Morphometric Study of Clavicle of Eastern Indian Population

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Abstract:
The clavicle is a modified long bone. It’s morphology is important in determining upper limb locomotion behaviour. The morphometric parameters of this bone vary between left and right sides and also between races and sex. It is a commonly fractured bone. Improved benefits derived from use of fixatives have resulted in renewed interest in interventional procedures in clavicle fracture. The knowledge of variations of curvatures and other parameters is indispensable for designing the intra-medullary and external fixatives.

Key words: clavicle, length of clavicle, midshaft-circumference.

INTRODUCTION
The clavicle is known as collar bone. It is also denoted as the beauty bone because it’s visibility depicted the so called skinny beauty of female. The bone has a double curvature in horizontal plane, hence the name (clavis =a key & icle = a diminutive, i.e a little key. Roman key was ‘s’ shaped.). Clavicle is one of the bones of shoulder girdle in humans and in those mammals who use their hands for prehension. It has no homologue in pelvic girdle. It is the first bone to start ossification in 5th or 6th week of intrauterine life and last bone to complete ossification usually after 21 years.

This is a horizontally placed modified long bone. It has a shaft and two ends, sternal end and acromial end. The shaft is gently curved resembling letter ‘f’ with convexity forwards in medial two thirds and concavity forwards in lateral one thirds.1 The shoulder complex includes three bones, those are scapula, clavicle, and humerus and more than 20 muscles. The clavicle has been considerably less studied from a comparative perspective than humerus and scapula. The bone is longer in broad shouldered male and curvatures are more pronounced than in females.

Clavicle fracture is a very common type of injury, and the break is always between costoclavicular and coracoclavicular ligaments, each of which is stronger than the clavicle itself. The fracture occurs most frequently (80-90%) in the middle third. Conventionally clavicular fracture was treated conservatively. But, there is increasing recognition of the morbidity associated with displaced fracture and also increased rate of non-union of fractures of this zone. The increased benefits derived from fixation have resulted in renewed interest in fixation of clavicle fractures.2

Various studies have shown that the length and curvatures of clavicle varies between left and right sides. This is usually significant in case of adults.3 The length of adult left clavicle is more than that of right side. In foetuses, newborns and children, the bone of any side may be longer than the other side. With the use of right hand, the
The curvature of the right clavicle in adults becomes greater than that of the left side which leads to a shorter right bone compared to the left one.\textsuperscript{4,5,6}.

Professor F.G. Parsons\textsuperscript{7} (1916) did his renowned work on proportions and characteristics of modern English clavicles and found that the length of the left-sided clavicles were greater by few millimetres than that of the right-sided bone. The left clavicle was longer than the right one in 50\% instances. In 34\% cases the right bone was longer and in 12\% both were equal.

The variations in dimensions and contour of the clavicle among different groups of population from different races point towards the implication of this bone in determination of identity (e.g. race, sex, stature, etc.) from skeletal remains. Recently, this bone has drawn the attention of many researchers because the line of treatment of clavicular fracture has shifted from conservative mode to interventional techniques. That is why it has become necessary for the orthopaedic surgeons to have a clear idea about the variations in morphometry of this bone.

Mohsin et al\textsuperscript{3} found in his study of foetal clavicles, that only the mid-shaft parameters showed right dominance in early foetal life and left dominance in late foetal life. However, in adulthood, the right clavicle is usually shorter and stronger than the left one. Hence, whatever bilateral variations are observed in adult clavicle are due to factors which play their role after birth.

Terry (1932)\textsuperscript{8} made his study among American Negroes & American Whites. He noted that in male and female negroes & in male whites, the left bone was longer. The clavicles of negroes were longer than those of whites. Oliver (1951)\textsuperscript{9} studied clavicles of the French people and observed that the left clavicle was longer. He pointed out that the length of the clavicle was not the same even in closely related racial groups, the average length of the bone was different in different races.

A study done by Kaur, Harjeet, Sahani, Jit\textsuperscript{4} among the north west Indians showed that the length of adult clavicle is more on the left than right. This difference was not present in foetuses, newborn and children. With continued use of right hand, the curve of right clavicle in adults become greater than that of left side which led to a shorter right bone. Nagarchi et al\textsuperscript{10} found the average length of male clavicle was 142.90 +/- 10.59 mm and average mean length of female clavicle was 132.30 +/- 10.44 mm. Hiren et al\textsuperscript{11} studied 213 adult clavicles in Gujarati population. Their objective was to find out comparative differences between right and left clavicles from certain metrical parameters. From this study they concluded that, the left clavicle was longer than the right one. Depending on length only, sex could be determined in 3.13\% males and 2.08\% females from right clavicles and 1.71\% male and 1.71\% female from left clavicles.

