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ORIGINAL PAPER

A study of sex determination from human patellae in a tertiary care centre

Panja Saumabrata[1], Sardar Tanmay[2], Bose Tapas Kumar[3], Roy DG[4]

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ABSTRACT

***Introduction**: For forensic personnel sex determination from bones is a critical factor and is commonly assessed by the morphological-metric traits of the pelvis, skull and long bones. However sometimes in cases of mass fatalities like blast injury or air- craft accidents these bones are unavailable for identification or very much fragmented. So sex prediction must be attempted from other parts of skeleton where as patella, being a sesamoid bone that forms within the tendon of the quadriceps muscle, is a robust bone and survives being fragmented which may be able to give valuable information for determination of sex of an individual.**Aims**: To find out any significant sexual differentiation between male and female by using different measurements and weight of patella of both sides.**Methods**:187 dead bodies (96 males and 91 females) were taken for the study from representative sample of different age group & sex, keeping in mind of inclusion and exclusion criteria.**Results**: This study is in agreement with most of the previous studies and small bones also show sexual dimorphism. **Conclusion**: With the implementation of discriminant function analysis it can be concluded that we can determine sex based on patella morphometry with quite high confidence limit.*

***Keywords**: Sesamoid bone, Dimorphism, Discriminant function analysis, Pearson's correlation, Graphical representation*

INTRODUCTION

Sex determination is one of the major challenges for the forensic anthropologist. Estimation of sex is more reliable if the complete skeleton is available for analysis but in majority of forensic cases human skeletal remains are either incomplete or damaged. The use of anthropometry in the field of forensic science and medicine dates back to 1882 when Alphonse Bertillon, a French police expert invented a system of criminal identification based on anthropometric measurements. The system of identification spread rapidly through much of the world but the system was not accepted much in view of some major drawbacks and discovery of other identification systems, e.g. dactylography.[1] The rise and development of the discipline was strongly accelerated with the publication of Wolton M. Krogman's "*Guide to the Identification of Human Skeletal Material"* and by significant involvement of physical anthropologists in the identification of victims from the Second World War.[2]Knowledge of the gender of an unknown skeletal set is essential to make a more accurate estimation of age.[3]With the lack of DNA analysis, forensic anthropology applies it's knowledge with the help of artificial intelligence (ANN) based on skeletal dimorphism which give contribution in identification, particular in gender determination.[4]

The bone studied was human patellae. Now, why the sesamoid bone-PATELLA had been chosen for the study? In cases of mass fatalities like blast injury or air- craft accident, the skull, pelvis and long bones are frequently absent or fragmented, incomplete, not intact, fragmented, burned, or damaged so sex prediction must be attempted from other parts of skeleton, whereas patella forms within the tendon of the quadriceps muscle it survives being fragmented easily. Since, the shape and size of the patella relies on the strength of the muscle

Address for correspondence:
[1]Demonstrator, RG Kar Medical College, Kolkata
[2]Assistant Professor (**Corresponding author**)
Bankura Sammilani Medical College & Hospital, Bankura
Mobile: 08777470934
Email: addicted.cyanomania@gmail.com
[3]Professor & HOD, Department of Forensic Medicine
NRS Medical College& Hospital, Kolkata
[4]Professor, KPC Medical College& Hospital, Kolkata
Department of Forensic Medicine

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mass, it is likely that stronger muscle masses could alter the shape and size of this bone. Given that females have a smaller build than males; it can be hypothesized that some measurements of the patella will display sexual dimorphism.[5]

Aim of the study: The aim is to find out any significant sexual dimorphism between male and female by using different measurements and weight of patella of both sides.

METHODS

Study Area: F.M.T. Department and mortuary at N.R.S Medical College & Hospital, Kolkata.

Study Period: A one year study was conducted from 1st April 2015 to 31st March 2016.

Study Population: Bengalee male & female dead bodies brought to N.R.S. M.C.&H. police morgue.

Inclusion Criteria: Age group – 18 to 60 years. The age of the deceased was obtained from the nearest relatives and police and was verified by necessary documents. The age of the deceased was rounded off to full figures.

Exclusion Criteria : Diseased patella, deformed patella, fracture patella with or without mal-union or bad erosion, unknown or unclaimed dead bodies where age cannot be confirmed, Non-Bengalee population, and in those cases where consent was not given by the relatives.

Sample Size: 187 dead bodies (96 males and 91 females) were taken for the study from representative sample of different age group & sex, keeping in mind of inclusion and exclusion criteria. Out of the 2786 autopsies done within this period of time in N.R.S. Police morgue, 1418 were within the age group of 18 to 60 years, of which 957 were of Bengalee origin of which 612 cases were known cases by name & age at the time of autopsy. Excluding the deformed patella, or missing leg of any side the number of cases were 603,of which consent could be taken from only 187 cases from the nearest relative of the deceased.

