



MORPHOMETRIC ANALYSIS OF CLAVICULAR ANGLES AND ITS VARIATIONS IN NIGERIAN POPULATION: APPLICATION AND IMPORTANCE

*¹Benwoke Ihunwo IW

¹Department of Human Anatom, PAMO University of Medical Sciences, Port Harcourt, Rivers State.

*Corresponding Author: Dr. Benwoke Ihunwo IW

Department of Human Anatom, PAMO University of Medical Sciences, Port Harcourt, Rivers State.

Article Received on 15/08/2018

Article Revised on 05/09/2018

Article Accepted on 26/09/2018

ABSTRACT

The dependence of morphometric values of human parts is very vital in the construction, replacement and treatment of affected parts, be it bone or soft tissues. The purpose of this study was to scientifically analyze the clavicular angles and to further evaluate its applications in event of fractures, dislocations or diseases. Clavicular angles were evaluated using a total of 40 clavicle (25 males and 15 females), extracted from adult human bodies, which were all macerated and dried. These clavicles were sourced from the Anatomy Department of various Universities in South-South and South-Eastern region of Nigeria. Degraded, deformed fractured clavicles with associated tumors were excluded. The clavicular angles (medial, lateral and total angle) were Measure with pencil, protractor, paper and metric rule, the angles were measured in degrees. The data were analyzed using statistical package for social sciences (IBM^(R) version 23 SPSS, Inc, Chicago, IL). Confidence interval was set at 95% and $p \leq 0.005$ was considered significant. The result showed that the (medial angle) for male right clavicle was $150.52 \pm 6.92^\circ$ and left was $148.72 \pm 6.96^\circ$, while that of female right clavicle was $134.13 \pm 7.84^\circ$ and $134.67 \pm 6.89^\circ$. The lateral angle for male right clavicle was $145.92 \pm 5.74^\circ$ and left was $148.16 \pm 5.47^\circ$, while that of female right clavicle was $136.53 \pm 7.85^\circ$ and that of left clavicle was $138.80 \pm 7.80^\circ$. The total angle for male right clavicle was $296.44 \pm 11.98^\circ$ and that of left was $296.88 \pm 11.31^\circ$, while the total angle for female right clavicle was $270.67 \pm 15.66^\circ$ And of left was $273.47 \pm 14.64^\circ$. The clavicular angle (medial, lateral and total angle) showed statistical difference with varying correlating values for males and females ($p < 0.001$). This study has provided morphometric data base of the clavicular angles of the Nigerian population which could be a useful guide to orthopedic- implant manufacturer and orthopedic surgeons in determining the correct size and shape of plates and intramedullary nails in treatment of clavicular fracture.

KEY WORDS: Clavicle, morphometric, medial angle lateral angle total angle, statistical difference.

INTRODUCTION

The clavicle (collar bone) as bony structure is a long curved somehow like the phonetic symbol “j” when in the horizontal position.^[1] It has a shaft and two ends (Sternal and Acromial), It is known to be the most frequently fractured bone in the body.^{[2] [3]} Clavicular angles variations have been observed in different populations and individuals, these differences are also found in males and females.it most times very pronounced in curvatures, thickness, length, and weight of the clavicle.^[4, 5, 6, 7] Good knowledge of clavicular osteometry prior to surgery is essential and applicable in operative management of clavicular fracture.^{[8] [9] [10]} Scientific information on the clavicular data are required to enhance the choice of devices and to further minimize the episode of complications and failures during surgery^[10] research has shown that the clavicle is thicker and more prominently curved in males than females,

therefore the present study is carried out to evaluate the variations in clavicular angles in Nigerian populations and to further asses some of its applications in the management of clavicular fracture. Scientific information on variations of clavicular angles has been beneficial to orthopedic surgeon in intramedullary nailing and clavicular fracture management.

MATERIALS AND METHODS

A total of 40 clavicles extracted from adult human bodies of known sex (25 males and 15 females) of right and left clavicles were sourced from Anatomy Departments of the following Universities, University of Port Harcourt Rivers State, Igbinedion University, Okada, Ambros Ali University Ekpoma Edo State and Nnamdi Azikiwe University, Akwa, Anambra State. Selections were specifically bodies ascertained to be adult with age ranging from 25-70 years; clavicles with complete

ossification, normal morphology were included in the present study. Bone showing deformity, degradation and fracture were excluded. The material used included; pencil, metric rule, protractor and paper.

