

Morphometric Variation of Adult Human Clavicle - A Tool for Gender Determination

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Abstract

Introduction: Bones can reflect the basic framework of human body and provide valuable information about the biological identity of the deceased. They often, survive the morphological alteration, decay/ mutation and decomposition insults. An in depth, knowledge and analysis of variation in clavicular length, midclavicular circumference and weight is imperative for both clinical and forensic anthropological perspectives. **Objectives:** The present study was done to determine morphometric variability of adult human clavicles by using length, weight and midclavicular circumference parameters. **Materials and Methods:** 300 pairs of adult human clavicles of known sex obtained from cadaveric dissection and bony collections of anatomy department were utilized for the study. The length, weight and midclavicular circumference were measured. The data obtained was statistically analysed. **Results:** Gender specific statistical analysis for length, weight and midclavicular circumference was found to be highly significant. The side specific significance was found only in male and in female clavicles for weight and midclavicular circumference respectively. No side specific significance found for length of clavicle. **Conclusions:** The present study provides morphometric data for North Indians and compares observations with other populations. The study establishes that length, weight and midclavicular circumference of clavicle have a dimorphic potential. This fact can play a decisive role in forensic identifications and clinical interventions. The results are of immense significance for anatomists, orthopedic surgeons and the forensic anthropologists in their professional endeavors.

Keywords: Clavicle, Gender Determination, Morphometry

1. Introduction

Bones reflect the basic framework of human body and may provide valuable information about the biological identity of deceased. They often, survive the morphological alteration, decay/mutilation and decomposition insults.^[1]

Estimation of age, sex and stature by skeletal remains has been explored by many workers since more than a century.

^[2] Osteometry, a vital component of anthropometry includes the measurements on the skeletal material. Through this technique, a forensic scientist can study variation in bony skeleton of different populations of the world. The technique has been successfully used in

the estimation of age, sex and race in forensic and legal science.^[3]

The clavicle, being subcutaneous, is easily examined and presents a tempting target for biopsy. This may be of both diagnostic and therapeutic value, but on occasion normal anatomical variations lead to unnecessary operations.^[4]

The clavicle has been described as a useful bone for the metric determination of sex of human remains. Sex determination is considered most reliable, if essential parts of skeleton are available in good condition. The midclavicular circumference of clavicle is one of most reliable indicators of sex and a combination of this

measurement along with weight and length is expected to yield better result accuracy. The length, weight and midclavicular circumference of clavicle are important parameters from both clinical and anthropological perspectives.^[5]

2. Materials and Methods

The present study was done on 600 adult human clavicles (300 pairs, 150 pairs of male and 150 pairs of female clavicles) obtained from the department of Anatomy, Government Medical College, Amritsar, Punjab, India. Prior ethical approval was duly taken from the ethical committee established at Government Medical College, Amritsar, Punjab, India. The bones were dried, macerated, cleaned and observed for any physical deformity.

An electronic weighing machine was used for weighing the clavicle (Figure 1).

The length of clavicle was measured by using a digital vernier caliper (least count .02 mm) without taking into account the bony curves. The length was measured as the distance between outermost part of acromial end to the innermost part of sternal end as shown in (Figure 2). The measurement was done with the bone placed on table keeping anterior and posterior borders in same horizontal plane.

While taking the length of clavicle the midpoint was calculated and marked a point with marking pencil at midpoint of clavicle. Then a cotton thread was taken and wrapped around the midpoint of clavicle to measure its circumference. Two points were marked on thread with red mark. Then thread was placed on the paper and the distance between two red points determined using a vernier caliper. This distance was taken as the midclavicular circumference of clavicle as shown in (Figure 2).



Figure 1. Electronic weighing machine.

