

# Morphometry of Clavicle

Khaleel Nagarchi<sup>1</sup>, Jayachandra Pillai T<sup>2</sup>, Shaik Hussain Saheb<sup>3</sup>, Khalid Brekeit<sup>4</sup>, Mohammad alharbi<sup>5</sup>

<sup>1</sup> Assistant professor, <sup>4</sup> Chairperson  
Department of Anatomy & Cell Biology,  
College of Medicine, Al-Imam Muhammad Ibn Saudi Islamic University,  
Riyadh 13317-4233, Saudi Arabia.

<sup>2</sup> HOD & Professor of Anatomy,  
SV Medical College, Tirupathi, India -517507.

<sup>3</sup> Assistant Professor of Anatomy,  
JMM Medical College, Davngere, India -577004.

<sup>5</sup> Assistant Professor of General Surgery  
Vice Dean of Administrative Affairs,  
College of Medicine, Al-Imam Muhammad Ibn Saudi Islamic University,  
Riyadh 13317-4233, Saudi Arabia.

## Abstract

**Background** - The clavicle is a complex bone structure, which has been globally studied in purpose of generating a suitable, correct and economical treatment of clavicle fractures. For measurement of clavicle there are several methods includes hand measurements, 2D and 3D measurements. The most expressive variations are the length and width. Variations in bending in the axial plane are present, especially at the acromial end. Curvature variation is present in lesser degree. Anatomical variations in the clavicle of relevance to form intramedullary fixation.

**Objectives** - The purpose of this study was to measure length, medial angle and lateral angles. To know about comparative differences between curvatures of the right and left clavicles.

**Methods** - 320(185 male and 135 females) clavicles used for this study collected from the first year M.B.B.S student from different medical colleges in south India during the period 2007 - 2012. These angles were measured with the help of a protractor.

**Results** - The average mean length of male was  $142.90 \pm 10.59$ mm, the average mean length of female was  $132.30 \pm 10.44$ mm. The average mean length of right male clavicle was  $142.10 \pm 11.70$ mm and left was  $143.8 \pm 9.55$ mm. The average mean length of right female clavicle was  $131.12 \pm 12.22$ mm and left was  $131.10 \pm 9.02$ mm. The range of medial angle of right clavicle was  $136^\circ$  to  $163^\circ$  and left was  $135^\circ$  to  $166^\circ$ . The range of lateral angle of right clavicle was  $122^\circ$  to  $162^\circ$  and left was  $126^\circ$  to  $168^\circ$ .

**Conclusion** - The measurements of clavicles helps for orthopaedic surgeons, anatomists and anthropologists.

**Key words** - Clavicle, Medical Angle, Lateral angle, Clavicle length.

## INTRODUCTION

The human clavicle is described as a long bone. It has a shaft and two ends that are sternal and acromial ends. The shaft is gently curved with convexity forwards in its medial two-thirds and concavity forwards in its lateral third. The clavicle is thicker and more curved in manual workers and its ridges for muscular attachment are better marked[1,2]. Clavicle fractures are common and occur most frequently (80-85%) in the middle third. Although usually treated conservatively, there is increasing recognition of the morbidity associated with displaced fractures, and also of the increased rate of non-union of fractures in this zone. The improved benefits derived from fixation have resulted in renewed interest in fixation of clavicle fractures. While plating and nailing have been popularised, an external fixation device can also be effectively employed for the midthird fractures as reported by Schuind, Demiralp, Tomic and others[3,4,5].

Recent studies have shown the efficacy of open reduction and internal plate fixation with high union rate and low complication rate. Several complications like lack of fixations, breaking or loosening of the plate happen [6,7,8]

and are partially due to bending of a straight plate. We believe that a set of osteosynthesis plates that is adapted to the shape variation of the human clavicles will not only reduce these complications but will also minimize the amount of bending required to adapt a plate to a specific clavicle during surgery.

