

# Morphometric Analysis of Clavicle in Nepalese Population

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## Citation

Haque MK, Mansur DI, Krishnamurthy A, Karki R, Sharma K, Shakya R. Morphometric analysis of clavicle in Nepalese population. *Kathmandu Univ Med J.* 2011;35(3):193-7.

## INTRODUCTION

Estimation of age and sex of human skeletal remains have always fascinated forensic workers, anthropologists, anatomists and students. Pioneer work has been done on the skeleton as a whole as well as an individual bone. While pelvic bones show sexual dimorphism to a greater degree than any other bone, the human clavicle shows the least dimorphism.<sup>1</sup> Determining the sex of deceased is easy when a complete skeleton is available for examination. Even when the entire human body, pelvis and skull are available not more than 98% accuracy can be achieved in identifying the sex.<sup>1</sup>

The female clavicle is shorter, thinner, less curved and smoother, and its acromial end is carried lower than the sternal in comparison with the male. In males the acromial end is on a level with, or slightly higher than the sternal

end. Mid-clavicular circumference is the most reliable single indicator of sex: a combination of this measurement with weight and length yields better results.<sup>2</sup>

The human clavicle is a long bone, which has a shaft and two ends. The right sided long bones of the limbs are usually larger than those of the left.<sup>3</sup> The right clavicle was heavier and its mid circumference was greater than those of the left clavicle.<sup>4</sup>

The purpose of this study was attempted to evolve an easily applied formula to enable the assessment of sex in an unknown clavicles and to know about comparative differences between the right and left clavicles, from certain metrical parameters.

## ABSTRACT

### Background

Determining the sex of deceased is easy when a complete skeleton is available for examination. On the whole, the bones are heavier, larger and markings of muscular attachments are more pronounced in the male than in the female.

### Objective

The purpose of this study was attempted to evolve an easily applied formula to enable the assessment of sex in an unknown clavicles and to know about comparative differences between the right and left clavicles, from certain metrical parameters.

### Methods

The study was an observational, cross-sectional and descriptive in nature. The present study was conducted on 257 adult clavicles out of which, 135 were of the right side and 122 of left side. The maximum length of the clavicle (in mm) was taken.

### Results

The length of the right clavicles varies from 108 mm to 178 mm with an average of 143.21 mm  $\pm$ 11.13 mm S.D. The length of the left clavicles varies from 111mm to 181 mm with an average 145.53 mm  $\pm$ 11.04 mm S.D. It has been observed that the left clavicle was longer than the right clavicle by 2.32 mm. There was no such single character which can determine the sex of all clavicles. Depending on the length alone, the sex can be decided in 13.33% male and 4.44% female right clavicles and 16.39% male and 9.83% female bones if the left clavicle is considered.

### Conclusion

The left clavicle was longer than the right clavicle. The determination of sex from the clavicle has a great medico legal significance to the toxicologists. It also helps the anthropologists in their study of evolution of mankind and migration of races.

## KEY WORDS

*Clavicle, card board, measuring tape, thread, vernier caliper*

## METHODS

Two hundred and fifty seven adult clavicles, 135 right and 122 left, were collected during the period 2010 – 2011. Clavicle showing any pathology, e.g. a healed fracture or malunion, was excluded. The maximum length of the clavicle (in mm) was taken. The length of the clavicles which was the maximum distance between the two ends of the clavicles, was measured with the help of a vernier caliper (Mitutoya). The midpoints at the sternal and acromial ends were obtained and were marked as points 'a' and 'b' and were joined by a straight line 'a b' as shown in figure-1.

The data were entered in Statistical Programme for Social Sciences (SPSS) computer programme. Then the analysis was done to derive regression equation and multiplication factor from the data. For assessing the correlation between the right and left clavicles, the Pearson's correlation coefficient was calculated and its significance was tested by students "t" test. "P" value of less than 0.05 was considered as significant.

## RESULTS

### Length of clavicles

The length of the right clavicles varies from 108 mm to 178 mm with an average of 143.21 mm  $\pm$ 11.13 mm S.D (table 1). The length of the left clavicles varies from 111mm to 181 mm with an average 145.53 mm  $\pm$ 11.04 mm S.D. It has been observed that the left clavicle was longer than the right clavicle by 2.32 mm. Although the length of the left clavicles to be marginally more than that to the right clavicles, the differences were statistically insignificant ( $p=0.096$ ).