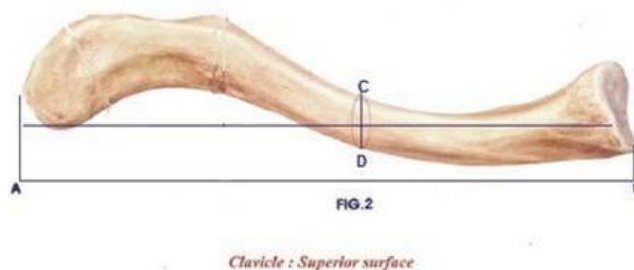


Figure 2. AB: Length of the clavicle CD: Midclavicular circumference of clavicle.

The parameters measured were analysed statistically. Mean, standard deviation, standard error of mean, range variance and 95% confidence interval, p value were determined. t -test was applied to assess the significance of difference between the various measurements of clavicles of both sides and in both genders.^[6,7]

3. Observations

Gender specific highly significant statistical analysis ($p < 0.001$) was found to exist in case of length, weight and midclavicular circumference of clavicle. Side specific significant statistical analysis was found to exist for male clavicles ($p < 0.01$) for weight and for midclavicular circumference in females. In general, the values of length, weight and midclavicular circumference were found to be higher for males than in the females.

4. Discussion

The present study establishes the morphometric criterion for the three clavicular parameters i.e., length, weight and midclavicular circumference in North Indian population and also establishes their dimorphic potential. For each of these parameters Mean \pm SD, Standard error of mean, Range, Variance and 95% confidence interval values were calculated. The measurements for each parameter as measured in male and females were compared and statistically analysed. The values of measurements for these parameters were also compared with similar measurements in different populations available from the accessible literature. The differences in values for the parameters measured in present and previous studies can

Table 1. Statistical analysis values for length of clavicle (mm)

Sex	Side	No.	Mean±SD	SEM	Range (Difference between max and min value)	Variance	95% Confidence interval	
							Lower bound	Upper bound
F	R	150	134.85±8.83	1.61	29.94	82.72	131.19	138.17
F	L	150	131.32±8.43	1.54	31.96	71.02	128.17	134.47
M	R	150	147.83±10.4	1.91	44.82	109.22	143.93	151.73
M	L	150	151.66±7.83	1.43	34.43	61.38	148.73	154.79
FL vs FR			t= 1.59		P= 0.12		NS	
ML vs MR			t= 1.61		P= 0.12		NS	
FL vs ML			t= 9.68		P= 0.00		HS	
FR vs MR			t= 5.19		P= 0.00		HS	

SD: Standard Deviation, SE: Standard error of the mean, NS: Not significant, HS: Highly significant

Table 2. Showing comparison of length values measured for sexes in present study with the previous studies done on different populations

Authors	Populations	Total No.		Mean±SD			
		Male	Female	Right female	Left female	Right male	Left male
Parson F.G ^[8]	English	100	100	138.00	139.00	152.00	154.00
Terry RJ ^[9]	American Negroes and white	100	100	140.98±0.76	141.78±0.3	153.30±0.083	155.86±0.92
Olivier G ^[10]	French	60	110	130.70	138.70	154.20	155.00
Deongen RV ^[11]	Australians	53	50	125.10±6.8	139.20±8.7	139.58±8.7	125.10±6.8
Jit and Singh ^[12]	Punjab Amritsar	236	112	130.30±9.11	129.20±1.77	145.58±8.60	147.59±9.25
Singh S & Gangrade K.C ^[13]	Varanasi	160	37	125.78±7.5	127.77±8.10	141.18±8.01	144.18±8.01
Singh S & Gangrade KC ^[14]	North Indians	150	150	119.78	119.84	157.69	156.11
Singh et al ^[15]	American Negroes	280	pairs	132.90	140.80	155.72	157.82
Jit I and Sahni D ^[16]	North Indians	260	80	132.40±8.40	134.00±8.10	148.00±8.60	149.80±8.40
Kaur H ^[17]	North Indians (Chandigarh)	748	252	134.53±9.68	136.21±9.64	149.40±8.91	151.14±8.42
Sayee R et al ^[18]	Karnataka Bangalore (South Indian)	136	120	123.90±8.00	128.20±9.00	137.00±9.00	141.15±13.00
Kaur K et al ^[19]	North Indian (Punjab)	200	200	138.85±7.83	131.83±8.56	148.2±10.45	151.66±7.83
Kaur H et al ^[20]	North Indian (Chandigarh)	748	252	137.65±8.78	138.90±8.83	150.48±9.65	151.12±7.24
Makandar UK and Kulkarni P.R ^[21]	South Indian (Karnataka Devangere)	196	137	125.4±8.6	129.7±9.95	141.9±9.7	143.5±10.35
Andermahr J et al ^[22]	German	90	106	140.6±1.00	140.9±1.1	150.6±10.00	150.2±11.0
Makandar UK & Kulkarni PR ^[23]	South Indian	90	70	132.26±7.68	133.89±7.79	146.98±9.42	148.78±9.12
Present study	North Indian	300	300	134.85±8.83	131.32±8.43	147.83±10.45	151.66±7.83