The ancient Egyptians were the first to report on management of clavicle injuries. Reports of non-operative management of clavicle fracture dates back to Edwin Smith Papyrus written in 17\textsuperscript{th} century BC. Hill et al\textsuperscript{12} published one of the first studies regarding treatment of fracture clavicle in 1997. They found that adult patients with completely displaced middle third clavicle fracture treated non-operatively had a non-union rate of 15.3\% which was considerably higher than previously reported rates.

This non-union was significantly associated with initial fracture shortening of more than 2cm. Jonathon et al\textsuperscript{13} concluded in their study that, many clavicle fractures though undergo bony union when treated non-operatively, an at risk population exists with displaced, comminuted mid-shaft clavicle fractures that have higher rates of non-union compared to historical figures. Factors associated with poor functional
outcomes as well as non-union in these injuries include fracture displacement, fracture comminution, female gender and advancing age.

In a multicenter randomised control trial undertaken by Canadian Orthopaedic Trauma Society, the workers found that operative fixation of a displaced fracture of clavicle results in improved functional outcome and a lower rate of mal-union and non-union compared with non-operative treatment at one year of follow up.

This study supports primary plate fixation of completely displaced mid-shaft clavicular fracture in active adult patients. Carre et al in a survey opined that there is significantly (p less than 0.01) predictive physician preference towards operative fixation in angulated, displaced, and isolated segmental clavicle fractures in older adolescents. They also suggested that randomised controlled trials are needed to evaluate the efficacy of primary operative fixation of mid-shaft clavicle fracture in adolescent population.

Yang et al also opined that adolescent clavicle fracture is being increasingly treated with open reduction and internal fixation, specially in 15 to 19 years age group.

By comparing the studies done by previous workers, it is quite evident that there is racial and sexual variations of measurement & contour of clavicles. These variations are obvious between the left and right sided clavicles. Such variations call for more research in this field to provide ample data for proper designing of intramedullary devices and other fixatives for interventional management of clavicular injury with least chance of failure.

AIMS AND OBJECTIVES.
The aim of this study is to make a comparison between length, mid-shaft circumference and weight of right and left clavicles among a defined population.

With regard to the change in protocol of surgical treatment of clavicular fracture, a clear idea about the variations in dimensions and parameters of clavicle of right and left side will be helpful in orthopaedics fields.

The studies performed among various populations of varied countries and origin, have shown that there are variations in dimensions and contours of left and right clavicles. So, addition of few more pages to the literature of our predecessors will help in anthropological studies and to analyse and compare the result of present study with that of the previous ones.

SPECIFIC OBJECTIVES
1. To determine the length, weight & mid-shaft circumference of the clavicle.
2. To ascertain any variations in parameters between left & right sided clavicles.

MATERIALS AND METHOD.
The study was done by measuring 156 clavicles of both right & left sides. Among them, 73 were right sided and 83 were left sided. The samples were collected from Department of Anatomy, Nilratan Sircar Medical College, SSKM & IPGMER, Calcutta Medical College and R.G.KAR Medical College. Students of First Professional MBBS course of N.R.S.M.C&H also provided bones from their own collection. The morphometric study was done in NRS Medical College and data were collected on various parameters. The samples were collected by simple random method and the study design is observational quantitative type.
INCLUSION CRITERIA

Dry adult clavicles were taken for measurements. The bones had completed ossification and without any deformity or signs of injury, or tumour or other pathological conditions. 73 number of clavicles were right sided and 83 number were left sided. The bones were cleaned and cleared of dust etc and divided into two groups according to the side of the body it belonged to. The different parameters were measured as follows:-

1) LENGTH OF THE CLAVICLE- The maximum length of each clavicle was measured from sternal end to acromial end. Each bone was taken and held in horizontal position and length was measured using Vernier Callipers. Each measurement was repeated twice and average length was recorded. The values for length of left and right sided clavicles and the values were recorded in centimetres in two separate charts.

