1.76, 2.4, 11.44 & 109.54 respectively. Statistical analysis of the above parameters was done. Standard deviation was extracted and 't' test was performed. It was seen that p-value in all cases was highly significant (< 0.005) (**Table no 3**). The percentage of accuracy is also calculated for the various anthropometric parameters of the patellae (**Table no. 4**).

Table No.1

Gender wise comparison of different anthropometric parameters measured from the patellae						
Parameters	Male			Female		
	Minimum	Maximum	Average	Minimum	Maximum	Average
DW	12.6	25.6	20.06	11.4	19.5	15.16
ML	3.7	4.1	3.89	3.4	3.8	3.61
MB	4.0	4.8	4.51	3.6	4.2	3.74
MT	1.9	2.4	2.07	1.5	1.9	1.68
VDA	3.2	3.7	3.34	2.9	3.5	3.20
TDA	4.3	4.7	4.48	4.0	4.3	4.17
BMAF	1.7	2.0	1.91	1.5	1.7	1.62
BLAF	2.4	2.8	2.56	2.0	2.4	2.22
SAP	12	16.2	14.16	9.3	10.0	9.66
PI	100	129	115.36	92	120	103.12

Table no 2.

Demarcating points for sex determination	
Variable	Demarcating value
DW	Female < 17.38 < male
ML	Female < 3.73 < male
MB	Female < 4.15 < male
MT	Female < 1.54 < male
VDA	Female < 3.26 < male
TDA	Female < 4.35 < male
BMAF	Female < 1.76 < male
BLAF	Female < 2.40 < male
SAP	Female < 11.44 < male
PI	Female < 109.54 < male

Table No: 3

Results of independent “t” test of different anthropometric parameters measured from the patella.

Parameters	Gender	Mean	Std. Deviation	‘p’ value
DW	MALE	20.060	2.7139	0.000
	FEMALE	15.160	2.2653	
ML	MALE	3.892	.1077	0.000
	FEMALE	3.608	.1498	
MB	MALE	4.508	.1891	0.000
	FEMALE	3.744	.1474	
MT	MALE	2.068	.1574	0.000
	FEMALE	1.680	.1000	
VDA	MALE	3.344	.1474	0.001
	FEMALE	3.200	.1323	
TDA	MALE	4.480	.1354	0.000
	FEMALE	4.168	.1108	
BMAF	MALE	1.908	.0997	0.000
	FEMALE	1.624	.0831	
BLAF	MALE	2.556	.1003	0.000
	FEMALE	2.224	.1200	
SAP	MALE	14.164	1.1500	0.000
	FEMALE	9.664	.1977	
PI	MALE	115.36	5.453	0.000
	FEMALE	103.12	6.044	

Table No: 4: Percentage of accuracy among the different anthropometric parameters taken from patella:

Parameters	Percentage of accuracy	
	Males	Females
DW	87.24%	75.2%
ML	97.94%	97.92%
MB	88.89%	97.3%
MT	92.3%	89.28%
VDA	97%	90.7%
TDA	95.9%	97.6%
BMAF	94.8%	92.03%
BLAF	96%	90.91%
SAP	84.75%	98.35%
PI	86.69%	89.3%

Discussion

Nearly for the last thirty years, several studies have been carried out in different corners of the globe to establish the fact of patellar sexual dimorphism. One such pioneer study conducted by Gunn and Mc Williams⁹ assessed the sexual dimorphism of patellae obtained from the Todd collection using volumetric analysis. This involved submerging the patellae into a container of water and using the displacement method in calculating the volume of the bone. The highest average accuracy of sex classification obtained in this study was 88% for the “Europids”. O’ connor¹⁰ demonstrated a statistically significant dimorphism in patellae. Measurements were collected from the Terry collection and radiographs of college students had an accurate result of 82.5% in the classification of females and 78.6% in males. Jana et al² in the northern part of the West Bengal conducted a similar study where a total of 46 intact patellae (23 male and 23 female) were taken from the human cadavers and the various parameters were studied. Results of their study revealed that all the parameters of the patellae were higher in males when compared to females except angulations at the vertical ridge (this parameter is not included in the present study) which was higher in females than males. Same results