Medial and lateral angles of the clavicle

The angles of clavicles were measured in degrees with the help of protractor. To measure the angles, a tracing of the bone was made from its superior aspect. Care was taken to ensure the same orientation in all bones. The

midpoint of both ends of sternal and acromial was located and connected by a line (straight). The mid axis of the tracing was made. Then the two (medial and lateral) angles were constructed to fit the curves of the mid axis at its greatest convexities and at that point of intersection with a protractor.

Total angle

The total angle was the sum of the medial and lateral angles of that clavicle. ^[5, 7, 13]

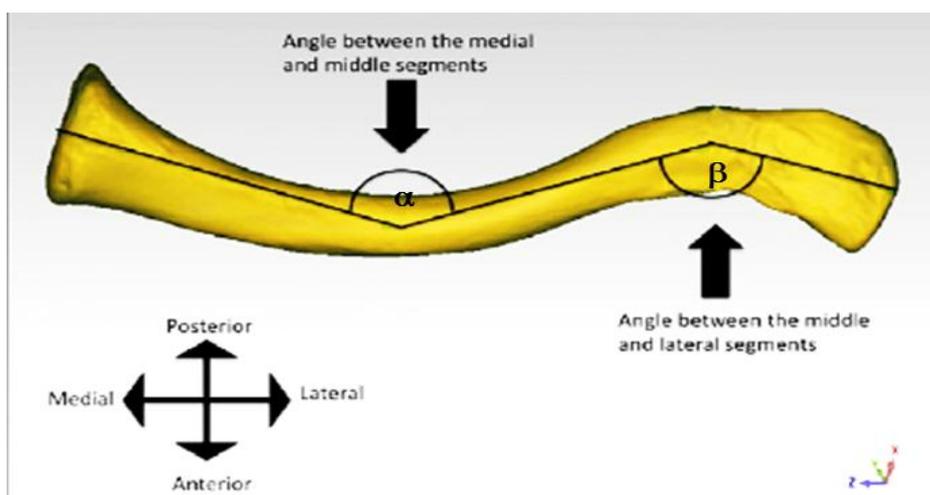


Fig. 1: measurement of the clavicular Angles (medial. Lateral, and total angle).

Data Analysis

The statistical analysis was performed using SPSS (IBM) ® Version 23.0; SPSS, Inc., Chicago, IL) and XLSTAT (Version 2015) Statistical packages. Continuous Variables were presented in mean (S.D). Paired sample t-test was used for side comparison while student t-test was used to determine sex-differences. Confidence interval was set at 95% with significance of the difference accepted at $P \leq 0.05$.

RESULTS

The results presented were measurements of the clavicular angles, tables were used to represent and compare mean values for the males and females clavicles. The descriptive characteristics and comparison of sex, side differences in the mean values were presented in Tables 1-3. Table 4 shows comparison of mean values (variations) in the present study with other studies.

Medial angle: The mean \pm (S.D) values obtained for right and left clavicles were $150.52 \pm 6.92^\circ$ and $148.72 \pm 6.96^\circ$ for males (M), while that of females (M) right clavicle was $134.13 \pm 7.84^\circ$ and $134.67 \pm 6.89^\circ$ respectively.

Lateral angle: The mean \pm (S.D) values obtained for right and left clavicles were $145.92 \pm 5.74^\circ$ and $148.16 \pm 5.47^\circ$ for males (M) while that of female (F)

right clavicle was $136.53 \pm 7.85^\circ$ and left clavicle was $138.80 \pm 7.80^\circ$ Total angle: The mean \pm (S.D) values obtained for right and left clavicles were $296.44 \pm 11.98^\circ$ and $296.88 \pm 11.31^\circ$ for males (M), while that of female (F) right clavicle were $270.67 \pm 15.66^\circ$ and $273.47 \pm 14.64^\circ$, (Table1).

The angles (medial, lateral, and total angle) of the right and left clavicles were highly significant. All males (M) values for the tested angles were significant ($p < 0.001$). The tested angles for the female clavicles was also significant with ($p < 0.001$) (Table1). The difference between the right(R) and the left (L) side of the angles of the clavicles were all significant in the males for medial and lateral angle ($t=6.803, p < 0.001$) and ($t=-5.527, p < 0.001$) except for the total angles of male clavicles where there was no significant difference ($t=-0.945, p=0.399$). For the females the difference between the right and left side of the clavicles (angles) were also significant for lateral and total angles ($t=-4.279, p < 0.001$) and ($t=-2.733, p=0.0016$), except for the medial angles of the female clavicles where there was also no significant difference between the side (Table2).The t-test for sex difference showed that all the male values were significantly higher than the females ($p < 0.001$) (Table3).

