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Employing Computed Tomography to Assess Clavicle Symmetry in Healthy Adults in the Indian Population of Dakshina Karnataka

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Abstract

Background The S-shaped collar bone lies horizontally at the root of the neck and is one of the most common bones to fracture. The symmetry of the clavicle bone differs between males and females, so the present study was conducted to assess the symmetry of the clavicle in healthy adults of the Indian population in the Dakshina Karnataka region.

Methods The data for this cross-sectional study were retrospectively collected from 138 adult patients who all underwent chest computed tomography (CT) for clinical reasons. Patients younger than 18 years and those with bony fractures, trauma, or other deformities were excluded. Axial chest CT images were used to trace the anatomy of the clavicle. The curved planar reconstruction technique was used to trace the maximum length of the bilateral clavicle.

Results There were 138 patients of both sexes. Patients ranged in age from 20 to 80 years. The chi-square test was used to investigate whether sex and clavicle symmetry were related. In women, bilateral symmetry and asymmetry were 42.5 and 41.2%, respectively, while in men, they were 57.5 and 58.8%, respectively; hence, there was no significant correlation (p-value = 0.877) between clavicle symmetry and sex. A linear-by-linear association test was performed to ascertain the relationship between the variance in clavicle symmetry and age. It was noted that 51 individuals had asymmetry and 87 had symmetry. The patients were further divided into three age groups. There were 34, 67, and 37 individuals in the 20 to 40, 41 to 60, and 61 to 80 years age groups, respectively. Clavicle symmetry was 27.6% in the 20 to 40 and 61 to 80 age groups and 44.8% in the 41 to 60 age group. The percentages of asymmetry were 19.6, 54.9, and 25.5% in the 20 to 40, 41 to 60, and 61 to 80 years age groups,

Keywords
- curved planar reconstruction
- multidetector computed tomography (MDCT)
- bone symmetry

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respectively, with no correlation between age and clavicle length symmetry (p-value = 0.643).

Conclusion Regardless of age or sex, the population under study had symmetric clavicles. As a result, the assumption of symmetry may be accepted in some clinical scenarios, such as simple fractures, but caution should be exercised when designing fixatives and surgical cases.

Introduction

The clavicle is a long bone that is occasionally pierced by the middle supraclavicular nerve. It is the first bone to start ossifying. It lies horizontally and is embedded subcutaneously throughout its entire length. It functions to support the shoulder in freely abducting the arm. The clavicle has a cylindrical shaft, a flat lateral end that articulates with the acromion process to form the acromioclavicular joint, and a large quadrilateral medial end that articulates with the manubrium sterni at the clavicular notch to form the sternoclavicular joint.[1]

The clavicle is smoother, curved less, shorter, thinner, and lighter in females than in males. Sex determination using the clavicle can be performed more reliably with the mid-shaft circumference and weight assessment of the clavicle. Gender variation in the lateral and medial ends of the clavicle shows that the lateral end in females is slightly below the medial end, while in males, it is at the same level or higher than the medial end.[2] The clavicle, except at its medial end, is the first bone to ossify; it has two primary and one secondary ossification center. The weakest point of the clavicle is the junction between its curvatures, and fractures commonly occur by falling on the outstretched hand.[3]

The secondary ossification center is found at the medial end as the only epiphysis of the bone end. This epiphysis is the last to ossify and fuse at the ages of 18 and 20 years and at the end of 25 to 26 years, respectively.[1,2] There are certain types of clavicular fractures reported in recent studies, which indicates that surgical treatments are the best. This has led to renewed interest in the clavicular anatomy. The anatomy of the clavicle is usually studied with the use of cadaver or bone specimens, but due to its unique anatomical variation, which varies between different races, genders, and ages, these variations must be studied according to the stated factors to manage injury to the clavicle and aid in the manufacturing/design of fixatives or surgical treatment. Computed tomography (CT) studies of the clavicle demonstrate its entire anatomy, and it is suitable for delineating the medullary cavity.[4]

One of the most common injuries, accounting for 5 to 12% of skeletal fractures, is clavicular fracture. Malunion can occur in adults despite various treatment strategies. Shortening of the affected clavicle impairs muscle strength and function of the shoulder.[5] According to the results of the present study, a clavicle shortening of more than 15 to 20 mm is a serious complication that can result in operative management. Several methods of shortening quantification have been reported in the literature, but all the techniques employed assume the clavicle to be symmetrical in determining clavicle shortening.[6] Therefore, to determine the clavicle length, two extremes are taken into consideration: the lateral-most point in the acromioclavicular joint and the medial-most point in the sternoclavicular joint, which define the clavicle length.[7] There is a need to derive a modern standard for assessing the age of individuals due to continuous changes resulting from epidemics such as obesity; similarly, forensic pathologists must study human biological factors that lead to variations in the modern human skeleton. Human nature is variable with regard to climate, race, and other genetic factors; this calls for research to standardize methods to determine variation in the human population.[2] The present study aimed to evaluate clavicle symmetry in the Dakshina Karnataka population using CT. We also investigated the correlation of clavicle symmetry with age and sex. It will be useful in providing a reference to the proportion and magnitude of asymmetry that may be expected in the study population.

