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Clavicle Morphometry for Sexual Dimorphism and Bilateral Asymmetry: Radiographic Assessment

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ABSTRACT

Background: The clavicle, modified long bone, presents morphological and bilateral variations. This may be due to genetic factors, hormones, or environmental and occupational influences. Anthropometric studies in clavicle of Nepalese population using radiograph has not been reported to best of our knowledge. This study, aimed to determine the sexual dimorphism and bilateral asymmetry of clavicle in Nepalese Population using Postero-Anterior Chest X Ray.

Methods: Chest x-rays with normal and clearly visible both clavicles of 1260 Nepalese adults (591 male, 669 female), aged above 20 years were utilized. Inbuilt software "Computed Radiography Fuji Computer System 7" was used for measurements (in centimeter) of sternal head length, acromial end length, mid shaft diameter and length of clavicle. Demarcating point and identification point were calculated. Patients having history of clavicles fractures in the past were excluded.

Results: All the parameters in male is greater than female which is significant except Length/Mid Shaft Diameter. Similarly, all the parameters of right clavicle is significantly greater than left clavicle in both sexes except Sternal Head Length and Mid Shaft Diameter. Demarcating point calculated from length of the clavicle (right >16.17, left >16.10 for male and right <11.20, left <10.65 for female) and Mid Shaft Diameter (right >1.33, left >1.38 for male and right <0.66 and left <0.67 for female) are important parameters to determine sex.

Conclusions: The clavicle shows significant sexual dimorphism and bilateral asymmetry in Nepalese population. The result of this study is helpful to anthropologist and forensic medicine.

Keywords: Anthropometry; clavicle; demarcating point; postero-Anterior chest x-rays; sexual dimorphism

INTRODUCTION

The clavicle is horizontally positioned, modified long bone that transmits the load from upper limb to sternum, provides maximum freedom for movement and also protects neurovascular bundle running behind it.[1] It's long duration of growth, may allude sexual dimorphism.[2] The female clavicle is shorter, thinner, less curved and smoother with its acromial end lower than the sternal end but in males the acromial end is on a level with or slightly higher than the sternal end in normal anatomical position.[3] The bone presents morphological variations and bilateral asymmetry, which may be due to genetic factor, growth and sex hormones, nutrition, life style activities and occupational stresses.[4,5]

Fracture of clavicle along with its shortening and displacement is common due to its position, morphology, and its muscles and ligaments attachment.[6] Variation in clavicle morphometry should be considered during fracture reduction. Bone can withstand decomposing for long duration, hence can be useful for medicolegal identification. Knowledge of clavicle morphometry, bilateral asymmetry and its sexual dimorphism is helpful to anthropologists, anatomists, forensic medicine, and surgeons during fracture reduction. Thus, this study aimed to determine the sexual dimorphism and bilateral variations of clavicles in Nepalese population using postero-anterior (PA) chest X ray.

METHODS

This was a descriptive cross sectional study conducted on 1260 PA chest X Rays, in 9th April - 8th May 2019.

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After obtaining the ethical clearance from Institutional Review Committee of Lumbini Medical College (IRC-LMC 05-C/019), the data was collected in department of Radiology. PA chest radiographs were obtained by random selection from the Radiology department of Lumbini Medical College and Teaching Hospital, Pravash, Tansen. The radiographs of Nepalese adults, aged above 20 years, with clear and normal represented clavicles showing complete secondary ossification were utilized. Radiographs with the clavicles suspected for fractures and pathological diseases were excluded from study.

The radiographs were taken by "Allengers X Ray machine" and further developed by CR system- Fuji. The technicians were trained, to keep the patients in standing position with their both hands on their iliac crest during procedure. This method was practiced for uniformity, so that all X Rays shows comparatively straight clavicle.