possibly be explained on account of racial variations, and effect of nutritional and environmental factors on the morphology and morphometry of bones of individuals.

The value of Mean \pm SD in females for right side is 134.85 \pm 8.83 where as for left side it is 131.32 \pm 8.43. The value of Mean \pm SD for right side in males is 147.83 \pm 10.45 but for left side it is 151.66 \pm 7.83. Value of range for length of clavicle in females for right side is 29.94 whereas for left side it is 31.96. In present study lower and upper bound of 95% of confidence interval is found to be 131.19 and 138.17 in case of right side in females whereas the values are 128.17 and 134.47 respectively for left side. 95% of confidence interval indicates that 95% of the values for a particular parameter were found to exist between the upper and lower bound values for that parameter.

The value of lower and upper bound of confidence interval in case of right side in males is 143.93 and 151.73 whereas it is 148.73 and 154.79 respectively for left side. The coefficient of variance is 82.72 for right side in females and 71.02 for left side, whereas the corresponding values are 109.22 for right side in males and 61.38 for left side.

The Mean \pm SD values for length of clavicle in present study are comparable to values observed in previous studies in North Indians^[16], Chandigarh^[17] and South Indians.^[21] Higher values have been reported in English population^[8], Americans^[9] and Germans^[7] whereas lesser values have been observed in some studies in South Indians^[16,21], North Indian^[11] and in French population^[10].

The gender specific statistical analysis for length of clavicle is found to be highly significant. This is in consonance with studies done by all authors mentioned in above (Table 2). The results indicate that there exists a

definite statistically significant dimorphic significance for length of clavicle.

No side specific significance was found to exist for length of the clavicle in present study which is contrary to the findings observed in studies done in English population^[8], French^[10], American Whites and Negroes^[9]. The work done by the authors depicted in (Table 2) suggests that left clavicle is somewhat longer than right clavicle and so the right clavicle is shorter and stronger. This is in consonance with our findings in males, but in females mean value was found to be more for right side as compared to left side (Table 1).

When the weight of the clavicle as measured for the right or left sides was compared in males and females, it came out to be statistically highly significant as evident from (Table 3). This indicates that there exists a statistically significant sexual dimorphism for the weight of clavicle in North Indian population ($p < 0.01$).

The Mean \pm SD values in present study for weight of clavicle are comparable to values observed in North Indians^[12], South Indians^[18], Agra population^[24] and in Varanasi population.^[13] Higher values of Mean \pm SD for weight of clavicle in previous studies were observed in Chandigarh zone^[17] and in North Indians^[16] whereas lesser values were observed in South Indians^[18,21] and in Amritsar^[12] zones compared to present study.