Study Design: Institutional based, cross sectional, Analytical and Mortuary based study.

Study Tools: Proforma, consent form, police requisition/ inquest report, standard autopsy instruments, gloves, metallic graduated scale, hydrogen peroxide, caustic soda.[6] and borax/ Biotex solution, instrument to boil patella in the above said solution, bristle brush& wooden chopsticks, measuring tape& slide caliper, digital camera, digital weighing machine, computer with accessories and software like MS Word and MS Excel, Windows SPSS of latest version.

Study Technique: The patellae were dissected out of both sides from each subject. During dissection care was taken to cut the skin as small as possible. Skin over the knee is sutured properly after that. Patellae thus collected were put in the instrument containing solution of either hydrogen peroxide, caustic soda or borax/Biotex solution and boiled for continuous 2 to 3 hrs so that it's get devoided of all soft tissues. Further these were washed and cleaned by rubbing with brush to get rid of any remaining soft tissue attached.[7]At last these processed patellae were air dried before measuring and weight taken. Length, breath, thickness of each patella was measured by vernier caliper after correction for zeroing of the caliper was done for each case. Each patellae was weighted in digital weighing machine. Body length was noted for each case. The findings of measurements and observations were compared and statistically calculated and evaluated. Metric data was summarized as Mean and Standard deviations.

RESULT

Table 1 Distribution of the study population according to body length (n=187)

Body Length	Male		Female	
	Frequency	%	Frequency	%
4'10"	3	3.12	5	5.49
4'11"	5	5.20	9	9.9
5'	4	4.16	17	18.68
5'1"	7	7.29	8	8.8
5'2"	3	3.12	22	24.17
5'3"	5	5.20	12	8.79
5'4"	19	19.79	10	10.99
5'5"	26	27.08	3	3.29
5'6"	15	15.62	3	3.29
5'7"	6	6.25	2	2.19
5'8"	3	3.12	0	0
Total	96	100	91	100

In the study population, we got maximum number of male between body length of 5'4" to 5'6" and female between body lengths of 5' to 5'4".

Table 2 Distribution of the study population according to age group (n=187)

Age Group (Years)	Male			
	Frequency	Percentage (%)	Frequency	Percentage (%)
18-24	9	9.37	16	17.58
25-31	16	16.66	14	15.38
32-38	14	14.58	17	18.68
39-45	21	21.87	14	15.38
46-52	14	14.58	13	14.28
53-60	22	22.91	17	18.68
Total	96	100	91	100

The study comprises of 51% of male population and 49% of female population.

Table 3 Mean, Sandard Deviation & the statistical significance of various measurements of patella among male and female(*p-value significant as less than 0.05 in all the parameters)

Variables(Different patellar measure)	**Male**		**Female**		**P-value**
	Mean	Standard Deviation	Mean	Standard Deviation	
Length- Rt.(in cms)	4.50	.435	3.59	.197	.003 *
Length- Lt. (in cms)	4.46	.428	3.55	.192	.003 *
Width- Rt. (in cms)	4.56	.398	3.69	.157	.001*
Width- Lt. (in cms)	4.55	.408	3.67	.161	.001 *
Thickness- Rt. (in cms)	2.51	.344	1.81	.171	.001 *
Thickness- Lt. (in cms)	2.51	.335	1.83	.150	.001 *
Patella weight-Rt.(in gms)	10.36	2.005	6.44	.849	.002 *
Patella weight-Lt.(in gms)	10.35	2.006	6.47	.881	.002 *

Table 4 Discriminate Function analysis done of the above variables of **Table 3**

Sex		Predicted Group Membership		Total
		1	2	
Original Count	1	82	14	96
	2	2	89	91
%	1	85.4	14.6	100.0
	2	2.2	97.8	100.0

Discriminant function analysis was done to access the dimorphism in patella and how the variables correctly assign the bones to the proper sex. Computationally discriminant function analysis is very similar to analysis of varience (ANOVA), what we had read in text books.[8] We can visualize how the two functions discriminate between groups by plotting the individual scores in graphs.[9]

Classification result showing that Sensitivity of 97.6%, Specificity of 86.4%and Accuracy of 91.4%.