Table 1: Side difference evaluation using paired sample t-test.

Parameters	Total (N=40)				Male (N=25)				Female (N=15)			
	Mean	S.D	t-value	P-value	Mean	S.D	t-value	P-value	Mean	S.D	t-value	P-value
R. Vs L Medial angle (°)	3.04	8.97	2.395	0.020 (S)	1.8	1.32	6.803	<0.001 (S)	-0.53	2.26	-0.913	0.377 (NS)
R. Vs L Lateral angle (°)	-5.92	8.98	-4.661	<0.001 (S)	-2.24	2.03	-5.527	<0.001 (S)	-2.27	2.05	-4.279	0.001 (S)
R. Vs L Total angle (°)	-1.98	16.47	-0.850	0.399 (NS)	-0.44	2.33	-0.945	0.399 (NS)	-2.8	3.97	-2.733	0.016 (S)

Note: R= Right, L=left, N= distribution, S.D= Standard deviation, r= Pearson's correlation, P-value= probability value, inf= inference (S= significant, NS= not significant).

Table 2: Descriptive characteristics and inter-predictability of the clavicle (side).

Parameters	Total (N=40)			Male (N=25)			Female (N=15)		
	Mean±S.D	r	P-value (Inf.)	Mean±S.D	r	P-value (Inf.)	Mean±S.D	R	P-value (Inf.)
R. Medial angle (°)	144.94±11.39	0.673	<0.001 (S)	150.52±6.92	0.982	<0.001 (S)	134.13±7.84	0.961	<0.001 (S)
L. Medial angle (°)	141.90±10.75			148.72±6.96			134.67±6.89		
R. Lateral angle (°)	142.26±7.93	0.548	<0.001 (S)	145.92±5.74	0.936	<0.001 (S)	136.53±7.85	0.966	<0.001 (S)
L. Lateral angle (°)	148.18±10.40			148.16±5.47			138.80±7.80		
R. Total angle (°)	288.12±19.86	0.669	<0.001 (S)	296.44±11.98	0.982	<0.001 (S)	270.67±15.66	0.968	<0.001 (S)
L. Total angle (°)	290.10±20.62			296.88±11.31			273.47±14.64		

Note: F-value = Fisher's calculated value, EVA = Equal variance assumed, Inf. = Inference, EVNA = Equal variance not assumed, df = degree of freedom, t-value = t-test calculated value, P-value = Probability value, M.D = Mean difference, S.E.D = Standard error of the difference, C.I = Confidence interval, S = Significant, NS = Not Significant.

Table 3a: Evaluation of the sex difference in right clavicular parameters using student t-test (cadaveric measurement).

Parameter	Levene's Test for Equality of Variances			t-test for Equality of Means					
	F-value	P-value	Inf	df	M.D	S.E.D	t-value	P-value	Inf.
R. Medial angle (°)	0.525	0.473	ENA	38	16.39	2.38	6.899	<0.001	S
R. Lateral angle (°)	3.637	0.064	ENA	38	9.39	2.15	4.360	<0.001	S
R. Total angle (°)	2.486	0.123	ENA	38	25.77	4.39	5.867	<0.001	S

Table 3b: Evaluation of the sex difference in left clavicular parameters using student t-test (cadaveric measurement).

Parameter	Levene's Test for Equality of Variances			t-test for Equality of Means					
	F-value	P-value	Inf.	df	M.D	S.E.D	t-value	P-value	Inf.
L. Medial angle (°)	0.009	0.925	ENA	38	14.05	2.27	6.203	<0.001	S
L. Lateral angle (°)	4.351	0.044	EVNA	22.354	9.36	2.29	4.082	<0.001	S
L. Total angle (°)	2.482	0.123	ENA	38	23.41	4.13	5.670	<0.001	S

Note: F-value = Fisher's calculated value, EVA = Equal variance assumed, Inf. = Inference, EVNA = Equal variance not assumed, df = degree of freedom, t-value = t-test calculated value, P-value = Probability value, M.D = Mean difference, S.E.D = Standard error of the difference, Inf = Inference (S = Significant, NS = Not Significant).

Table 4: Comparison of mean angles for male and female clavicle in the present study with other studies (in degrees).

