A Morphological and Morphometric Study on Curvatures of Clavicle

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Abstract

Introduction: The clavicle is subcutaneous throughout its length and makes a prominent aesthetic contribution to the contour of the neck and upper chest. The use of clavicular curvature analysis offers a new dimension in assessment of the functional morphology of the clavicle and its relationship to the shoulder complex. **Objectives:** The present study was done to determine gender and side specific variations in the medial angle, lateral angle, anterior lateral length and height, index of curvature and sinuosity of the clavicle. **Material and Method:** 300 pairs (600 clavicles) of known sex adult clavicles were obtained from cadaveric dissection and bony collections of anatomy department. The medial and lateral angle, anterior lateral curve height and length were measured. Also, index of curvature and sinuosity were calculated. The data obtained was statistically analysed. **Results:** There exists a statistically significant gender specific variation for index of curvature, anterior lateral curve length and height and index of sinuosity whereas medial and lateral angle values were found to be statistically insignificant. **Conclusions:** The study establishes morphometric criterion for clavicular curvatures in North Indians and compares observations with other populations giving a special emphasis on influence of sex factor. The curvatures should be taken in to account while performing clinical procedure like intramedullary fixation and plate fixation of fractures.

Keywords: Clavicle, Curvature, Morphometricde

1. Introduction

The clavicle is highly variable in shape and exhibits dramatic variation in both curvature and cross-sectional geometry along its length. Being subcutaneous clavicle is easily examinable and presents a tempting target for biopsy.[1] The variations in clavicle morphology should also be taken in to account while performing clinical procedures. The clavicle is the most frequently fractured bone of the human skeleton. 70-80% fractures occur at middle third of shaft of bone. Recent literature has described that 10 to 30% of patients treated non-operatively develop unsatisfactory outcome clinically, radiologically and subjectively.[2]

The procedure of intramedullary fixation is being used increasingly to treat clavicular fractures. The main difficulties encountered when placing a nail are secondary to the S-curvature of the clavicle.[3] The clavicle displays definite gender and side specific anatomical features in term of curvature which should be considered when performing intramedullary fixation. The same is true for management of clavicular fractures.[4] In the present study a special emphasis has given to the curvature of the clavicles and the associated applied implications.

2. Materials and Methods

The material for present study consisted of 600 clavicles (300 pairs, 150 males and 150 females) obtained from department of Anatomy, Govt. Medical College, Amritsar. Prior ethical approval was duly taken from the ethical committee established at Govt. Medical College,

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Amritsar. The bones were dried, macerated, cleaned and observed for any physical deformity. A Vernier caliper (with least count of 0.02mm) was used to measure length, breath and height. Scales and protractor were used for quantifying curvatures and angle of clavicle. A cotton thread was utilized to measure curved length. The morphometric features of clavicles were obtained and recorded. The measurement procedure for medial angle, lateral angle shown in (Figure 1 to 4). The measurement procedure for length and height of anterior lateral curve is shown in (Figure 5 and 6).

The index of curvature was calculated as the sum of medial and lateral angles. The index of sinuosity was determined by the formula.

Index of sinuosity = length of anterior lateral curve/ Height of anterior lateral curve

The values of parameters calculated by different methods analyzed statistically. Mean, standard deviation, standard error of mean, range variance and 95% confidence interval, 'p value' have been calculated for all the measurements. T-test is applied to assess the significance of difference between the various measurements of clavicles of both side and in both genders[5,6].

Figure 1. Showing different measurement points on clavicle (a, b, c and d).
a: Midpoint at sternal end; b: Midpoint at acromial end; c: Point on maximum convexity on medial 2/3rd; d: Point on maximum convexity on lateral 1/3rd

Figure 2. Showing measurement of lateral and medial angles.
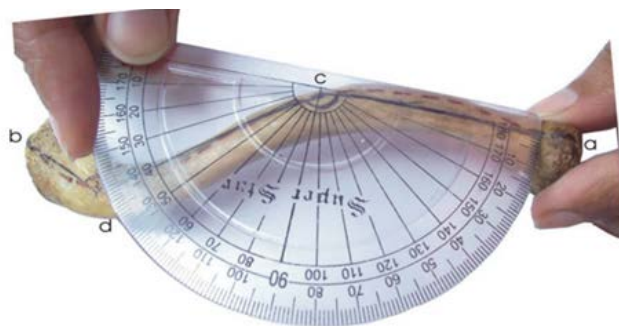Angle cdb = Lateral angle; Angle acd = Medial angle

Figure 3. Shows measurement of medial angle.
Angle acd: Medial angle

Figure 4. Shows measurement of lateral angle.
Angle cdb: Lateral angle

Figure 5. AB: Length of anterior lateral curve.