2) MIDSHAFT CIRCUMFERENCE- The midpoint of the shaft of the clavicle was marked by a marker while measuring the total length of the bone. Then the circumference of that area of the shaft was measured by using a millimetre graph paper. The graph paper was folded into a narrow strip for convenience.
3) WEIGHT OF DRY CLAVICLE- The weight of each dry clavicle was recorded with the help of an electronic weighing machine. The bones were put on a beaker which is a part of the machine. The weight of the beaker was deducted from the measured weight and actual weight was measured and recorded in grams.
RESULTS.

The study done with 156 dry clavicles of both sides and the measurements were done. Data were collected from individual bone and were tabulated.

The results of this study came out to be as follows:

1. LENGTH:

<table>
<thead>
<tr>
<th></th>
<th>RIGHT CLAVICLES</th>
<th>LEFT CLAVICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANGE</td>
<td>9.6-15.2 cm</td>
<td>10.1-15.8 cm</td>
</tr>
<tr>
<td>MEAN</td>
<td>12.43 cm</td>
<td>12.40 cm</td>
</tr>
<tr>
<td>SD</td>
<td>1.37</td>
<td>1.39</td>
</tr>
</tbody>
</table>

p - 0.903

GRAPH-1.

The mean lengths of the right and left sided clavicles as shown in the above table varied only by 0.3mm, right clavicles being slightly longer than left clavicles, though this difference is not statistically significant.
2. MIDSHAFT CIRCUMFERENCE:-

<table>
<thead>
<tr>
<th></th>
<th>RIGHT CLAVICLES</th>
<th>LEFT CLAVICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANGE</td>
<td>1.2-4 cm</td>
<td>1.6-4 cm</td>
</tr>
<tr>
<td>MEAN</td>
<td>3.08 cm</td>
<td>3.13 cm</td>
</tr>
<tr>
<td>STANDARD DEV</td>
<td>0.57</td>
<td>0.48</td>
</tr>
</tbody>
</table>

p - 0.57.

The mean value of mid-shaft circumference of right sided clavicles is 3.08cm and 3.13cm on the left side. This shows a difference of 0.05cm between the two sided bones. But, this difference is statistically insignificant (p-0.57).

1. WEIGHT:-

<table>
<thead>
<tr>
<th></th>
<th>RIGHT CLAVICLES</th>
<th>LEFT CLAVICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANGE</td>
<td>6.7-23.8 grams</td>
<td>5.7-21.1 grams</td>
</tr>
<tr>
<td>MEAN</td>
<td>14.71 grams</td>
<td>13.12 grams</td>
</tr>
<tr>
<td>STANDARD DEV</td>
<td>4.48</td>
<td>4.29</td>
</tr>
</tbody>
</table>

p-0.025
The mean weight of the right sided clavicles was 14.71 grams and that of the left sided was 13.12 grams. The ‘p’ value was 0.025. Therefore, the difference in weights of right and left sided clavicles is statistically significant.

**DISCUSSION**

**LENGTH:**

The comparative study of work of different authors regarding length of the clavicle showed that it varied even in closely related racial groups. The length of the clavicle as recorded by different workers in other countries and India are shown in the following tables.

Mean values of length of clavicle in different countries:

<table>
<thead>
<tr>
<th>Population</th>
<th>Mean length of right clavicles in mm</th>
<th>Mean length of left clavicles in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>French (Oliver G)</td>
<td>146.05</td>
<td>146.85</td>
</tr>
<tr>
<td>U.S. ANegroes(Terry RJ)</td>
<td>147.14</td>
<td>148.82</td>
</tr>
<tr>
<td>U.S. AWhites(Terry RJ)</td>
<td>152.90</td>
<td>154.10</td>
</tr>
<tr>
<td>English(Parsons)</td>
<td>145</td>
<td>146.50</td>
</tr>
<tr>
<td>U.S.A Negroes(Singh)</td>
<td>146.66</td>
<td>149.06</td>
</tr>
<tr>
<td>U.S.A Whites(Singh)</td>
<td>142.54</td>
<td>144.10</td>
</tr>
<tr>
<td>Nepal (Haque et al)</td>
<td>143.21</td>
<td>145.53</td>
</tr>
<tr>
<td>Present study(eastern Indian zone)</td>
<td>124.3</td>
<td>124.0</td>
</tr>
</tbody>
</table>
Mean values of length of clavicle in different zones of India:-

