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Research Article

Variability of length and Osteometrical study of human clavicle and its applied importance

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Abstract: To determine the bilateral variability in length of clavicle bones, its relationship with location of nutrient foramen and clavicular Osteometry and its applied importance. Length of clavicle differs with gender, population or race. The length has correlation with its Osteometry. It is essential for clavicular surgeries, designing or selecting the clavicular implants, sex determination in forensic science, anthropology and anatomy. This study was done on 120 dry clavicles (n=120) to determine the bilateral variability in length, correlation between location of nutrient foramen and length and to get data set of clavicular Osteometry of Indian population. ANOVA, correlation-regression analysis and descriptive statistics were done on the collected data. Mean length of clavicles in groups on right side, left side and of both sided was 138.99±5.006mm, 142.618±4.48mm and 140.685±4.88mm respectively. Significant difference was found between right and left side groups. Significant and Strong positive correlation was observed [r=0.9445 on right side and r=0.9654 on left side] between location of nutrient foramen and length. Foramina index was 65.92 [right] and 66.34 [left]. Mid shaft circumference was 57.58mm [right] and 59.93 mm [left]. Distance of Conoid tubercle from acromial end was 41.23mm [right] and 42.91mm [left]; and that of mid trapezoid line was 19.27mm [right] and 21.22mm [left] in the present study. Conclusions- Bilaterally Significant variability is present in the clavicle bones. Left side clavicles were longer than that of right side. Strong positive correlation is present between location of nutrient foramen and length of clavicle in the present study.
Keywords: Clavicle, applied, circumference, osteometric, variability.

INTRODUCTION

While teaching osteology, clavicles with different length were observed and question was encountered about the possible difference in bilateral sides. The clavicle differs [1] in males and females about length, thickness, curvature and smoothness. In manual workers it is thicker and has prominent curves and ridges. Previous studies found that the length is more on left side than the right side and it was not same in a race [2]. The length has correlation with its dimensions [3] at different parts. Among them Midshaft circumference is a reliable factor in determination [1] of gender. Knowledge of clavicular Osteometry prior to surgery is emphasized in the [4, 5] previous researches. Clear idea of clavicular Osteometry is essential for orthopedic surgeries [6, 7, 8], designing and selecting the clavicular implants [9], sex determination [1] in forensic science, anthropology and anatomy. This study was designed to determine the variability in length of clavicle bones of bilateral sides, its relationship with location of nutrient foramen and different osteometric measurements.

MATERIALS AND METHODS:

This primary research study was done on one hundred and twenty dry clavicle bones (n=120), not paired, of Indian origin assigned in three groups. They were collected with following criteria and study was performed in the Department of Anatomy, Malabar Medical College and Research Centre, Modakkallur, Calicut, Kerala, India, during 19th November 2013 to 18th October 2014.

Table-1: Summary of methods and materials [10] of clavicle study

1	Sample size (n)	120. Not paired. Group-1: (right-40), Group-2: (left-40), Group-3: (Right-20 and Left-20).
2	Units	Dry clavicle bones
3	Study population	Indian
4	Pilot study	Done On thirty bones
5	Calculation of Sample size	With minimum 80% power
6	Inclusion criteria	Adult clavicle Bone in regular form
7	Exclusion criteria	Fractured or having pathological features
8	Selection Method	Simple random sampling
9	Instruments & materials	Vernier Caliper, Magnification hand lens, divider, camera, tables of random digits, hypodermic needles no 20, 24; fine metallic wire, Microsoft word, exel worksheet.
10	Parameters	(1).Total length of bone (TL). (2).Location: distance between sternal to the nutrient foramen [D-NUF]. (3).Foramina [11] index (FI)=(D-NUF/TL)*100 (4).Mid shaft circumference. (5).Conoid tubercle to acromial [1] end-distance [CT-AE] (6).Mid trapezoid line to acromial end-distance.[TR-AE]

PROCEDURE

After careful inspection, nutrient foramen [Fig-1 c, d, e] was identified by method followed by Carroll SE [12, 13] under proper illumination. The measurements of parameters were taken carefully by single investigator to avoid inter investigator variability. Average of three reading was taken and entered in the chart accordingly as right side, left side and both side groups. Preparation of Master chart, data analysis, calculation of Parameters and statistical assessments were done accordingly. Statistical assessment [14, 15]: Frequency distribution [Fig-2] was observed and data exploration was carried out. The descriptive measures [Table-4] and inferential calculations were done manually. The one way ANOVA, Least Squares Difference method, Bonferroni method, Pearson's correlation coefficient and Regression analysis were used [Fig-2, 3] to evaluate the objectives. Statistical tests with p-values < 0.05 was considered significant.