Figure 6. EF: height of anterior lateral curve.

3. Observations

In present study it was observed that there exists a definite gender and side specific statistically insignificant difference (p > 0.05) found for medial and lateral angle of clavicle. Female clavicle were more curved than male clavicle (Table 1 & 3 respectively). Side specific difference was found insignificant (p > 0.05). Gender specific statistical analysis for index of curvature of clavicle found significant (p < 0.05). Side specific difference was found insignificant (p>0.05) (Table 5). Gender specific statistical difference was found highly significant for anterior lateral curve length and height for left and right side respectively. Side specific statistical difference was found insignificant for both the cases (Table 7 & 8). Index of sinuosity was found highly significant for gender specific difference. Side specific statistical difference was found for male only (p < 0.05) (Table 9).

4. Discussion

The present study establishes the morphometric criteria for clavicular curvature in North Indian population. The medial and lateral angles, index of curvature, height and length of anterior lateral curve and index of sinuosity were determined. For each parameter Mean ± standard Deviation, Standard error of mean, Range, variance and 95% confidence interval values were calculated. The measurements for each parameter as measured in males and females were then compared and statistically analysed. The results were also compared with reference values for other populations available in literature.

5. Medial Angle of Clavicle

The medial angle values as measured for right and left sides for the same sex were compared and were found to be

Table 1. Medial angle values and their statistical significance

Sex	Side	No	Mean±SD	SEM	Range (Difference between max and min value)	Variance	95% Confidence interval	
							Lower bound	Upper bound
F	R	150	152.73±7.2	1.33	35.00	53.09	150.01	155.45
F	L	150	150.36±8.5	1.56	31.00	73.48	147.68	153.47
M	R	150	152.33±8.1	1.49	35.00	66.43	149.28	155.38
M	L	150	152.80±5.7	1.06	25.00	33.47	150.63	154.96
FL vs FR		t = 1.152		p = 0.25			NS	
ML vs MR		t = 0.256		p = 0.80			NS	
ML vs MR		t = 1.289		p = 0.20			NS	
FL vs ML		t = 0.20		P=0.84			NS	

NS: not significant S: significant HS: highly significant

Table 2. Medial angle measurements by different authors

Authors	Population	Total No.		Mean ± SD			
		Male	Female	Right female	Left female	Right male	Left male
Parson F.G [7]	English	50	50	155	155	153	153
Terry R [8]	American Negroes and whites	50	50	151.12	153.52	153.52	151.58
Olivier [9]	French	60	110	151.00	150.00	150.00	151.40
Kaur H [10]	North Indian (Chandigarh)	252	748	152.61	152.65	150.76	150.94
Kaur K [11]	North Indian (Punjab)	200	200	151.76	151.03	150.46	150.79
Kaur H et al [12]	North Indian (Chandigarh)	748	252	154.82±2.40	154± 3.77	152.50± 3.09	152.35± 2.31
Makander UK et al & Kulkarni PR [13]	South Indian	90	70	153.1	153.1	153.00	152.05
Present study (2018)	North Indian	300	300	152.73±7.29	150.36±8.57	152.33±8.15	152.80±5.78

statistically insignificant (p>0.05), When the medial angle values for the same side as measured in males and females were compared, they were again found to be statistically insignificant (p>0.05). This establishes that there exists no statistically significant sexual dimorphism for medial angle measurements in North Indians (Table 2).

Our values for medial angle of the clavicle were comparable to values observed in French[9], Americans[8] and in North Indians[10,11]. Values of medial angle higher than in present study were observed in Chandigarh population[12], South Indians[13] and in English[7] subjects.

Gender specific statistical difference was found insignificant in case of medial angle of clavicle which is in consonance with studies done in South Indians[13] whereas these results are in contrast with studies. Gender specific statistically significant dimorphism was found

to exist for medial angle in studies done in Chandigarh population[10], North Indians[12] and Americans.[8] This is in contrast to the findings in our sample (Table 2).

The medial angle values as measured for right and left sides for the same sex were compared and were found to be statistically insignificant in our study and this finding is in consonance with the work done om French[9] and North Indians[10] clavicles. Contrary results were obtained in a study on American clavicles[8] (Table 2). This could be attributable to right/left handedness of individuals and also preference of limb use by particular individuals.