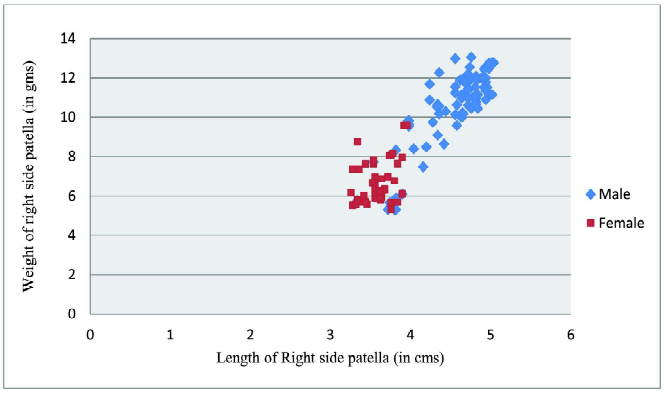

Figure 1 Scatter diagram showing distribution of Length vs. Weight of patella-Right side in male & female

There is positive correlation and Pearson's correlation co-efficient is 0.909 which is statistically significant.Pearson's correlation is the covariance of the two variables divided by the products of their standard deviations. It is a measure of value between +1 and -1, where 1 is the total correlation, 0 is no linear correlation and -1 is total negative linear correlation.

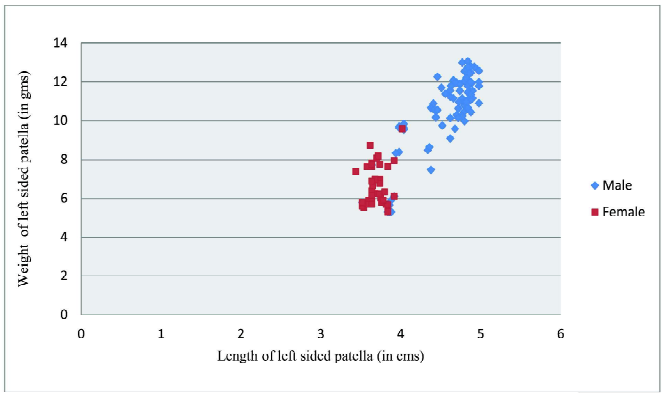

Figure 2 Showing distribution of Length vs. Weight of patella of Left side in male and female

There is also statistically significant positive correlation co-efficient of 0.910

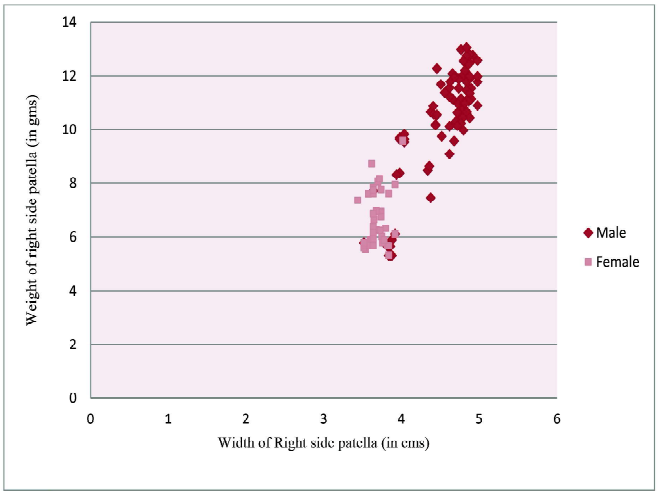

Figure 3 Showing distribution of width vs. weight of patella of Right side in male & female

Here also statistically significant positive correlation co-efficient 0f 0.920. Similarly graph was plotted for searching the relation between weight and width of left sided patella and result showed positive correlation of 0.918.

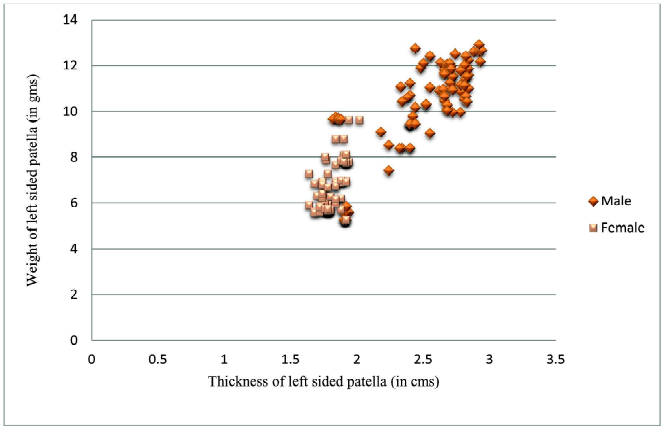

Figure 4 Showing distribution of Thickness vs. Weight-Left sided patella in male and female

Here also positive correlation and correlation co-efficient is 0.908. Similarly graph was plotted for weight and thickness of right sided patella and result showed positive correlation of 0.904.