Authors	Population	Side	Medial Angle		Lateral Angle			Total Angle	
			Male	Female	Male	Female	Male	Female	
Parsons (1916)	English	R	153.00	155.00	148.00	150.00	-	-	
		L	153.00	155.00	148.00	151.00	-	-	
Olivier (1951)	France	R	150.20	151.00	141.80	143.00	-	-	
		L	151.40	-	143.00	-	-	-	
Kaur <i>et al.</i> (2002)	India	R	150.76	152.4	143.27	144.65	293.08	297.06	
		L	150.94	152.82	148.20	148.73	298.04	301.31	
Shobha (2010)	India North Karanataka	R	151.54	149.47	147.62	142.43	229.15	291.90	
		L	150.89	149.15	152.63	145.53	303.52	294.68	
Ishwarkumar <i>et al.</i> (2016)	South Africa	R	151.20	152.10	148.00	150.30	-	-	
		L	151.20	153.70	152.40	147.67	-	-	
Present study	Nigeria	R	150.52	134.13	145.92	136.53	296.44	270.67	
		L	148.72	134.67	148.16	138.80	296.88	273.47	

DISCUSSION

There has been a paucity of scientific data in clavicular angles in Nigerian populations which has adversely affected the diagnosis and treatment of clavicular pathology among Nigerians. There is documented evidence of racial variations in clavicular parameters.^[4, 5, 6, 7] This poses a great challenge to Nigerian orthopedic surgeons who undertake clavicular surgeries and treatment with poor knowledge of clavicular variations.

The medial angle in the present study showed that the mean value for the male right clavicle was 150.52°. This was slightly lower than the values obtained by Ishwarkumar *et al.* (151.20°)^[12], Shobha (151.54°) Kaur *et al.* (150.76°)^[7] and Parson (153.00°)^[13].^[12, 5, 7, 13] It was slightly higher than the value obtained by Olivier (150.20°).^[4] The mean value for female right medial angle in this study was found to be 134.13°, this was lower than the values obtained by Ishwarkumar *et al.*^[12] (152.10°), Kaur *et al.*^[7] (152.61°), Shobha^[5] (149.47°), Olivier^[4] (151.00°), Parson^[13] (155.00°). The mean value for left medial angle in this study was found to be 148.72° for males. This was lower than the values of Shobha (150.89°)^[5], Kaur *et al.* (150.94°)^[7], Ishwarkumar *et al.* (153.70°)^[12] Olivier (151.40°)^[4] and Parson (153.00°).^[13] For the female left medial angle the mean value in the present study was 134.67°. This was lower than the values obtained by Shobha (149.15°)^[5] Kaur *et al.* (152.82°)^[7], Ishwarkumar *et al.* (152.70°)^[12] and Parson (155.00°).^[13] The reason for the differences cannot be easily explained, but might be due to genetic and other environmental factors. From the present study it was observed that the mean medial angle for male clavicles were greater than that of the females, this difference was also statistically significant for sex determination. This agrees with the finding of Shobha but differs from Kaur *et al.* and Ishwarkumar *et al.*,^[7, 12] where the medial angles for the female clavicle were found to be greater than that of the male.

The lateral angle in the present study showed that the mean value for male right clavicle was 145.92°. This

was slightly lower than the findings of Shobha (147.62°)^[5], Ishwarkumar *et al.* (148.00°)^[12], Parson (148.00°)^[13] but was higher than Kaur *et al.* (143.29°)^[7] and Olivier (141.80°). [5, 12, 13, 7, 4] The mean value of the female Right lateral angle was 136.53° which was lower than the findings of Shobha (145.64°)^[5], Kaur *et al.* (145.65°)^[7], Ishwarkumar *et al.* (150.30°)^[12] Olivier (143.00°)^[4], Parson (150.00°)^[13].^[5, 7, 12, 4, 13] The mean value of the lateral angle for the male left clavicle in the present study was 148.16°. This is lower than the finding of Kaur *et al.* (148.20°)^[7], Shobha (152.63°)^[5], and Ishwarkumar *et al.* (152.40°) but higher than the values obtained by Olivier (143.00°)^[4], Parson (148.00°).^[13] The present study showed a mean lateral angle of 138.80° for female left clavicle which was lower than Shobha, (145.53°)^[5], Kaur *et al.* (148.73°)^[7] and Ishwarkumar *et al.* (147.67°)^[12], Parson (151.00°).^[13] The present study revealed that the left lateral angle was greater than the right lateral angle for both sexes, this was similar to the results from Shobha and Kaur *et al.* However Ishwarkumar *et al.* found that for the female clavicle the lateral angle of the right side was greater than the left lateral angle. The difference observed in the values of the female lateral angle in the present study (Nigeria) with other studies cannot be easily explained but can be attributed to genetic, nutritional and environmental factors.