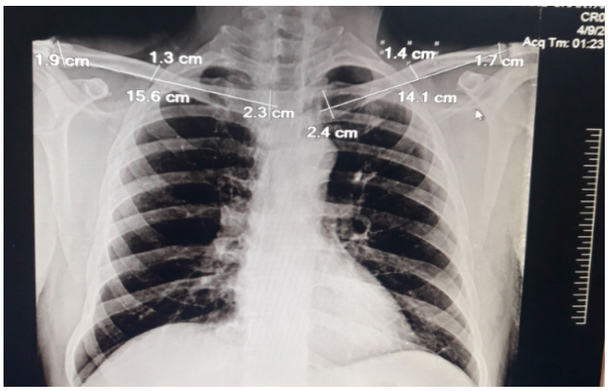

Figure 1.Digital measurements in PA chest X Ray.

Inbuilt software "CR Fuji CS7" was used for measurements. Length of the clavicle (L) was measured from the most medial point on the medial boarder of the sternal end to the most lateral point of the lateral boarder of the acromial end (linear measurement of clavicle length).Sternal head length (SHL) was taken from the highest vertical extent of sternal head to its lowest extent. Mid-shaft diameter (MSD) was measured from the superior borderline of the middle point of the shaft of the clavicle to the inferior borderline of the same. Acromial head length (AHL) was taken from the highest vertical extent of acromial head to its lowest extent.

The ratio of the length of the clavicle to the mid-shaft diameter (L/MSD) and the product of the length of the clavicle and the mid-shaft diameter (L X MSD) were calculated for all the radiographs. The identification points (IP) and the demarking points (DP) of both sexes were determined. The identification point was derived from the normal range in the sample and the demarking point analysis was "mean ± 3 SD".[7] Using the IP and DP percentages of bone identified for sex determination was calculated.

The data was entered and analysis were done by using statistical package for social sciences software (SPSS™) software version 20.Basic descriptive statistics i.e. mean (M), standard deviation (SD), range (R) using maximum and minimum values were calculated in different sex.

RESULTS

The present study was conducted in 1260 radiographs, out which 591 were of male and 669 were of female. The mean length of left clavicle varied 12.89 cm to 14.25 cm and right clavicle varied from 13.17 cm to 14.47 cm.

Table 1 shows sexual dimorphism in different parameters of clavicle. The mean length of clavicle, sternal head length, acromial head length and mid shaft diameter in male is bilaterally longer in comparison to female. IP calculated from maximum and minimum range of different parameters helps to identify the male and female bones, but the overlapped values of male and female cannot discriminate sex. Hence, only few percentages of bones were identified as male and female bones. The calculated IP of "L X MSD" bilaterally in both sex can be considered as important value for sexual dimorphism. Using the IP, none of female left bones were identified only by utilizing AHL and MSD. Similarly utilizing IP of L/MSD none of male and female right clavicles were identified.

The DP calculated from Mean ± 3SD (cm) is shown in table 2.The use of SD in DP, fixed the maximum and minimum range of bone in both sex statistically. The lowest range of male is considered as DP for identification of female clavicle. Similarly, the highest range of female is considered as DP for identification of male clavicle. Similar to IP, by using the DP, the clavicle having the value between lowest range of female and highest range of male cannot be identified for sex determination. However, it is considered more effective to identify bones. If we compare table 1 and 2; the number of bones identified in different sex by using DP in table 2 is more than number of bones identified by using IP in table 1. The present study shows DP calculated from length of clavicle alone is important for identifying both male and female bones, as comparatively more bones are identified in both sexes. Similarly, DP calculated from MSD in male identified more percentage of bones in male, hence highest numbers of male bones are identified using demarcating point of L X MSD.

Table 1. Comparative study of clavicle parameters between male and female and identification point.