However, in a normal distribution, the maximum and the minimum limits can be safely calculated by the formula (mean  $\pm$ 3S.D.) by Jit I et al where mean +3S.D. gives the maximum value and mean -3 S.D. gives the minimum value. This range includes 99.75 percent of the sample.<sup>4</sup> Assuming that measurements on clavicles are all distributed normally, the maximum and minimum values of the measurements on clavicles for both males and females separately can be fixed.

From calculations of mean and mean  $\pm$ 3 S.D., it is noticed that the maximum and minimum points of the range of males are higher than the maximum and minimum points of the range for females (Table-3). Thus, it can be statistically fixed, a measurement above which no female clavicles can be found and another measurement below which no male clavicles can be seen. This measurement can be termed as the demarking points.

### Right clavicle

The length of the right clavicles varies from 108 mm to 178 mm with the mean of 143.21 mm  $\pm$ 11.13 mm S.D. On the basis of this criteria (Demarking points = mean  $\pm$ 3 SD), the range was 109.82 - 176.60 mm. Therefore, a right

clavicle having length of more than 176.60 mm should be considered as male. Only 18 out of 135 (13.33 percent) right clavicles of the present series with length more than 176.60 mm can be considered as definitely male. Similarly, a right clavicle having length of less than 109.82 mm can be female. Only six out of 135 (4.44 percent) right clavicles of the present series with length less than 109.82 mm can be considered as definitely female. If the lengths of the clavicles are between 109.60 mm and 176.60 mm; sexing on this basis is not possible in 82.23%.

### Left clavicle

The length of the left clavicle varies from 111 mm to 181 mm with the mean of 145.53 mm  $\pm$ 11.04 mm S.D. On the basis of this criteria (Demarking point = mean $\pm$ 3S.D.)<sup>4</sup>, the range was from 178.65 mm to 112.41 mm. Therefore, a left clavicle having length of more than this figure (178.65 mm) should be considered as male. Only 20 out of 122 (16.39 percent) left clavicles of the present series having more than 178.65 mm can be considered as definitely male. Similarly, a left clavicle having length of less than 112.41 mm can be considered as female. Only 12 out of 122 (9.83 percent) left clavicles of the present series having less than 112.41 mm can be considered as definitely female. If the length of a bone is between 112.41 mm and 178.65 mm; sexing on this basis is not possible in 73.78%.

## DISCUSSION

In the present study an effort has been made to determine the sex of unknown clavicles and to know about the comparative differences between the right and left clavicles from certain parameters in Nepalese population. Several authors have attempted to determine sexual differences and side differences in course of their research. Evaluation and comparison of present data with the previous study reveals several differences as well as similarities.

Measurements of clavicles in western countries have been studied by Parsons FG, Terry RJ Olivier G and Singh S.<sup>6-10</sup> In India, the subject has been studied extensively by Jit I et al.<sup>4,9,11,12</sup>

### A. Length

In the present study the average length of right clavicle was 143.21  $\pm$ 11.13 mm and the mean length of left clavicles was 145.53  $\pm$ 11.04 mm. Though length of left clavicle was slightly more, it was not statistically significant. This shows that the length of right clavicle was slightly less than that of the left clavicle. The averages were compared to the values recorded in other studies (table-3).

### a. Side and racial differences

In a comparative study of the work of other authors, regarding the average length of the clavicle in large number of racial groups, the length of clavicle was not the same even in closely related racial groups, the average length of the bone was different in different races.

**Table 1. Mean length of clavicle in western population as compared to the present observations in Nepalese population.**

| Population                                   | No. of cases examined |        | Mean length (in mm) |             |              |             |
|--|-----------------------|--------|---------------------|-------------|--------------|-------------|
|  |                       |        | Right               |             | Left         |             |
|  | Male                  | Female | Male                | Female      | Male         | Female      |
| English (Parsons FG) <sup>6</sup>            | 50                    | 50     | 152                 | 138         | 154          | 139         |
| U. S. A Negroes (Terry RJ) <sup>7</sup>      | 50                    | 50     | 153.30±0.83         | 140.98±0.76 | 155.86±0.92  | 141.78±0.03 |
| French (Olivier G) <sup>8</sup>              | 110                   | 60     | 154.20              | 137.90      | 155.00       | 138.70      |
| U. S. A. Whites (Terry RJ) <sup>7</sup>      | 50                    | -      | 152.90±0.88         | -           | 154.10±0.91  | -           |
| U. S. A. Whites (Singh S) <sup>10</sup>      |                       | 230    | 151.40              | 133.68      | 153.37       | 134.84      |
| U. S. A. Negroes (Singh S) <sup>10</sup>     |                       | 80     | 155.72              | 157.32      | 137.60       | 140.80      |
| Present study findings (Nepalese population) |                       | 257    | 143.21±11.13        |             | 145.53±11.04 |             |