Shobha^[5] calculated the total angle for male and female clavicles and concluded that the total angle for males were greater than that of females on both sides. This is in line with the findings in the present study that the total angle of male clavicle: (Right 294.441°, left 296.88°) was greater than that of the females (Right = 270.67°, left = 273.47°). On the contrary Kaur *et al.*^[7] working in the Indian population found that the total angle for female clavicle: (Right = 297.06°, left 301.31°) were greater than the males (Right 293.08°, left 298.04°). The study observed that the left total angle was greater than the right total angle for both sexes. This confirms the findings of Shobha and Kaur *et al.*^[5, 7] The clavicle has been found to fracture easily as the junction between the

lateral and intermediate thirds therefore proper study of angles of clavicle and its osteometry is necessary for surgical intervention. In depth knowledge of clavicular Angles variations will aid in the application of specific devices for clavicular fixation and clavicular prosthesis. It will also promote the development of cutting edge techniques for designing screws, nails, plates for immobilization of clavicular fractures. Extensive evaluation of the clavicular angle will reduce clavicular incompatibility of implants and also minimize post-operative complications and failure rates.^[6]

CONCLUSIONS

Differences in clavicular angles are obvious in diverse races or population. Good knowledge of clavicular osteometry and variations in angles is required for surgical intervention and in designs of clavicular implant materials and other accessories used by orthopedic surgeons.

ACKNOWLEDGMENTS

The author acknowledges numerous aid received from the author, editors and the publishers of all those articles, journals and books where the literature for this article has been discussed. Author thankfully acknowledges all the institutions visited in course of the research, members of teaching and non-teaching staff for their support and cooperation.

REFERENCES

1. Ellis, H. Clinical Anatomy. Clinical Anatomy and Applied Anatomy for Student 11th Edition Oxford, Blackwell Publishers, 2006; 168-169.
2. Standring Susan. Gray's anatomy, the anatomical basis of clinical practice, 40th ed. Churchill Livingstone, Elsevier, 2008; 791-792.
3. Chris. Clavicle (Human Collar bone) Anatomy Parts, Location and Functions. Available at www.headthhype.com, 2016
4. Olivier G. Anthropologic de la clavicula III La clavicule du Français. *Bull soc Anthropol*, 1951; 2:121-157, 1951
5. Shobha. Determination of Sex of Adult human clavicle by Morphometric Parameters; Department of anatomy medical college Davangere-57704, karnataka, 2010; 32-41.
6. Patel, J.P. Shah, R.K. Merchant, S.P. Nirvan, A.B., and Shah, G.V. Sexing of the human adult clavicle in Gujarat zone. *Gujrat Medical Journal*. 2009; 2: 40-46.
7. Kaur, H., Harjeet, Sahni, D., and Jit, I. Length and curves of the Clavicle in Northwest Indians. *Journal of Anatomical Society of India* 2002; (51)2: 199-209.
8. Banerjee R, Waterman B, Padalecki J, Robertson W, Management of distal Clavicle Fractures. *JAM Acad orthop*, 2011; 19: 392-401.
9. Mathieu, P., Marchei, P., Hummel, V., (2014). Anatomical study of the Clavicle :Endomedullary Morphology. *Surg Radio Anat* 2014; 36: 11. doi:10.1007/00276-013-1140-2.
10. Gopalakrishna, K., and Rathna B.S. Variability of length and osteometrical study of human clavicle and its applied importance. *Sch. Acad J. Biosci* 2015; 3(9): 814-820.
11. Nagarchi, K. Pillai J., Saheb, S.H, Brekeit, K. and Alharbi, M. Morphometry of clavicle. *Journal of Pharmaceutical sciences and Research*, 2014; 6(2): 112-114.
12. Ishwarkumar, S., Pillay, P., Haffajee, M.R., and Rennie, C. Sex Determination using Morphometric and Morphological Dimensions of the Clavicle within the Kwazulu-Natal population. *International Journal of Morphology* 2016; 34(1): 244-251.
13. Parsons, F.G. On the proportions and characteristics of the modern English clavicle. *Journal of Anatomy*, 1916; 51: 71-93.