6. Lateral Angle of Clavicle

The lateral angle values as measured for right and left sides for the same sex were compared and were found to be

Table 3. Lateral angle values and their statistical significance

Sex	Side	No	Mean±SD	SEM	Range (Difference between max and min)	Variance	95% Confidence interval	
							Lower bound	Upper bound
F	R	150	142.62±10.10	1.84	46.00	102.10	138.86	146.41
F	L	150	139.10±10.4	1.91	38.00	110.02	135.18	143.01
M	R	150	145.00±9.0	1.66	35.00	82.41	141.61	148.39
M	L	150	145.13±9.0	1.65	37.00	82.12	141.74	148.52
FL vs FR		t= 1.32		p= 0.18			NS	
ML vs MR		t= 0.05		p= 0.95			NS	
FL vs ML		t= 2.38		p= 0.02			NS	
FR vs MR		t= 0.95		p= 0.34			NS	

NS: Not significant S: significant HS: Highly significant

Table 4. Lateral angle measurements by different authors

Authors	populations	Total No.		Mean±SD			
		Male	Female	Right female	Left female	Right male	Left male
Parson F.G [7]	English	50	50	150.00	151.00	147.00	148.00
Terry RJ [8]	American Negroes and whites	50	50	144.06	145.82	138.42	143.54
Olivier [9]	French	60	110	145.00	144.00	141.80	143.00
Kaur H [10]	North Indian Chandigarh	252	748	144.65	148.73	143.27	148.20
Kaur K [11]	North Indian (Patiala)	200	200	142.00±9.9	140.00±10.10	144.00±9.08	145.00±9.00
Kaur H et al [12]	North Indian (Chandigarh)	748	252	145.22±5.59	152.22±7.81	142.93±9.65	150.87±8.62
Markander UK & Kulkarni PR [13]	South Indian	90	70	142.00±11.1	144.00±11.00	141.00±11.3	141.00±11.9
Present study (2018)	North Indian	300	300	142.63±10.10	139.10±10.49	145.00±9.08	145.13±9.06

statistically insignificant (p>0.05), When the lateral angle values for the same side as measured in males and females were compared, they were again found to be statistically insignificant (p>0.05). This establishes that there exists no statistically significant sexual dimorphism for lateral angle measurements in North Indians (Table 4).

The mean values for lateral angle of clavicle in present study are comparable to values observed in South Indians[13] and in North Indians[11]. Mean values higher than for the present study was observed in Chandigarh population[12], French[44], American[8] and in English[7] (Table 4).

Gender specific statistical difference is found insignificant incase of lateral angle of clavicle which is in consonance with studies done in South Indians[13] and North Indians[12] (Table 4). There exists a side specific statistically insignificant difference in present study for lateral angle of clavicle which in accordance to studies done in French[9], North Indians[10,11] and Chandigarh population.[12]

7. Index of Curvature

The gender specific statistical analysis for index of curvature of clavicle was found to be significant (p<0.05).

The mean values for Index of Curvature of clavicle in our study are higher than values observed in Americans[8] and comparable to values observed in North Indians[11,12] and for Chandigarh population.[10] Significant gender specific statistical difference is found to exist in case of Index of Curvature of clavicle (p<0.05) which is in consonance with studies done in English,[7] Americans,[8] French[9], South Indians[13] and North Indians.[11,12] No side specific statistically significant difference was found to exist in present study for Index of Curvature of clavicle which is in accordance to studies done by all authors mentioned in (Table 6).

Table 5. Index of curvature values and their statistical significance

Sex	Side	No	Mean±SD	SEM	Range	Variance	95% Confidence interval	
							Lower bound	Upper bound
F	R	150	295.37±12.43	2.27	61.00	154.72	290.72	300.01
F	L	150	289.47±15.15	2.76	49.00	229.77	283.81	295.13
M	R	150	297.33±10.90	1.99	40.00	118.78	293.26	301.40
M	L	150	297.93±11.63	2.12	57.00	135.23	293.59	302.27
FL vs FR			t = 1.64		P = 0.10		NS	
ML vs MR			t = 0.21		P = 0.84		NS	
FL vs ML			t = 2.43		P = 0.01		S	
FR vs MR			t = 0.65		P = 0.04		S	

NS: Not significant S: Significant HS: Highly Significant

Table 6. Index of curvature measurements by different authors

Authors	Population	Total No		Mean±SD			
		Male	Female	Right female	Left female	Right male	Left male
Parson F.G [7]	English	50	50	305.00	306.00	300.00	301.00
Terry RJ [8]	American negro and white	50	50	293.88	297.90	292.00	294.94
Olivier [9]	French	60	110	296.50	296.50	292.00	294.94
Kaur H [10]	North Indian	748	252	297.06	301.31	293.98	298.64
Kaur K [11]	North indian	200	200	294.48±10.48	290.00±12.15	297.49±9.90	296.64±11.43
Kaur H et al [12]	North Indians	748	252	297.06±10.61	301.31±8.95	293.08±10.90	298.04±9.5
Markander UK & Kulkarni PR [13]	Karnataka	45	35	293.2±18.5	297.3±15.8	294.1±12.79	294.2±15.4
Present study (2018)	North Indian	300	300	295.37±12.43	289.47±15.15	297.33±10.90	297.93±11.63