Materials and Methods

The present cross-sectional study was conducted on patients who all underwent chest CT on a 64-slice brilliance multidetector CT scanner (Philips, Department of Radio Diagnosis and Imaging, Kasturba Hospital, Manipal, Karnataka, India). A total of 138 patients aged 20 to 80 years according to the convenience sampling technique were included in the study. Patients with a history of trauma or any bony pathology and any CT chest image that did not reveal the entire clavicle or the acromioclavicular or sternoclavicular joint were excluded from the study. Approval was obtained from the Institutional Research Committee, School of Allied health Sciences (SOAHS), and Ethics Committee, Kasturba Hospital. The data were collected with the permission of the Head of the Department, Department of Radio Diagnosis and Imaging, Kasturba Hospital. The confidentiality of all patient information was maintained. CT scans were performed using a routine CT chest protocol. Axial images were acquired. The curved planner reconstruction (CPR) technique was used to acquire the entire length of the clavicle in one image as seen in ►**Fig. 1**. The maximum length of the clavicle was measured through the medullary cavity in the bone window using the available measuring tool and reconstructed in three-dimension (3D) as shown in ►**Fig. 2**. All the measurements were

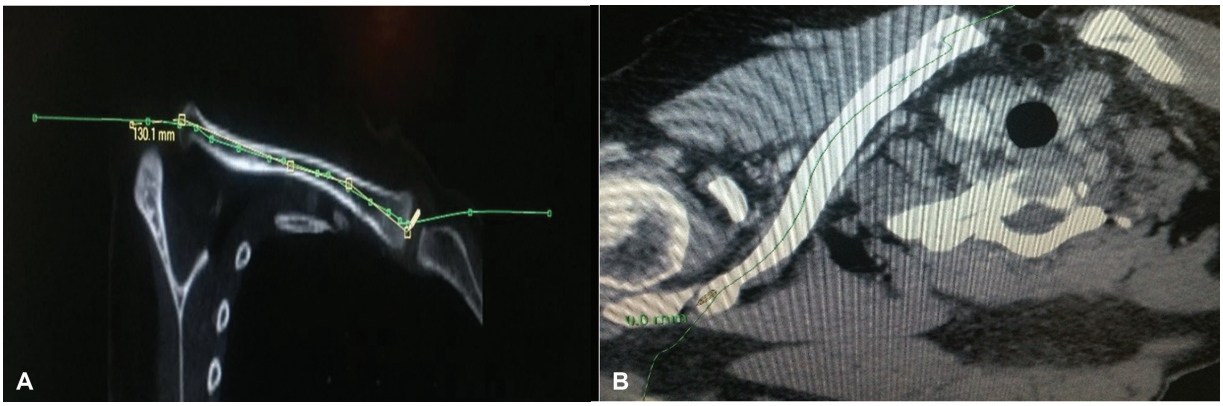

Fig. 1 (**A**) Line drawn on coronal and (**B**) axial section to track the maximum length of clavicle using the curved planar reconstruction (CPR) technique.

tabulated, and the data were analyzed using SPSS version 20. The data were tested using linear and chi-square tests.

Results

Bilateral clavicular length was measured after CPR of plain axial CT images of 138 adult patients of both genders aged 20 to 80 years. Our sample included 80 male and 58 female subjects. To determine the association of clavicle symmetry with sex, statistical analysis was performed using the chi-square test. Bilateral symmetry and asymmetry were found in 42.5 and 41.2% of females and 57.5 and 58.8% of males, respectively. There was no association between sex and clavicle symmetry ($p = 0.877$).

The mean length of the right clavicle was 146.71 mm, with a standard deviation of 12.7, while the mean length of the left clavicle was 148.69 mm, with a standard deviation of 12.58. Symmetry (< 5 mm difference) between the clavicles bilaterally was noted in 87 (63%) of the participants, while 51 (63%) subjects had asymmetry of the clavicle with a difference of > 5 mm. This finding showed that although clavicle symmetry is more prevalent in the research population, a substantial number of individuals experienced asymmetry.