Parameters	Sex	Range (cm)		Mean±SD (cm)		IP value(cm)		No. of bone identified by IP value (%)	
		Right	Left	Right	Left	Right	Left	Right	Left
SHL	M	1.20-3.60	1-3.30	2.22 ± 0.35	2.27 ± 0.34	>3.2	>3.1	3(0.6%)	4(0.6%)
	F	0.78- 3.20	0.78- 3.10	2.09± 0.33	2.12± 0.32	<1.20	<1	2(0.2%)	1(0.1%)
AHL	M	0.67-2.30	0.60-2.20	1.32 ± 0.25	1.28 ± 0.24	>2	>2	4 (0.71%)	3 (0.5%)
	F	0.63-2.0	0.67-2.0	1.13 ± 0.20	1.10 ± 0.19	<0.67	<0.60	1 (0.1%)	0 (0%)
Linear Measurement of Clavicle (L)	M	10.70-17.50	9.70-17.40	14.47 ± 1.09	14.25 ± 1.20	>16.10	>16.70	34 (5.8%)	5 (1%)
	F	9.20-16.10	9-16.70	13.17 ± 1	12.89 ± 1.07	<10.70	<9.70	10 (1.1%)	3 (0.3%)
MSD	M	0.73-1.90	0.60- 1.80	1.14 ± 0.16	1.15 ± 0.17	>1.40	>1.50	28 (4.7%)	9 (1.6%)
	F	0.61-1.40	0.64- 1.50	0.97 ± 0.12	0.99 ± 0.13	<0.73	<0.60	14(1.9%)	0(0%)
L/MSD	M	7.79-19.87	7- 22	12.93 ± 1.90	12.55 ± 2.02	>21.15	>20.47	0(0%)	1(0.2%)
	F	8.64-21.15	6.80-20.47	13.68 ± 1.92	13.17 ± 1.95	<7.79	<7	0(0%)	1(0.1%)
L X MSD	M	9.24-29.24	7.88- 27.36	16.53 ± 2.90	16.54 ± 2.99	>21.14	>23.25	36 (6.7%)	11(2.2%)
	F	7.35-21.14	6.97-23.25	12.90 ± 2.09	12.85 ± 2.17	<9.24	<7.88	21(2.1%)	2(0.2%)

Table 2. Demarcating point calculation in male and female.

Parameters	Sex	Mean ± 3SD (cm)		Demarcating point (cm)		No. of bone identified by DP value (%)	
		Right	Left	Right	Left	Right	Left
SHL	M	1.17-3.27	1.25-3.29	>3.08	>3.08	10 (1.69%)	11 (1.86%)
	F	1.11-3.08	1.16-3.08	<1.17	<1.25	2 (0.29%)	4 (0.59%)
AHL	M	0.57-2.07	0.56-2	>1.73	>1.67	39 (6.59%)	50 (8.46%)
	F	0.53-1.73	0.5-1.7	<0.57	<0.56	0 (0%)	0 (0%)
Linear Measurement of Clavicle (L)	M	11.2-17.74	10.65-17.85	>16.17	>16.10	34 (5.75%)	30 (5.07%)
	F	10.17-16.17	9.68-16.1	<11.20	<10.65	32 (4.78%)	20 (2.98%)
MSD	M	0.66-1.62	0.64-1.66	>1.33	>1.38	60 (10.15%)	84 (14.21%)
	F	0.61-1.33	0.60-1.38	<0.66	<0.64	1 (0.14%)	1 (0.14%)
L/MSD	M	7.23-18.63	6.49-18.61	>19.44	>19.02	1 (0.16%)	1 (0.16%)
	F	7.92-19.44	7.32-19.02	<7.23	<6.49	0 (0%)	0 (0%)
L X MSD	M	7.83-25.23	7.57-25.51	>19.17	>19.36	97 (16.41%)	99 (16.75%)
	F	6.63-19.17	6.34-19.36	<7.63	<7.57	1 (0.14%)	1 (0.14%)

Table 3.Comparison of right and left clavicle parameters in male.

Parameters	Side	Mean ± SD (cm)	Mean Difference (M.D) cm
SHL	Right	2.22 ± 0.35	-0.042
	Left	2.27 ± 0.34	
AHL	Right	1.32 ± 0.25	0.035
	Left	1.28 ± 0.24	
Linear Measurement of Clavicle (L)	Right	14.47 ± 1.09	0.221
	Left	14.25 ± 1.23	
MSD	Right	1.14 ± 0.16	-0.018
	Left	1.15 ± 0.17	
L/MSD	Right	12.93 ± 1.90	0.379
	Left	12.55 ± 2.02	
L X MSD	Right	16.53 ± 2.90	-0.010
	Left	16.54 ± 2.99	

Table 4. Comparison of right and left clavicle parameters in female.