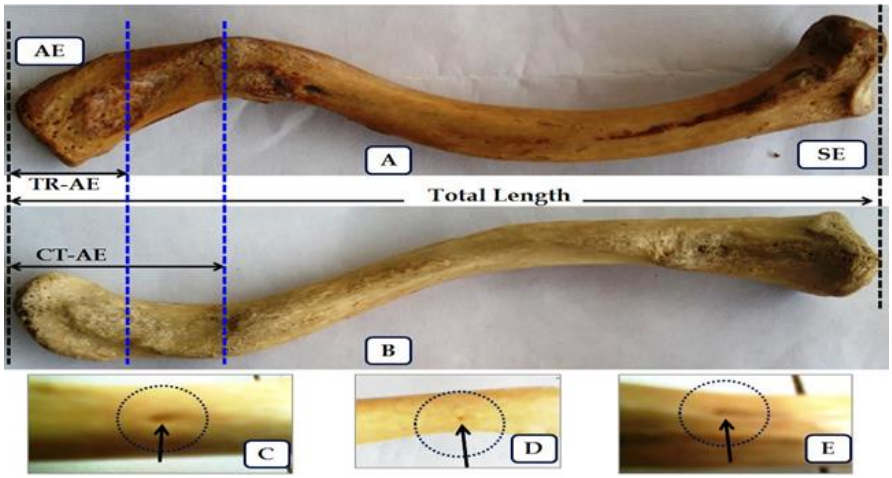

Fig-1: clavicle: inferior view. A-left side, B-right side, (C, D, E)-nutrient foramen, AE-acromial end, SE-sternal end, TR-AE: trapezoid ridge to acromial end-distance, CT-AE: conoid tubercle to acromial end-distance.

RESULTS

Totally 120 nutrient foramina were found. The results were presented in the following tables and figures.

Frequency distribution

The frequency distribution curve (fig 2) of clavicular length is similar to bell shape and symmetrical [15] around the grand mean (140.76) with minimum skewness towards right side and it indicates that frequency distribution does not vary from normality. Values of median and mode were nearer to mean in each group. Values (table-4) were spread with standard deviation of 5.01mm, 4.48mm and 4.88 mm for group 1, 2, and 3 respectively. Outliners were not observed.

Assessment of variance in length

The summary of comparisons [15] of length of clavicle in three groups and the data exploration were presented [Fig- 3, 4 & Table-2].

Variance between groups [15] (figure-3)

The means for Group-1(138.99), Group-2 (142.61) and Group-3 (140.68) were had variation of (-1.77), (+1.34) and (-0.075) with grand mean value of (140.76).

Variance within the groups [15]

The variation of each value of clavicular length around the group mean with standard deviation of 5.01mm (group-1), 4.48mm (group-2), and 4.88mm (group-3) in the three groups were presented (figure-4)

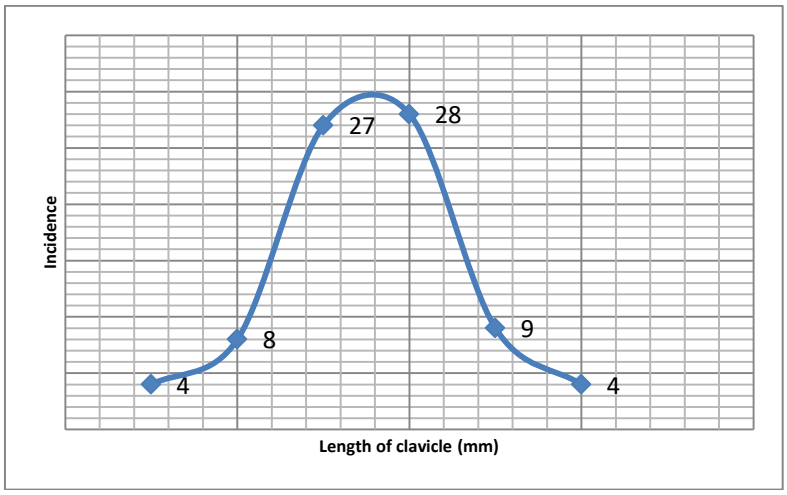

Fig-2: Frequency distribution of clavicular length. X-axis: clavicular length, y-axis: incidence.