To determine the association between clavicle symmetry variation and age, a linear-by-linear association test was used. Among the study participants, 87 had symmetry and 51 had asymmetry. The subjects were grouped into three age groups for the analysis. The numbers of participants in the 20 to 40, 41 to 60, and 61 to 80 age groups were 34, 67, and 37, respectively. The clavicle symmetry in the 20- to 40-year-old and 60- to 80-year-old age groups was 27.6%, while 44.8% symmetry was noted in the 40- to 60-year-old age group. Asymmetry was found to be 19.6, 54.9, and 25.5% in the 20- to 40-, 41- to 60-, and 61- to 80-year-old age groups, respectively. The test results for the association of clavicle symmetry with age revealed that there was no association between age and the symmetry of clavicle length (p-value $= 0.643$).

The clavicle symmetry percentage in 50 males and 37 females were 57.5 and 42.5%, respectively, while the clavicle asymmetry percentage in 30 males and 41 females was determined to be 58.8 and 41.2%.

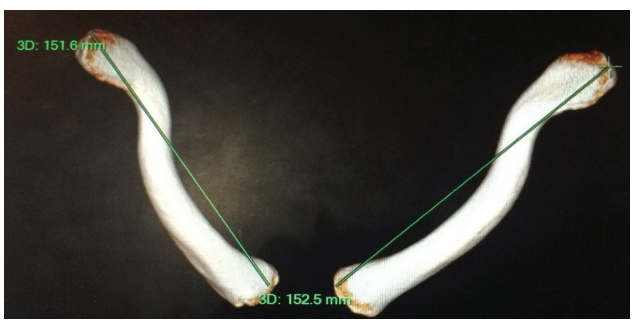

Fig. 2 Three-dimensional (3D) reconstructed image of bilateral clavicle for measuring the maximum length of the clavicle.

Discussion

The results of the present study showed that irrespective of age or sex, there was slight bilateral variation in clavicle length, which was in agreement with several published articles. Similar results were reported by King et al. In their study, in 66 of 101 (65%) patients, the average bilateral clavicle length difference in men was 4.55 mm, while in women on average, the right and left clavicular length difference was 3.14 mm, but slight variation was noted in the current study.[8] The present study revealed that the left clavicle was slightly longer than the right, with a difference of 1.98 mm. Similar findings were reported in some studies in which the left clavicle was longer than the right in both genders.[8,9] In another study by Khaleel et al the left clavicle was 1.6 mm longer than the right.[10] In addition, Benjamin et al reported that the length of the left clavicle was greater than that of the right clavicle, which resulted in significant asymmetry in the clavicle length.[11] This might favor the current study in which the left clavicle was mostly longer than the right clavicle.

The present population-specific study showed that there might be a difference in the average mean length of the clavicle depending on the population studied. Similar findings were observed in a study conducted by Khaleel et al who reported that the right and left average mean clavicle lengths of males were 142.10 ± 11.70 and 143.8 ± 9.55 mm,

respectively. The female average mean clavicular length was 131.12 ± 12.22 mm on the right and 131.10 ± 9.02 mm on the left. In their study, King et al reported that on average, the length of male clavicles was 156.87 mm, while that of female clavicles was 145.79 mm. Generally, the average clavicular length was 151.15 mm, with acromial and sternal curvatures of 133 and 146 degrees, respectively.[8]

Khaleel et al and King et al reported similar findings to those of Trinkaus et al regarding the variation in male and female clavicular length; in all their findings, it was evident that males had longer clavicular lengths than females,[8,10,12] while in the present study, the average clavicular length, irrespective of sex, was 147.75 mm. Bernat et al reported that the mean clavicular length was 149.4 ± 10.3 mm. The female clavicle was significantly shorter than the male clavicle (151.0 ± 8.2 and 166.8 ± 7.3 mm, respectively). Additionally, the left clavicles were significantly longer (159.8 ± 10.9 mm) than the right clavicles (158.0 ± 11.2 mm).[13]

Limitations and Recommendations

The need for further investigation to compare clavicle symmetry measurements using axial CT reconstructed images (multiplanar reformations) and 3D volume-rendered images is advised, as a wide discrepancy in length measurements between the two methods was noted during this pilot study. Geographically, population-specific symmetry of the clavicle should be documented as there is slight difference noted when comparing the present study mean clavicle length and other population.

Conclusion

The findings of this study revealed that the clavicle is symmetric according to the population studied, irrespective of age or sex. Therefore, the assumption of symmetry might be accepted in some clinical scenarios, such as simple fractures, but in the construction of fixation devices and surgical cases, caution should be taken because there is a significant number of individuals with an asymmetric nature; similarly, in the case of any anthropometric or forensic study, the symmetry of the clavicle might not be used as a basis for sex or age determination based on the present geographic population studied.

Conflict of Interest
None declared.

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