Parameters	Side	Mean ± SD (cm)	Mean Difference (M.D) cm
SHL	Right	2.09 ± 0.33	-0.032
	Left	2.12 ± 0.32	
AHL	Right	1.13 ± 0.20	0.035
	Left	1.10 ± 0.19	
L	Right	13.17 ± 1	0.278
	Left	12.89 ± 1.07	
MSD	Right	0.97 ± 0.12	-0.017
	Left	0.99 ± 0.13	
L/MSD	Right	13.68 ± 1.92	0.511
	Left	13.17 ± 1.95	
L X MSD	Right	12.90 ± 2.09	0.046
	Left	12.85 ± 2.17	

The clavicles of right side and left side were compared in male and female, in table 3 and 4 respectively. In both sex all the parameters showed significant difference except L X MSD. In both male and female SHL and MSD of left side clavicle is more than that of right sided clavicle. AHL, L and L/MSD of right sided clavicle are significantly higher than left sided clavicle in both sex. The result justified bilateral asymmetry in clavicle irrespective of sex.

DISCUSSION

In the past, the methods used for sexing the skeleton were mainly non-metric i.e., based on the observations of the morphology of bones.[8] Mid-shaft circumference was considered as the most reliable single indicator of sex and combination of this measurement with weight and length.[3] The present study was an effort to determine sex and compare difference between right and left clavicle using digital PA chest radiographs of Nepalese adult population. Similar to our study, radiologic evaluation of clavicular morphology in chest radiograph of Southern Nigerian population was done in which only left clavicle was selected. The authors had also calculated identifying point and demarcating point, however, their difference in sexual dimorphism was not significant.[9]

Earlier studies also implied the presence of rhomboid fossa on clavicle for sex and age estimator.[10-13]The result of present study showed significant sexual dimorphism and bilateral asymmetry in which clavicles of male pointed out more values than female which resembled with other previous studies, but bilateral asymmetry of the bone had not affected sexual dimorphism.[2-5,9,14-21]

Only length of clavicle was used for sexual dimorphism in different regions of world.[4,5,15-18] Studies resembled to our study, having mean length of right clavicle longer than left clavicle,[15,17,20] while, other pointed out the length of left clavicle was greater than right clavicle.[4,5,12,16,18,19]

Unlike present study, earlier study in Nepalese population showed the left clavicle bones were longer than right ones. The same study also compared the length of Nepalese clavicles with French population, American Negros and whites, population of Amritsar and Chandigargh zones of India; and revealed clavicles of Nepalese population was longer than population of different regions of India but shorter than American whites, Negros, and French population.[5]

The difference in morphometry of right and left clavicle of adult is also thought to be due to dominant hand in their life, i.e. the use of right hand dominantly, increased the curve of right clavicle, leading to shorter right bone in comparison to left bone; but none of earlier articles have clearly correlated handedness with morphology of clavicle. However, Mays suggested asymmetry could be caused by the development of the brain and blood flow. Hence, even if there is a correlation between clavicle size and dominant hand, the cause may be irrelevant.[21]The variation in result of present study with other studies may be due to racial, genetic and environmental factor. Beside this, the present study was linear measurements in digital radiograph while other studies were performed in dried bone.

The present study was linear measurements of clavicle in PA chest radiograph. Further studies on circumference and perimeter along with morphology of clavicle can be conducted in future. Beside this handedness and clavicle morphology can be correlated in studies of bilateral asymmetry.

CONCLUSIONS

This study elicited clavicle has significant sexual dimorphism and bilateral asymmetry in Nepalese population. The result of this study can be helpful to anthropologist, anatomists, forensic medicine and surgery.

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