Highly significant gender specific statistical difference was found to exist for weight of clavicle which is in consonance with studies done by all authors mentioned in above (Table 4). The results indicate that there exists a definite statistically significant dimorphic significance for weight of clavicle. There is no side specific significant difference found in present study for weight in females

Table 3. Statistical analysis values for weight of clavicle (gms)

Sex	Side	No.	Mean \pm SD	SEM	Range (Difference between max and min value)	Variance	95% confidence interval	
							Lower bound	Upper bound
F	R	150	13.52 \pm 3.52	0.66	12.56	12.40	12.16	14.89
F	L	150	13.66 \pm 3.95	0.72	11.47	15.63	12.18	15.14
M	R	150	21.45 \pm 4.75	0.87	17.63	22.57	19.67	23.22
M	L	150	17.83 \pm 4.61	0.84	19.75	21.29	16.11	19.56
FL vs FR			t=0.21		P=0.83		NS	
ML vs MR			t=2.99		P=0.00		S	
FL vs ML			t=3.76		P=0.00		HS	
FR vs MR			t=7.46		P=0.00		HS	

SD: Standard Deviation, SE: Standard error of the mean, NS: Not significant, HS: Highly significant

Table 4. Showing comparison of weight values measured for sexes in present study with the values of previous studies done on different populations

Authors	Populations	Total No.		Mean±SD			
				Right female	Left female	Right male	Left male
Olivier G ^[10]	French	60	110	17.10	16.20	26.10	25.50
Jit I and Singh S ^[12]	North Indian	236	112	12.83	12.84	21.46	21.32
Singh S &Gangrade KC ^[13]	Varanasi	160	37	12.83	12.84	21.46	21.32
Arora et al ^[24]	UP Agra	200	100	12.59	12.29	22.05	20.12
Jit I &Sahni D ^[16]	North Indian	260	80	17.55±3.21	17.21±3.22	25.78±4.15	25.34±4.37
Kaur H ^[17]	North Indian (Chandigarh)	748	252	16.38±3.14	16.11±3.44	23.18±4.16	22.77±4.00
Sayee R et al ^[18]	South Indian (Karnataka Banglore)	136	120	13.48	12.48	18.73	19.96
Kaur K ^[19]	North Indian (Punjab)	200	200	18.38±3.00	16.11±2.11	25.18±4.00	23.11±3.11
Makandar UK &Kulkarni P.R ^[21]	South Indian (Karnataka Devangere)	196	137	10.31±4.08	10.70±3.27	16.99±4.08	17.09±4.53
Makandar UK & KulKarni ^[23]	South Indian	90	70	16.86±3.03	16.04±2.90	25.43±4.60	24.02±4.79
Present Study	North Indian	300	300	13.52±3.52	13.66±3.95	21.45±4.75	17.83±4.61

which is in accordance to the studies done by all authors in (Table 4). When the values for weight for right and left sides as measured for the males were compared they were found to be statistically significant. This could be attributable to right/left handedness or preference of limb use by particular individuals.

When the midclavicular circumference of the clavicle as measured for the right or left sides was compared in males and females, it came out to be statistically highly

significant as evident from (Table 5). This indicates that there exists a statistically significant sexual dimorphism for the midclavicular circumference of clavicle in North Indian population ($p < 0.01$).

The Mean±SD values in present study for midclavicular circumference was comparable to values observed in English population^[8], French^[10], South Indians^[21] and in North Indian population^[17]. Values of Mean±SD higher than the present study were observed in American Negroes and whites^[9], North Indians^[17] whereas lesser

Table 5. Statistical analysis of values for midclavicular circumference of clavicle (mms)

Sex	Side	No.	Mean±SD	SEM	Range (difference between max and min value)	Variance	95% confidence interval	
							Lower bound	Upper bound
F	R	150	32.14±3.99	0.73	16.18	15.95	30.64	33.63
F	L	150	29.74±4.09	0.74	15.38	16.76	28.21	31.27
M	R	150	37.95±3.21	0.58	13.84	10.29	36.75	39.15
M	L	150	36.59±2.94	0.53	11.09	8.66	35.49	37.69
FL vs FR			t=2.30		P=0.025		S	
ML vs MR			t=0.92		P=0.095		NS	
FL vs ML			t=7.45		P=0.00		HS	
FR vs MR			t=6.21		P=0.00		HS	

SD: Standard Deviation, SE: Standard error of the mean, NS: Not significant, HS: Highly significant S: Significant

Table 6. Showing comparison of midclavicular circumference values measured for sexes in present study with the previous studies done on different populations