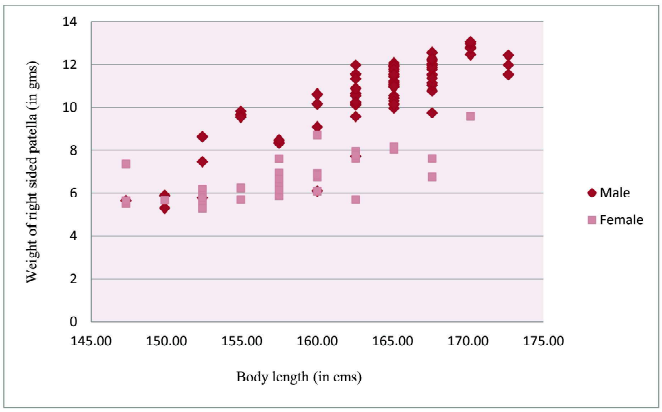

Figure 5 Showing distribution of Body length vs. weight of Right sided patella in male and female

Statistically significant positive correlation and correlation co-efficient is 0.867. Similarly graph was plotted for body length and weight of left sided patella and result showed statistically significant positive correlation of 0.870.

- No statistically significant difference between right and left side patella. Discriminant function analysis was done of the variables as p-value is significant and the results showing that Sensitivity of 97.6%, Specificity of 86.4%and Accuracy of 91.4%.
- Discriminant Function Analysis of those variables taken individually showed highest accuracy in width of 91.4%, followed by thickness of 90.6% then length 89.7% and with patellar weight of 86.3%.
- Highest correlation was found between right sided width of patella and their weight which is 0.920 considering both male and female together.
- Lowest correlation was found between right sided patellar weight and body length of the deceased which is 0.867, considering male and female together but this is also quite strong statistically.
- It was clearly observed that most of the male patella of both sides are more than 8 gms, where as it is less than that in most of the case of females.

DISCUSSION

The results of the study reveal that we can determine sex of an individual with high confidence limit by using sesamoid bone-patella. Few previous study also emphasis on this what we have observed in our study like Kayalvizhi *et al*. conducted study in North Indian population which is in accordance with our result.[10]I Afrianty et al. conducted study on human patellae using BNPP and found result of average accuracy of 96.1%.[11] Olateju OI et al. The study was carried out on South African cadavers of European ancestry also shows sexual dimorphism.[12] Paolo Phoophalee *et al*. conducted a study on Thai population. They performed univariate and multivariate discriminant analysis.[13] Kar MN. & Bhakta A. *et al*. conducted a study on patella in North Bengal Medical College and concluded that statistical tests shows no significant difference.[14] Akhlaghi M.et al found maximum accuracy in height and weight in their Iranian population study on patellae with average accuracy of 93.5%.[15]Kazuhiro Sakaue study on Japanese population used patellar weight as one of the parameter but found no significant difference in their study.[16]Dayal *et al*. worked on South African blacks and concluded that the highest rate of classification was 85%, thereby making the patella useful for sex determination.[17]O'Connor WG. stated in the study that small bones to be recovered with high proficiency where it is unable to rescue intact long bones due to some odd situations because small bones like patella are of much help showing sexual dimorphism if studied accurately.[18] Bidmos MA. conducted the study and concluded that statistically significant difference is maximum in height and breadth of patella with an average accuracy of 85% and 79% respectively.[19] Magdy M. Ashmawy El-Hanafy et al revealed that the measurements of male patellae were significantly higher than those of females except for the height of the medial articular surface.[20]

CONCLUSION

The results of this study revealed that we can determine sex with high confidence in situations such as explosions, air crashes and etc, just by using the patellar measurement. The current study is in agreement with most of the previous studies and supports the idea that the small bone patella has got definitive sexual dimorphism and is a reliable indicator for sex differentiation between male and female. However like any other study this study also has its limitations like-sample size. If study could have been done on more samples there would have been lesser chance of bias in the results, correlation with other bones like pelvis, skull, mandible could

not be done. Limitation of consideration of age between 18 to 60 years, non-Bengalee population was not considered in the study. Modern analytical methods like BPNN or ANN could not be used for analysis.

Ethical clearance: Clearance of the ethical committee was obtained on 24/12/14 before the study was started.

Contributions of authors: We declare that this work was done by the authors named in the article. All of us worked as a team to design, collection of data and analysis to find out the result of the study.

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Conflict of interest: No conflict of interest associated with this work.

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