Table-2: Summary statistics of clavicle study.

Groups	Study units	Mean	(n)	SD	Variance	Max	Min
G-1	right side bones	138.99	40	5.006	25.068	152.27	120.16
G-2	left side bones	142.618	40	4.485	20.123	153.21	122.17
G-3	Both side	140.685	40	4.889	23.906	152.23	120.13
*Comparisons by LSD**		*P-value*: [two sided] is between*				*Significance*	
1. G-1 with G-2.		0.003 ≤ p≤ 0.0015				Significant	
2. G-1 with G-3		0.30 ≤ p≤ 0.15				Not-Significant	
3. G-2 with G-3		0.15 ≤ p≤ 0.075				Moderately-Significant	
Study units=clavicle bone,(n)= sample size, SD= standard deviation, Max=Maximum, Min=Minimum, p-value= significance at α=0.05, (LSD*)= comparison of groups by least squares difference method, (p-value*)=by Bonferroni's method.							

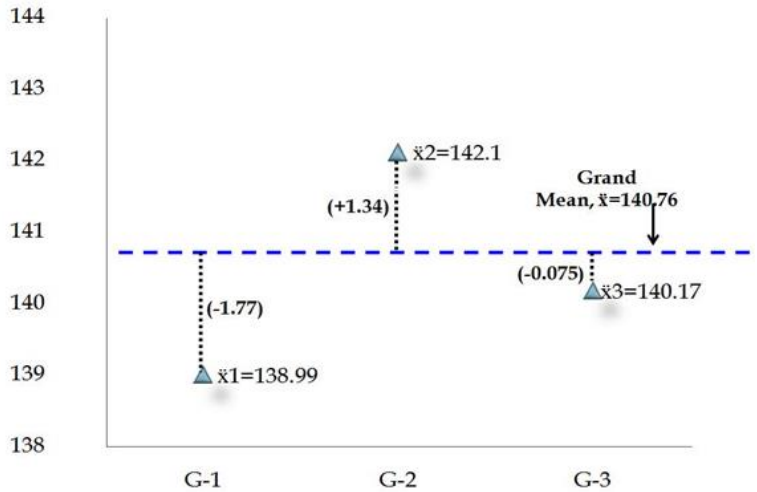

Fig-3: Variance between three groups (G-1, G-2, G-3) in clavicle study.[x-axis: G-1:Right side, G-2:Leftt side, G-3:Both side. y-axis: length of clavicle (mm), (x̄)=group mean]

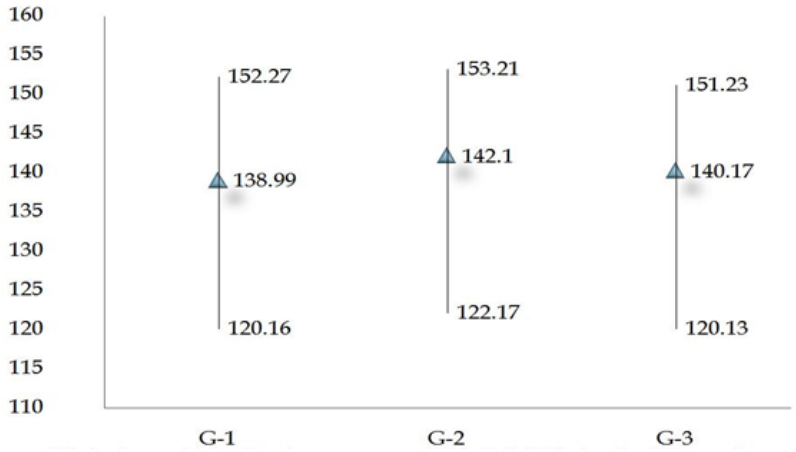

Fig-4: Variance within the three groups (G-1, G-2, G-3) in clavicle study. [x-axis: G-1: Right side, G-2:Leftt side, G-3:Both side. y-axis: length of clavicle (mm)]

Correlation between clavicular length and location of nutrient foramen

Significant and Strong positive correlation can be observed in Scatterplot [14, 15] of right side group [fig-5] and left side group [fig-6]. Scatter plot is fitted with least squares regression line model. Proportionate interrelationship between length and location was quantified by coefficient of determination (table-3).

Table-3: Correlations between length and location of nutrient foramen.