Authors	Population	Total no.		Mean±SD			
		Male	Female	Right female	Left female	Right male	Left male
Parson F.G ^[8]	English	50	50	32.6	32.6	38.9	38.9
Terry R J ^[9]	American Negroes and whites	50	50	36.02	33.58	40.02	38.58
Olivier G ^[10]	French	60	110	32.04	31.09	39.00	37.00
Deongen RV ^[11]	Australian	53	50	29.5±3.36	28.5±3.34	36.2±3.44	36.2±3.44
Jit I & Singh S ^[12]	North Indian (Punjab)	112	236	26.69±1.74	29.51±1.97	35.17±3.17	35.70±3.16
Arora et al ^[24]	UP, Agra	200	100	28.15±2.32	27.6±2.56	32.85±3.66	33.3±3.79
Jit I & Sahni D ^[16]	North Indian (Chandigarh)	280	80	30.40±2.40	30.00±2.80	36.20±3.50	35.90±
Kaur H ^[17]	North Indian (Chandigarh, Haryana)	252	748	31.05±2.52	30.87±2.48	36.54±3.31	35.54±3.31
Sayee R et al ^[18]	South Indian (Karnataka, Bangalore)	256 pairs		32.00±4.00	35.00±4.00	37.00±3.00	37.00±3.00
Kaur K ^[19]	North Indian (Punjab)	200	200	35±3.58	38.00±4.04	36±3.02	36.78±4.00
Makandar UK & Kulkarni P.R ^[21]	South Indian (Karnataka, Devangere)	196	137	22.17±2.09	22.00±2.00	25.45±2.19	25.61±2.50
Makandar UK & Kulkarni P.R ^[23]	South Indian	90	70	31.00±2.9	30±3.0	37.00±3.5	36.00±3.7
Present study	North Indian	300	300	32.14±3.99	29.74±4.09	37.95±3.21	36.59±2.94

values were reported in Amritsar zone^[12], Varanasi^[13] and in Agra zone^[24].

Highly significant gender specific statistical difference was found to exist for midclavicular circumference of clavicle which is in consonance with studies done by all authors mentioned in (Table 6). The results indicate that there exists a definite statistically significant dimorphic significance for midclavicular circumference of clavicle.

There is no side specific significant difference found in present study for midclavicular circumference in males which is in accordance to the studies done by all authors in (Table 6). When the values for midclavicular circumference for right and left sides as measured for the females were compared they were found to be statistically significant. This could be attributable to right/left handedness or preference of limb use by particular individuals.

5. Conclusions

The present study establishes the dimorphic potential of length, midclavicular circumference and weight

of clavicle. The morphometric values of these three parameters used in combination will definitely aid in determination of sex from the clavicle. Thus, the clavicle can be a valuable adjunct for sex estimation of unknown skeletal remains found at crime scene or mass disaster sites. The present study findings are expected to help not only the anatomists but also the orthopedic surgeons and forensic anthropologists in their professional endeavors. The morphometric profile established for North Indians is also expected to assist in designing of more accurate clavicle fixation devices. The bone clavicle exhibits sexual dimorphism and bilateral asymmetry. The clavicle possesses sex, side, activity and occupation dependent osteological variations in its morphological profile and these features need to be considered while carried out forensic, anthropological and clinical (orthopedic or anatomical) examinations using this bone.

6. References

- Schrawat JS, Pathak RK. Variability in anatomical features of human clavicle: Its forensic anthropological and clinical