8. Anterior Lateral Curve Length

When the mean values for length of anterior lateral curve as measured for males and females were compared they were found to be statistically significant for left side (P<0.05). No statistical significance was observed for the right side. This could be attributable to right/left handedness or preference of limb use by particular individuals[14]. No side specific significant difference was found to exist in present study for anterior lateral curve length of the clavicle (Table 7). No work has been done on measurements of anterior lateral curve length of clavicle, so no data is available for comparison with present study. Thus, the present study provides pioneer baseline data for comparison amongst different populations.

9. Height of Anterior Lateral Curve

When the mean values for length of anterior lateral curve as measured for males and females were compared, they were found to be statistically significant for right side (P<0.05). No statistical significance was observed for the left side. This could be attributable to right/left handedness of preference of limb use by particular individuals[14]. There was no side specific significant difference found in present study for anterior lateral curve height of the clavicle (Table 8).

No work has been done on measurements of anterior lateral curve height of clavicle, so no data is available for comparison with present study. Thus, the present study

Table 7. Anterior lateral curve length values and their statistical significance

Sex	Side	No	Mean±SD	SEM	Range (Difference between max and min value)	Variance	95% confidence interval	
							Lower Bound	Upper Bound
F	R	150	60.15±6.97	1.27	30.26	48.56	57.55	62.75
F	L	150	57.19±6.66	1.22	30.03	44.39	54.71	59.68
M	R	150	65.9±6.75	1.23	24.05	45.55	61.07	66.11
M	L	150	65.50±7.85	1.43	37.46	61.57	62.57	68.43
FL vs FR		t= 1.68		P= 0.09			NS	
ML vs MR		t=1.009		P= 0.31			NS	
FL vs ML		t= 4.41		P=0.00			HS	
FR vs MR		t= 1.94		P= 0.05			NS	

NS: Not Significant S: Significant HS: Highly Significant

Table 8. Height of anterior lateral curve values and their statistical significance

Sex	Side	No	Mean±SD	SEM	Range (Difference between max and min value)	Variance	95% Confidence interval	
							Lower Bound	Upper Bound
F	R	150	15.55±2.45	0.45	9.76	6.00	14.63	16.46
F	L	150	15.75±3.09	0.56	12.38	9.55	14.60	16.90
M	R	150	17.28±3.55	0.64	14.81	12.62	15.96	18.61
M	L	150	15.73±2.44	0.44	9.91	5.97	14.82	16.65
FL vs FR		t= 0.28		P= 0.77			NS	
ML vs MR		t= 1.97		P= 0.05			NS	
FL vs ML		t=0.02		P= 0.97			HS	
FR vs MR		t= 2.20		P= 0.03			S	

NS: Not Significant S: Significant HS: Highly Significant

Table 9. Index of sinousity values and their statistical significance

Sex	Side	No	Mean±SD	SEM	Range (Difference between max and min value)	Variance	95%confidence interval	
							Lower Bound	Upper Bound
F	R	150	3.97±0.76	0.14	2.69	0.57	3.68	4.25
F	L	150	3.73±0.67	0.12	2.45	0.45	3.48	3.56
M	R	150	3.81±0.85	0.15	3.58	0.71	3.49	4.13
M	L	150	4.27±0.89	0.16	3.88	0.79	3.94	4.61
FL vs FR		t= 1.25			P= 0.21		NS	
ML vs MR		t= 2.06			P= 0.04		S	
FL vs ML		t= 2.66			P= 0.01		S	
FR vs MR		t= 0.74			P= 0.04		S	

NS: Not significant S: significant HS: Highly Significant

provides pioneer baseline data for comparison amongst different populations.

10. Index of Sinousity

Gender specific statistical difference was found significant (p< 0.05) for index of sinousity which is contrasting to finding in Europeans. No side specific significant difference was found in females in contrast to the findings in males (p<0.05) (Table 9). No work has been done on measurements of index of sinousity of clavicle, so no data is available for comparison with present study. Thus, the present study provides pioneer baseline data for comparison amongst different populations.

11. Conclusions

The study establishes the morphometric criterion for curvatures of clavicle and compares the observations with those for other populations and races giving special emphasis on influence of sex factor on these parameters. A statistically significant sexual dimorphism was found to exists for index of curvature, anterior lateral curve length and height and index of sinousity. These parameters assess curvature of clavicle which should be taken in to account while performing clinical procedures like intramedullary fixation and plate fixation of fractures.

12. References

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