Side	CC	CD	Regression model	P-value	Significance
Right side	0.9445	0.892	y=0.735x-10.50.	P<0.001	Significant
Left side	0.9654	0.9319	y=0.691x-3.939.	P<0.001	Significant
CC=coefficient of correlation, CD=coefficient of determination, p value=(two sided), significance= statistical significance at α=0.05.					

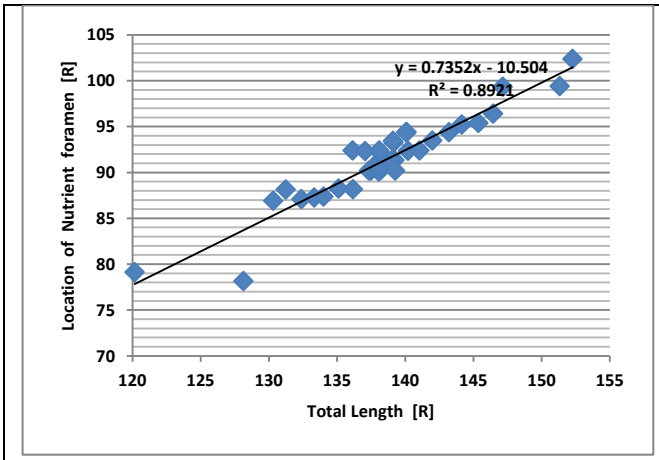

Fig-5: Correlation: clavicular length and location of nutrient foramen [R]

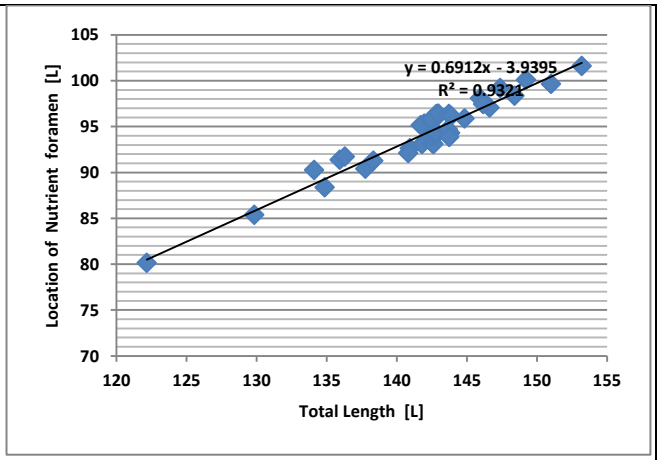

Fig-6: Correlation: clavicular length and location of nutrient foramen [L]

Summary of clavicular Osteometry

It is displayed in table-4.

DISCUSSION

Present study was done on one hundred and twenty (n=120) clavicle bones. Mean length of clavicles in groups on right side, left side and of both sided was 138.99±5.006mm, 142.618±4.48mm and 140.685±5.82mm respectively. Significant difference was found between right and left side groups with p value between 0.003 and 0.0015. Mean length was more on left side than right side. Significant (P<0.001) and Strong positive correlation was observed in both right side group (r=0.9445) and left side group (r=0.9654) between location of nutrient foramen and clavicular length. Foramina index was 65.92 [right] and 66.34 [left]. Mid shaft circumference was 57.58mm [right] and 59.93 mm [left]. Distance of Conoid tubercle from acromial end was 41.23mm [right] and 42.91mm [left]; and that of mid trapezoid line was 19.27mm [right] and 21.22mm [left] in the present study.

Comparison of study of different populations

Marked racial variation was observed while comparing mean length of clavicle of different populations (Table-5).

Table-4: Osteometry of Clavicle study (mm)

No	Description		Right	Left	Both
1	Sample size		40	40	Right (20), left (20)
2	Total length	Mean	138.52	142.11	140.17
		Median	138.24	142.82	141.15
		Maximum	152.27	153.21	152.23
		Minimum	120.16	122.17	120.13
3	Standard deviation		5.01	4.48	4.88
4	Standard error		0.91	0.86	0.92
5	Location of nutrient foramen from proximal end		91.33	94.29	94.28
6	Foramina index		65.92	66.34	66.44
7	Mid shaft diameter		18.34	19.09	18.54
8	Mid shaft circumference		57.58	59.93	58.21
9	Conoid tubercle to acromial end: distance		41.23	42.91	41.91
10	Mid trapezoid line to - acromial end: distance		19.27	21.22	20.12