were observed in our study too. Our study is similar to the study that was done by Francesco Intronajr et al¹¹., KayalVizhi, S. Arora et al¹², TA Rathbun, BC Rathbun paolo et al¹³ and Dayal and Bidmos et al¹⁴. The present study reported that the surface area of the articular part and maximum length of the patellae can be used in correct sex classification with an average percentage of accuracy of 98.35% and 97.94 % respectively. Introna et al¹⁵ reported the highest average accuracy of 79%, for each of the maximum thickness and height of the lateral articular facet. The results of a study conducted in Iran (Akhlagi et al⁶) in which a higher average accuracy was obtained for the ML (89%) and MB (91%). Our study is similar to this study with accuracy for ML (97.94%) and for MB (88.89%)

Conclusion

The implementation of discriminant function analysis based on patella morphometry offers a simple and well-studied approach for sex determination on small bones of an individual from incomplete skeletal remains. The present study was conducted on patellae collected from 50 autopsied bodies in the Department of Forensic Medicine, Sri Venkateswara Medical College, Tirupati, shown that the mean values of males were

higher than that of females. The equation thus derived from this study can be used for sex determination in a group of south Indian population with the highest accuracy of 98.75% using variables. Similar studies are to be carried out in different zones of India, to verify findings in order to obtain uniform values for the Indian population, which has not been reported to date.

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References

1. W.M. Krogman, M.Y. Iscan, *The Human Skeleton in Forensic Medicine*. Springfield, Charles C. Thomas, 1986, pp. 189–26.
2. Tapan Kumar Jana, SushmitaGiri et al., Human Patellar Anthropometry in Sex differentiation, *J Indian med assoc* 2013; 111: 657-60.
3. J. Introna, G. Di Vella, C. Campobasso, Sex determination by discriminant function analysis of patella measurements, *Forensic Sci. Int.* 95 (1998) 39–45.
4. M. Mahfouz, A. Badawi, B. Merkl et al., “Patella sex determination by 3D statistical shape models and nonlinear classifiers,” *Forensic Science International*, (2007), vol. 173, no. 2-3, pp. 161–170.
5. M. Dayal, M. Bidmos, discriminating sex in South African blacks using patella dimensions, *J. Forensic Sci.* 50 (6) (2005) 1294–1297.
6. M. Akhlaghi et al. / *Journal of Forensic and Legal Medicine* 17 (2010) 150–155.
7. RaveendranathVeeramani, Nachiket Shankar, Sujatha Narayanan, et al; Gender differences in the mediolateral placement of the patella and tibial tuberosity: a geometric analysis “*International journal of experimental and clinical anatomy*” (2010) no. 4: p 45–50.
8. MartinR,Knussmann R- *Anthropologie: Handbuch Der VergleichendenBiologie Des Menschen*. Stuttgart: Gustav Fischer, 1988.
9. Gunn MC, McWilliams KR. A method for estimating sex of the human skeleton from the volume of the patella, talus, or calcaneus. *HOMO*. 1980; 31:189-198.
10. W.G. O’Connor. The dimorphic sesamoid: differentiating the patella of females and males by height, width, and thickness measurements. Master’s thesis of Arts in the Department of Anthropology-University of South Carolina, 1996.
11. Francesco IntronaJr, Giancarlo Di Vella, Carlo PietroCampobasso; Sex determination by discriminant analysis of patella measurements (1998) 2-8.
12. I. Kayalvizhi, S. Arora, B. Dang, et al Sex Determination by Applying Discriminant Functional Analysis on Patellar Morphometry; *International Journal of Science and Research (IJSR)* ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6-14
13. T.A. Rathbun, B.C. Rathbun, Human remains recovered from a shark’s stomach in South Carolina, *J. Forensic Sci.* 29 (1984) 269–276.
14. M. Dayal, M. Bidmos, discriminating sex in South African blacks using patella dimensions, *J. Forensic Sci.* 50 (6) (2005) 1294–1297.
15. Introna Jr F, Di Vella G, Campobasso CP (1998) Sex determination by discriminant function analysis of patella measurements. *Forensic Sci Int* 95:39–45.