In Primates, the shoulder complex includes 3 bones that are scapula, clavicle, and humerus, more than 20 muscles, the exact number depending on the particular species and 4 joints working together. The clavicle has been considerably less studied from a comparative perspective than has the humerus and scapula. Clavicle morphology is important element to determining upper limb locomotion behaviour. The design of fixation devices depends to a large extent on the anatomical and physical characteristics of this bone. In order to get data on the normal variation of the dimensions of the clavicle to assist with design, the previous studies reported that the physical characteristics and appearance of the clavicle to assist with gender identification and length[9,10]. The clavicle having two curvature that are lateral and medial curvatures. Lateral curvature is shorter and medial curvature is longer and shows a slight

difference between genders. The main differences are the length and diameter. In the sagittal plane, the lateral end has an elliptic shape, which becomes circle shaped in the medial end. The inflection point lies around the thinnest point of the bone. The main difference in curvature lies at the lateral side. Attention to the length and curvature is needed when using a plate and to the width and diameter when using an intramedullary nail. The purpose of this study was to measure length, medial angle and lateral angles. To know about comparative differences between curvatures of the right and left clavicles.

#### MATERIALS AND METHODS

320(185 male and 135 females) clavicles used for this study collected from the first year M.B.B.S student from different medical colleges in south India during the period 2007 – 2012. These angles were measured with the help of a protractor.

#### RESULTS

The average mean length of male was  $142.90 \pm 10.59$ mm, the average mean length of female was  $132.30 \pm 10.44$ mm. The average mean length of right male clavicle was  $142.10 \pm 11.70$ mm and left was  $143.8 \pm 9.55$ mm. The average mean length of right female clavicle was  $131.12 \pm 12.22$ mm and left was  $131.10 \pm 9.02$ mm. The range of medial angle of right clavicle was  $136^{\circ}$  to  $163^{\circ}$  and left was  $135^{\circ}$  to  $166^{\circ}$ . The range of lateral angle of right clavicle was  $122^{\circ}$  to  $162^{\circ}$  and left was  $126^{\circ}$  to  $168^{\circ}$ .

#### DISCUSSION

The clavicle is considered a long bone as it has a medullary cavity and an epiphysis at either end to permit growth. The clavicle is the first fetal bone to undergo primary ossification, and its medial epiphysis is the last to fuse. However, whereas other long bones undergo initial endochondral ossification, the clavicle ossifies via intramembranous ossification with no prior endochondral ossification. The two primary ossification centers appear by the 6th week intrauterine and fuse together about one week later. After the osteoid matrix is laid down, cartilage appears at the acromial and sternal ends of the bone, at which point growth becomes a combination of endochondral and membranous ossification. The medial cartilaginous mass contributes more to clavicular growth in length than does the lateral mass, perhaps as much as 80% of the bone length. The combination of the spatial location of the two ossification centers at either end of the bone and endochondral ossification at these sites gives the clavicle its unique s-shape by 8-9 prenatal weeks. The bone attains its adult form by 11 prenatal weeks. Growth slows after birth until the growth spurt between 5 and 7 years, then slows again until the pubertal growth spurt. During adolescence secondary ossification centers appear at the medial and lateral ends of the clavicle. Medial epiphyseal ossification begins at the onset of puberty, but the medial epiphysis does not fuse to the shaft completely until some 10 years after its initial appearance. Consequently, medial epiphyseal fusion has proven useful in estimating skeletal age in young adults. The epiphysis appears initially as a small speck of bone in the center area of the sternal end and

spreads until it nearly covers the entire medial surface. The timeline for clavicular maturation: a well-defined medial flake appears between 16 and 21 years; the flake covers the majority of the medial surface between 24 and 29 years; complete fusion occurs between 22 and 30 years[11].