**Table 2. Mean values of the length of clavicle in different zones of India.**

| Zone   | No. of cases examined |        | Mean length (in mm) |             |              |             |
|--|-----------------------|--------|---------------------|-------------|--------------|-------------|
|  |                       |        | Right               |             | Left         |             |
|  | Male                  | Female | Male                | Female      | Male         | Female      |
| Amritsar zone (Jit I et al) <sup>4</sup>     | 236                   | 112    | 145.58±8.60         | 130.36±9.11 | 147.59±9.25  | 129.80±1.77 |
| Chandigarh zone (Jit I et al) <sup>12</sup>  | 280                   | 80     | 148.00±8.60         | 132.40±8.40 | 149.80±8.40  | 134.00±8.10 |
| Chandigarh zone (Kaur H et al) <sup>14</sup> | 748                   | 252    | 149.40±8.91         | 134.53±9.68 | 151.14±8.72  | 136.21±9.64 |
| Varanasi zone (Singh et al) <sup>15</sup>    | 97                    |        | 141.49±8.22         | 125.78±7.50 | 144.18±8.01  | 127.77±8.09 |
| Present study findings (Nepalese population) | 257                   |        | 143.21±11.13        |             | 145.53±11.04 |             |

**Table 3. Statistical measurements of the length of clavicles (n=257).**

| Measurements                     | Right                                  | Left                                   |
|----------------------------------|--|--|
| Numbers                          | 135                                    | 122                                    |
| Range                            | 108-178 mm                             | 111-181 mm                             |
| Mean                             | 143.21 mm                              | 145.53 mm                              |
| Standard deviation(S.D.)         | 11.13                                  | 11.04                                  |
| Mean±3 S.D. (Range)              | 109.82-176.60 mm                       | 112.41-178.65 mm                       |
| Demarking points                 | Male= >176.60 mm<br>Female= <109.82 mm | Male= >178.65 mm<br>Female= <112.41 mm |
| Percentage clavicles beyond D.P. | Male= 13.33%<br>Female= 4.44%          | Male= 16.39%<br>Female= 9.83%          |
| 'P' value                        | 0.096                                  | 't' value 1.673                        |

The length of the clavicle as recorded by different workers in western countries and as found by workers in India are given in Tables-1 and 2.

In England, the average length of the clavicle was 145 mm on the right side and 146.50 mm on the left side which were higher than the value got in the present study.<sup>6</sup> Therefore, the clavicle of Nepalese population was shorter than the clavicle of English population. This also suggested that the left clavicle was longer than the right clavicle which was in accordance with the present study.

The average length of the clavicle was 147.14 ±0.79 mm on the right side and 148.82 ±0.47 mm on the left side in American Negroes and 152.90 ±0.88 mm on the right side and 154.10 ±0.91 mm on the left side in American whites.<sup>7</sup> The findings of the present study were very less than the

findings of Terry. Therefore, the clavicle of the Nepalese population was shorter than the clavicle of the American Negroes and whites. This also suggested that the left clavicle was longer than the right which was in accordance with the present study.

In France, the average length of the clavicle was 146.05 mm on the right side and 146.85 mm on the left side which was more than the value got in the present study.<sup>8</sup> Therefore, the clavicle of the Nepalese population was shorter than the clavicle of the French population. This also suggested that the left clavicle was slightly longer than the right which was in accordance with the present study.

The mean length of the clavicle of Amritsar zone was 137.97 ±8.85 mm on the right side and 138.69 ±5.51 mm on the left side which were shorter than the value got in the present study.<sup>4</sup> Therefore, the clavicle of the Nepalese population was longer than the clavicle of the Amritsar zone. This also suggested that the left clavicle was slightly longer than the right which was in accordance with the present study.

The average length of the clavicle of Varanasi zone was 138.63 ±7.85 mm on the right side and 135.97 ±8.5 mm on the left side which was less than the value got in the present study.<sup>13</sup> Therefore, the clavicle of the Nepalese population was longer than the clavicle of the Varanasi zone. This also suggested that the left clavicle was longer than the right which was in accordance with the present study.