<table>
<thead>
<tr>
<th>Population</th>
<th>Mean length of right clavicles in mm</th>
<th>Mean length of left clavicles in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varanasi zone(Singh et al)</td>
<td>138.63</td>
<td>135.97</td>
</tr>
<tr>
<td>Amritsar zone(Jit et al)</td>
<td>137.97</td>
<td>138.69</td>
</tr>
<tr>
<td>Chandigarh zone(Jit et al)</td>
<td>140.20</td>
<td>141.90</td>
</tr>
<tr>
<td>Chandigarh zone(Kaur H et al)</td>
<td>141.96</td>
<td>143.67</td>
</tr>
<tr>
<td>Gujarat zone(Hiren et al)</td>
<td>142.28</td>
<td>145.14</td>
</tr>
<tr>
<td>Telengana zone(Kamdi et al)</td>
<td>138.71</td>
<td>137.83</td>
</tr>
<tr>
<td>Present study (eastern Indian)</td>
<td>124.3</td>
<td>124.0</td>
</tr>
</tbody>
</table>

In France⁶, the mean lengths of right and left sided clavicles were 146.05 mm and 146.85mm respectively. These values are more than those of present study. Therefore, eastern Indian clavicles are shorter than French clavicles. They found the left clavicles to be slightly longer than right clavicles, which is in contrast to the present study.

Terry⁸ found that, in American negroes, right sided clavicles measured 147.14mm and left sided bones measured 148.82mm. Therefore, the left clavicles were longer than the right clavicles. The values for American whites were 152.9mm on right and 154.1mm on left. In another study done on same group of peoples of America by Singh S et al¹⁷, the values came out to be 146.66 mm and 149.06 mm for right and left sided clavicles of the negroes and 142.54 mm and 144.10 mm for right and left sided bones of the white people. Therefore, all these values show that, American clavicles are longer than eastern Indian clavicles.

From the work of Parsons⁷ on English clavicles, we get the lengths of right and left sided clavicles to be 145 mm and 146.50 mm respectively. Both these values proved the eastern Indian clavicles to be shorter than English clavicles. Parsons also pointed out that the left clavicles were longer than the right ones. But, the present study observed the right clavicles to be slightly longer than the left ones. Unlike the present study, Haque MK et al⁶ observed the lengths of Nepalese clavicles to be 143.21mm on the right side and 145.53 mm on the left side, that is the left bones were longer than the right ones. Also, the mean values of Nepalese clavicles are greater than those of the eastern Indian people.

Many workers studied the morphometry of clavicles in different regions of India. Singh et al¹⁸ recorded the lengths of clavicles of people of Varanasi zone. Mean lengths were 138.63 mm on the right side and 135.97 mm on the left side. Therefore, the right clavicles were found to be longer than the left ones, and this finding is in accordance to the present study. Among the eastern Indian population, the difference between the mean lengths of right and left sided clavicles was 0.3 mm and the difference was statistically insignificant. But, other than these eastern Indian people, the population of Varanasi zone and Telengana zone had longer clavicle on the right side than the left one among the different groups of population studied till date in different regions of India.

The average lengths of clavicles of people of Chandigarh region were recorded in two separate studies done by Jit I et al²⁰ and Kaur H et al⁴. In the first study, the mean length of right clavicles was 140.20
mm and that of left clavicles was 141.90 mm. In the second study, the values were 141.96 mm and 143.67 mm for left and right sided clavicles respectively. All these values are greater than the mean lengths of right and left sided clavicles of the present study, suggesting the clavicles of eastern Indian people to be shorter than that of people of Chandigarh region.

Similar observations were obtained by Jit 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.

Hiren S Chavda et al. studied the lengths of clavicles of Gujarati population and found the mean lengths to be 142.28 mm on right and 145.14 mm on the left. Hence, clavicles of people of this zone of India also, is longer than that of the people of eastern India. The left clavicles of Gujarati people were longer than those of right side, which was also not in accordance to the present study.

According to some of these workers, this bilateral disparity in length in clavicles is due to overuse of right hand, which has made the angulations more acute and shortening in length of right sided clavicles in comparison to left side. The scenario is a bit different in our observation.

We can infer from the present study, that, the clavicles of eastern Indian population can be regarded as the shortest among the clavicles studied till date among different groups of population in India as well as other countries, with a slightly longer bone on the right side.