According to Toon Huysmans et al, the most expressive variations are the length and width. Variations in bending in the axial plane are present, especially at the acromial end. Curvature variation is present in lesser degree. The average length is  $163 \pm 11$  mm for the general population,  $169 \pm 10$  mm for the male and  $154 \pm 8$  mm for the female population. The left clavicle is on average 1.6 mm larger than the right one. The biggest diameter is at the extremities, which decrease towards the middle. The difference between the genders is 1.5-2 mm. The smallest average diameter is  $12 \pm 1$  mm and is aligned with the inflection point. The axial diameter is up to 50% bigger laterally and 10% smaller medially. The lateral curvature is shorter and, in males, is more accentuated. The medial curvature is longer and shows a slight difference between genders. The main differences are the length and diameter. In the sagittal plane, the lateral end has an elliptic shape, which becomes circle shaped in the medial end. The inflection point lies around the thinnest point of the bone. The main difference in curvature lies at the lateral side. Attention to the length and curvature is needed when using a plate and to the width and diameter when using an intramedullary nail[12].

According to J Walters study the mean angle differences between the medial and lateral ends of the clavicle to the shaft were  $25.2^{\circ}$  and  $35.8^{\circ}$  for the medial and lateral angles respectively.

The same study divided the clavicle as five zones as follows. Zone I is represent the medial and lateral ends of the clavicle. Zone II point which represents the lateral most extent of the insertion of the sternocleidomastoid muscle superiorly, and sternoclavicular ligament inferiorly, Zone III is point at the junction of the medial and middle thirds of the clavicle. Zone IV is the junction of the middle and lateral thirds of the clavicle. Zone V is the midpoint of the outer third where a significant change of cross-sectional profile occurs between zones IV and V. The author believed that the zone categorisation to be relevant in order to define the ideal area for the attachment and design of a fixation device. According to author the knowledge of the appropriate area for fixation and the length of bone available for application of a fixation device are vital to optimal design of an external fixation device. In same study found that the average length available for application of a device is 40 to 60 mm, but laterally this may be limited to 40 to 55 mm as defined by zones I and II and zones IV and V respectively. The cross-sectional profile will also influence the ease or difficulty with which an external fixation device can be securely applied. From the cross-sectional profile it can be seen that zones I and II, the medial end, can be consolidated into one group with the profile being overwhelmingly tubular or somewhat quadrilaterally faceted, lending it to a variety of fixation

options and inclinations. At the other end, the lateral end is flattened supero-inferiorly and fixation is more intuitively restricted to perpendicular to the superior/ inferior surfaces. In its mid portion the clavicle undergoes a transition from a faceted surface to a more rounded or ovoid profile which favours anterior and superior placement of a fixation device[13].

In present study the average mean length of male was  $142.90 \pm 10.59$ mm, the average mean length of female was  $132.30 \pm 10.44$ mm, our results are near to studies of following, The overall length of the clavicle measured in this study of J Walters was 150.1 mm by direct dry bone measurement. Ahmad et al who recorded a mean length of 136.2 mm and range was 112.6–172.0 mm in a radiographic study[14], Gumina et al who recorded a mean of  $138 \pm 12.3$ mm[15] and Galley et al was 138.4mm and range was 113.8–167.6mm in wet cadaver dissections[16].

According to study of Parsons FG, the medial angle of English clavicle was  $154^\circ$  on the right side and  $154^\circ$  on left side. In same study found that the lateral angle of clavicle was  $149^\circ$  on right and  $149.5^\circ$  on left side, same study also calculated the sum of both angles of the clavicle was  $302.5^\circ$  on right and  $303.5^\circ$  on left side[17]. In study of Terry RJ found that the mean medial and lateral angles of clavicle of American Negroes were  $152.32^\circ$  and  $141.24^\circ$  on the right and  $152.60^\circ$  and  $144.68^\circ$  on the left side respectively. The same study also calculated the average sum of both angles was  $292.94^\circ$  on the right and  $296.42^\circ$  on the left side[18]. The study Kaur H et al recorded that the average medial angle of clavicle was  $151.68^\circ$  on the right and  $151.89^\circ$  on the left side, the side differences in the mean medial angle on the two sides were statistically insignificant. Same study recorded that the average lateral angle of the clavicle of the north-west India was  $143.96^\circ$  on right and  $148.46^\circ$  on the left side. They also recorded that the sum of the angle of the clavicle of the north-west Indian was  $292.55^\circ$  on right and  $297.18^\circ$  on the left side[19]. The morphometric values of clavicle helps for orthopaedic surgeons, anthropologists, forensic and anatomy practice.