- significance. *Trans Rec in Anat.* 2016; 3(4):5-14. <https://doi.org/10.1016/j.tria.2016.08.001>
2. Thulasi SM, Kumari CRV, Kumar KV, Indira MV. Clavicle, a tool for sex determination- A study in South Indians. *IOSR- JDMS.* 2017 Feb; 16(2):54-8. <https://doi.org/10.9790/0853-1602045458>
 3. Cardoso HF. Age estimation of adolescent and young adult male and female skeletons II, epiphyseal union at the upper limb and scapular girdle in a modern Portuguese skeletal sample. *Am J phys Anthropol.* 2008; 20-21. <https://doi.org/10.1002/ajpa.20850> PMID:18553494
 4. Treble NJ. Normal variations in radiographs of clavicle Brief report. *J Bone Joint Surg.* 1988; 70B:490-9. <https://doi.org/10.1302/0301-620X.70B3.3372581>
 5. Kewal K. Anthropometry in forensic medicine and forensic science. *Int J Forensic.* 2007; 2(1). <https://doi.org/10.5580/1dce>
 6. Armitage P. In statistical methods in Medical research Oxford. Blackwell. 1971; 332-5.
 7. Parikh MN, Gogtay N, Arulkumaran S, Sathyanarayan K. Applied biostatistics. ABC of Research and Methodology and Applied Biostatistics. A primer for clinicians. 1st ed. Jaypee Brothers Medical Publishers; 2009. p. 45-70. https://doi.org/10.5005/jp/books/10026_7
 8. Parson FG. On the propotions of characteristics of the Modern English clavicle. *J of Anat.* 1916; 51:71-93.
 9. Terry RJ. The clavicle of the American Negroes. *Am J of Phys Anthropol.* 1932; 16:351-80. <https://doi.org/10.1002/ajpa.1330160315>
 10. Olivier G. Anthropologie de la clavicle III la societe D Anthropologic Paris 2, 10e series; 1951. p. 121-57. <https://doi.org/10.3406/bmsap.1951.2889>
 11. Doengen RV. The shoulder girdle and humerus of Australian, Arborgine. *Am J of phys Anthropol.* 1963; 21(4):469-8. <https://doi.org/10.1002/ajpa.1330210405>
 12. Jit I, Singh S. The sexing of adult clavicles. *Ind J of Med Res.* 1966; 54:551-7.
 13. Singh S, Gangrade KC. The sexing of adult clavicles demarking points for Varanasi zone. *J of Anatsoc of In.* 1968b; 17:89-100.
 14. Singh S, Gangrade KC. The sexing of adult clavicles-verifications and applicability of the demarking points. *J of Ind Academy of Forensic Sci.* 1968b; 17:89-100.
 15. Singh S, Jit I, Singh SP, Gangrade KC. Identification of sex from the skeletal remains. *Bulletin Institute of Medical Sciences Banaras Hindu University.* 1972; 3:65-75.
 16. Jit I, Sahni D. Sexing the North Indian clavicles. *J of Anat Soc of India.* 1983; 32(2):61-72.
 17. Kaur H. A study of human clavicle [PhD thesis]. Chandigarh: Punjab University; 1989.
 18. Sayee R, Jana Kirans, Rajangam RK, Thomas IM. A metrical study. *J Ind Acad of Forensic Sci.* 1992; 31:24-9.
 19. Kaur K, Sidhu SS, Kaushal Sand Kaur B. Sexing the Northwest Indian adult clavicles of patiala zone [Thesis done in Govt]. Patiala: Medical College; 1997.
 20. Kaur H, Sahni D, Jit I. Length and curve of clavicle in Northwest Indians. *J of Anat Soc Ind.* 2002; 51(2):199-209.
 21. Makandar UK, Kulkarni PR. Sexual diamorphism of adult clavicle [Thesis]. Bijapur: AI- Ameen Medical college; 2007.
 22. Andermahr J, Jubel A, Elsner A, Johann J, Prokop A, Rehm KE et al. Anatomy of clavicle and intramedullary nailing of midclavicular fractures. *Clin Anat.* 2007; 20(1):48-56. <https://doi.org/10.1002/ca.20269> PMID:16506232
 23. Makandar UK, Kulkarni PR. Identification of sex and race from "Adult Clavicle" (South Karnataka); 2009. p. 1-18.
 24. Arora AK, Gupta CS, Jaeyesingh P, Gupta CD, Maheshwari BB. Identification of sex from adult clavicle. *J of Ind Acad of Forensic Sci.* 1978; 20:41-5.

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