Table-5: Comparison of clavicular length in different populations

No	Author	Time	Population	Length of clavicle (mm)	
				Left	Right
1	Present study	2015	Indian	142.618	138.99
2	Kaur H et al. [16]	2002	Indian	143.67	141.96
3	Parsons et al [17]	1916	English	146.5	145.0
4	Oliver et al [2]	1951	French	146.85	146.05
5	Andermahr et al. [18]	2007	German	152.0	149.0
6	Beryl S et al [19]	2015	Kenyan	150.4	146.8
7	Kim H et al. [20]	2013	Korean	146.2	144.3
8	Haque MK et al [21]	2011	Nepalese	145.53	143.21
9	Walters et al. [22]	2010	South African	148.2	151.6
10	Nagarchi et al [9]	2014	Saudi Arabian	143.8	142.1
11	Terry RJ et al [23]	1932	U.S.A. Whites	154.10	152.90

On comparing the research on different populations, interpopulation variability can be observed [table-5]. Hence the length is not the same in different population or races. Bilateral variance in the length is evident in most of studies. Similarly left side clavicle is longer than the right side. Hence present study corroborates well with previous study results.

Developmental evidence

Clavicle is first to start the ossification process and the last to complete in the body. The shaft is ossified by mesenchymal condensation in two primary centers (5^{th}-6^{th} weeks) and fuse (by the 45th day of prenatal life). Initially clavicle develops by Intramembranous ossification. Afterwards Growth cartilages are formed at both ends and interstitial growth in them increases the Length of clavicle. Diameter is increased by subperichondral and subperiosteal deposition [1]. The length is contributed more by medial cartilaginous mass than lateral. These ossification centers will meet at junction between the intermediate and lateral thirds of the shaft. A sternal secondary ossification centre appears in late teen age, or even in early twenties. It is Usually 2 years earlier in females. An acromial secondary ossification centre (appears 18 to 20 years) is rudimentary and rapidly joins the shaft [1, 24].

Bilateral variation

During the intrauterine life clavicular growth has no significant bilateral variations [25]. Variations are resulted in postnatal life by various factors influencing its growth. Usually adult right clavicle is stronger and shorter than the left clavicle [25]. Bilateral differences may be due to genetic, population, hormonal, body stature and muscle activity levels [26, 27].

Gender wise variation

Study [24] observed identical growth pattern in clavicle until puberty in both genders. Significant variation was observed after 12 years between male and females. Hormonal factors were found to be the

possible cause as androgens increase the skeletal growth and estrogen inhibits [24, 28].

Length and dimensions

The length of the clavicle has influence on its dimensions and they will vary with respect to gender, side and geographical factors [3, 27].

Applied and clinical significance

The clavicle is frequently injured bone and usually fracture occurs at the junction between lateral and intermediate thirds, by indirect forces on out stretched hand. Where medial fragment is little displaced and lateral fragment is dragged downwards by weight of upper limb [1, 29, 30].

Location of nutrient foramen

Nutrient artery enters the shaft through this foramen. Any damage to the precise area of nutrient foramen or nutrient artery by traumatic or iatrogenic reasons may result with delay in fracture healing because healing process is dependent on blood supply. By avoiding vascular damage to this limited area of the cortex, better result and faster healing can be achieved [12, 31].

Length and Osteometry

The clavicular length and its Osteometry is essential for the surgical intervention and to apply [32] screw, nailing, plating for immobilization of clavicular fracture fragments, for designing and choosing the specific devices for clavicular fixation and clavicular prostheses [9] or clavicular implants, compatibility of implants [20] and to avoid the post operative complications and failure rates [9] of surgery. The distance [6, 7, 8] of conoid tubercle [9] and trapezoid ridge from Acromial end are essential in treatment for subluxation of acromioclavicular joint and in treatment coracoclavicular ligament injuries or in its reconstruction [8] and essential for the accuracy of surgical procedure, alignment of clavicle [33]. Iatrogenic injury to subclavian vessels and brachial plexus and rotator cuff can be achieved with good information on Osteometry.

Medico legal significance

Clavicle is used for determination of age (medial end) and sex (by size and shape) in forensic science and anthropology. Midshaft circumference- is a reliable factor in determination [1] of gender.

CONCLUSIONS

Bilaterally Significant variability is present in the clavicle bones. Left side clavicles were longer than that of right side. Strong positive correlation is present between location of nutrient foramen and length of clavicle in the present study.

Limitations of study

The age and gender wise groups were not done. Radiographs were not utilized. Prenatal and postnatal comparison was not attempted.

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