In American Negroes, the average length of the clavicle was 146.66 mm on the right side and 149.06 mm on the left side which were more than the value got in the present

study.<sup>10</sup> Therefore, the clavicle of the Nepalese population was shorter than the clavicle of the American Negroes. This also suggested that the left clavicle was longer than the right which was in accordance with the present study. The average length of them clavicle in American whites which was 142.54 mm on the right side and 144.10 mm on the left side which were less than the value got in the present study.<sup>10</sup> Therefore, the clavicle of the Nepalese population was longer than the clavicle of the American whites. This also suggested that the left clavicle was longer than the right which was in accordance with the present study.

The average length of clavicle of Chandigarh zone was 140.20 ±8.50 mm on the right side and 141.90 ±8.50 mm on the left side which were less than the value got in the present study.<sup>12</sup> Therefore, the clavicle of the Nepalese population was longer than the clavicle of the Chandigarh zone. This also suggested that the left clavicle was longer than the right which was in accordance with the present study.

The average length of the clavicle of Chandigarh zone was 141.86 ±9.29 mm on the right side and 143.80 ±9.18 mm on the left side which were less than the value got in the present study.<sup>14</sup> Therefore, the clavicle of the Nepalese population was longer than the clavicle of the Chandigarh zone. This also suggested that the left clavicle was longer than the right which was in accordance with the present study.

Therefore, the present observations showed that in various zones of India the length of the clavicle were different; the clavicle of the Nepalese population were longer than Varanasi zone, Amritsar zone and Chandigarh zone but shorter than those of American whites and Negroes, English and French population. These differences in length of the clavicles in the four zones in India may be due to the fact that the present people of Nepal are better fed and healthier than those of Varanasi zone.

Olivier G found that the French left clavicle was longer than the right clavicle.<sup>8</sup> Similar observations were obtained by Jit I et al; they noted that the left clavicle was longer than the right clavicle by 0.5 mm to 22.5 mm in 63.3% paired male clavicles in Amritsar zone.<sup>4</sup> Singh S et al in Amritsar zone observed that the left clavicle was usually longer than the right clavicle.<sup>15</sup> Singh S et al in Varanasi zone also found that the mean length of the left clavicle of male and female clavicle was longer than that of the right clavicle.<sup>13</sup> Similarly, observations made by Jit I and Sahni D in Chandigarh zone concluded that the left clavicle was longer than the right in 60% instances and both clavicles were equal in length in 30% clavicles.<sup>12</sup> The left clavicle was longer in the right handed persons. Kaur K et al found that in Patiala zone the left clavicle was longer than the right clavicle.<sup>16</sup> Kaur H et al observed that the length of left clavicle was longer than the right in 61.6%; the right was longer in 24.7% and both the clavicles were of equal length in 13.6% cases.<sup>14</sup>

The findings of the present study also supported the findings

of various authors that the left clavicle was usually longer than the right clavicle. Explanation for this observation was not forthcoming till Kaur H et al reported that greater curvatures in the right clavicles were responsible for its being shorter than the left clavicles. However, curvilinear length of the right clavicle was longer than that of the left clavicle.<sup>17</sup>

According to Trotter M et al, the human clavicle is described as a long bone which has a shaft and two ends, the right sided bones of the limbs are usually longer than those of the left side.<sup>3</sup> The finding of the present study was not in accordance with previous study.

#### **b. Determination of sex**

In the present study, only 13.33% male and 4.44% female can be determined from right clavicles of the present series; sexing on this basis is not possible in 82.23%. From left clavicles, 16.39% male and 9.83% female can be determined in the present series; sexing on this basis is not possible in 73.78%.

Kaur K et al. reported that 18% male and 3% female were determined from right clavicles; 19% male and 3% female were determined from left clavicles.<sup>17</sup> The percentage of male were more than the value got in the present study but percentage of female were less than the value got in the present study.

Jit I et al observed that 8.3% male and 13.7% female were determined from right clavicles; 19.8% male and 11.5% female were determined from left clavicles.<sup>4</sup> The percentage of male were less than the value of the present study of right side but percentage of male and female left side were more than the value got in the present study.

## **CONCLUSION**

The observation in the present study was the left clavicle was longer than the right clavicle. From the observations we infer that with the use of right hand, the curve of the right clavicle became greater than that of left side which led to a shorter right bone as compared to the left. There was no such single character which can determine the sex of all clavicles. Depending on the length alone, the sex can be decided in 13.33% male and 4.44% female right clavicles and 16.39% male and 9.83% female bones if the left clavicle is considered.

The determination of sex from the clavicle has a great medico legal significance to the toxicologists. It also helps the anthropologists in their study of evolution of mankind and migration of races.

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