## REFERENCES

1. Trotter M, Peterson RR. Morri's Human Anatomy. B.J. Anson (ed). 12th edition, 244 McGraw Hill, New York. 1966:24.
2. Johnson D, Ellis H. Gray's Anatomy. 39th edition. 2005:817-818.
3. Schuind F, Pay-Pay E, Andrianne Y, Donkerwolcke M, Rasquin C, Burny. External fixation of the clavicle for fracture or non-union in adults. *J Bone Joint Surg Am* 1988 Jun;70(5):692-5. Demiralp B, Atesalp AS, Sehirlioglu A, Yurttas Y, Tasatan E. Preliminary results of the use of Ilizarov fixation in clavicular non-union. *Arch Orthop Trauma Surg* 2006 Aug;126(6):401-5.
4. Tomić S, Bumbasirevic M, Lesić A, Bumbasirević V. Modification of the Ilizarov external fixator for aseptic hypertrophic nonunion of the clavicle: an option for treatment. *J Orthop Trauma* 2006 Feb;20(2):122-8.
5. Hill J.M., (1997) *Journal of Bone Joint Surgery*, 79-B, 69-74.
6. Verborgh O., Pittoors K., *Acta Orthop. Belg.*, 2005, Vol. 71, 17-21.
7. Der Tavitian J., (2002). *Injury: International Journal of Care Injured*, 33, 135-143.
8. McCormick WF, Stewart JH, Greene H. Sexing clavicles using length and circumference measurements. *Am J Forensic Med Pathol* 1991 Jun;12(2):175-81.
9. Jit I, Singh S. Estimation of stature from clavicles. *Indian J Med Res* 1956 Jan;44(1):137-55.
10. Natalie Renee Shirley . Age And Sex Estimation From The Human Clavicle: An Investigation Of Traditional And Novel Methods. U.S. Department of Justice. Document number . 227930(2007).
11. Toon Huysmans, Wilrijk Francis van Glabbeek, Jan Sijbers, Romulo Pinho, Jan L Gielen, Amit Bernat. Exploring the Clavicle: Morphometric Differences Using a 3D Model. Poster Number: P308/Location: Venetian/Sands EXPO Hall D.
12. J Walters, M Solomons, S Roche. A morphometric study of the clavicle. *SA Orthopaedic Journal*. Spring 2010; 47 -52pp.
13. Ahmad M, Trehwella MJ, Bayliss NC. Study to describe the morphology of a series of clavicles and the dimensions of its intramedullary canal. *J Bone Joint Surg*, 2000;88-B, Issue SUPP III:401.
14. Gumina S, Salvatore M, De Santis P, Orsina L, Postacchini F. Coracoclavicular joint: osteologic study of 1020 human clavicles. *J Anat* 2002 Dec;201(6):513-9.
15. Galley I, Watts A, Bain G. The anatomic relationship of the axillary artery and vein to the clavicle: a cadaveric study. *Journal of Shoulder and Elbow Surgery* 2009 18(5):21-25.
16. Parsons FG. On the proportions and characteristics of the modern English clavicle. *Journal of Anatomy*. 1916;51:71-93.
17. Terry RJ. The clavicle of American Negro. *American journal of Physical Anthropology* 1932;16:351-80.
18. Kaur H, Harjeet, Sahni D, Jit I. Length and curves of the clavicle in Northwest Indians. *Journal of Anatomical Society of India* 2002;51(2):199-209.