The right sided clavicles of the present study were found to be longer than those of the left side by 0.3 mm. This difference was statistically insignificant and the clavicles can be regarded to more or less bilaterally symmetrical in length. This finding is similar to the findings in people of Varanasi zone where the right clavicles were found to be longer than left clavicles by 2.7 mm. Kamdi et al., while doing the morphometry of clavicles in Telengana zone, found the right clavicle to be longer by 0.88 mm than the left one.

These findings should be kept in mind while planning surgical management of fracture clavicle. Many clavicle fractures undergo bony union with non-surgical treatment. But, displaced, comminuted mid-shaft clavicular fracture have higher rates of non-union. Operative fixation of a displaced clavicular fracture results in improved functional outcome and a lower rate of mal-union and non-union compared to non-operative treatment.

MID-SHAFT CIRCUMFERENCE:- The mid-shaft circumference was compared between the right and left sided clavicles. The range was 1.2 to 4 cm in the right sided clavicles and 1.6 to 4 cm in case of left sided clavicles. The mean circumference of the right sided bones was 4.48 cm with a standard deviation of 0.57. the values for the left sided bones were 3.14 cm mean and 0.48 standard deviation. The difference was statistically insignificant with a ‘p’ value of 0.57.

Clavicle fracture is very common and most frequently occur in middle third. Besides plating and nailing, an external fixation device can also be effectively employed for middle third fractures. Our results may be of help while during these procedures.

WEIGHT:-

The range of weight measured in grams of individual dry bone ranged from 6.7 to 23.8 grams in case of right clavicles and 5.7 to 21.1 grams in the left sided clavicles. The mean and standard deviations were 14.71 and 4.48 on right side and 13.12 and 4.29 on the left side respectively. With ‘p’ value of 0.025, this difference is statistically significant. Therefore, while designing internal or external fixatives
for treating clavicular fractures, the difference in weight between left and right sided bones must be taken into consideration. A fixation device of improper weight for a bone may not serve the purpose of proper fixation.

The dissertation submitted by Dr Sobha\textsuperscript{22}, contains comparisons between right and left sided clavicles on these parameters of clavicle.

In that study, the mid-shaft circumference of right sided male clavicle ranged between 30-46 mm with a mean of 37.14 mm and standard deviation of 4.10. The right sided female bones ranged between 25.5-41.5 mm with a mean of 30.50 mm and standard deviation of 3.3. The left sided male bones ranged from 30 to 48 mm. the mean and standard deviations were 37.04 mm and 4.2 respectively. Values of left sided female bones were, range 24.5 – 39.5 mm, mean 30.3 mm and standard deviation 3.3. The mean weight of right sided male clavicles was 17.45 grams and of the female bones was 11.32 grams. The left sided clavicles weighed 17.29 grams in case of males and 10.44 grams in case of females.

In the present study of eastern Indian clavicles, the differences between the means of length and mid-shaft circumference of right and left sided clavicles were found to be statistically insignificant. But, the weights of the bones of the two sides showed significant difference. The right sided clavicles of the eastern Indian population were found to be heavier than that of the left ones.

**CONCLUSION**

The study of morphometric analysis of clavicles in Eastern Indian population was done in Department of Anatomy, N.R.S Medical college Kolkata. The bones were collected from N.R.S and other medical colleges of Kolkata and first professional MBBS students of N.R.S Measurements were done on individual bones and data recorded (73 right clavicles and 83 left clavicles, total 156). The various parameters measured were total length, mid-shaft circumference, weight. Statistical analysis was done on the collected data and the values were compared to find out whether the differences were statistically significant or not. The findings were corroborated with the findings of similar studies done by various workers among populations of different zones of India and other countries. Some results were in accordance to the present study and some were not.

We conclude from our study of clavicles of eastern Indian population, that, there is wide variation between the different parameters studied and compared with results obtained from observations of other workers. The eastern Indian clavicles were found to be shortest among all the clavicles studied so far among different groups of populations of India as well as of other countries. This is probably due to short stature. The right sided clavicles were slightly longer than those of the left side. This difference was statistically insignificant and the clavicles can be regarded as bilaterally symmetrical in length. The right sided clavicles were found to be significantly heavier than the left sided bones.

Thus, in our own small way, we have tried to add few pages to the works of our predecessors on morphometry of clavicles and their bilateral variations. These parameters are of great importance while considering surgical fixation. It will also be helpful in anthropology and forensic practices.
REFERENCES.


