ORIGINAL COMMUNICATION

Anatomy Journal of Africa. 2015. Vol 4 (1): 450 - 456

ANATOMICAL MEASUREMENTS OF THE DISTAL CLAVICLE IN A KENYAN POPULATION

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ABSTRACT

Anatomical measurements of the distal clavicle are important in the design of clavicular implants for fixing clavicular fractures and reconstruction of the coraco-clavicular complex in acromio-clavicular joint dislocations. These measurements show population variations however, little data exists from the African population and none for the Kenyan one. One hundred and eighty unpaired dry adult human clavicles were obtained from the Department of Human Anatomy, University of Nairobi. The length of clavicle and distance of conoid and trapezoid tuberosities from the distal end were measured using a ruler. The superoinferior thickness of the distal end was measured using a vernier caliper. The mean clavicle length was 148.57±12.63mm. The left clavicle was longer (150.4mm) than the right one (146.8mm). Conoid tubercle (CT) and trapezoid tuberosity (TT) were 39.52±5.93mm and 17.96±3.42mm respectively from the lateral edge of clavicle. These distances correlated positively with the length of clavicle and occupied 0.3 and 0.15 of total clavicular length respectively. The supero-inferior thickness of the lateral edge was 10.09±2.36mm. The distance of CT and TT positively correlated with clavicular length. The CT lies at a junction of lateral one third and medial 2/3 while the TT is midway between CT and lateral end. Designers of clavicular implants should consider these measurements and surgeons involved in fixation of acromoclavicular joints fractures.

Key words: Clavicle, conoid tubercle, trapezoid tuberosity.

INTRODUCTION

The clavicle is the most frequently fractured bones in the body (Pecci and Kreher, 2008). Of these fractures, those of the lateral third comprise 25-30% (Robinson, 1998; Donelly et al., 2013). Recent advocacy for operative treatment of the lateral clavicular fractures (Toogood et al., 2011; Tiren and Vroemen, 2013) for example, involving use of tension band, screw fixation, nailing, plating and arthroscopy (Oh et al., 2011; Tiren and Vroemen, 2013) demands sound knowledge of anatomical measurements of the lateral clavicle (Banerjee et al., 2011; Mathieu et al., 2014). The position of CT and TT are important during surgical intervention for acromioclavicular joint (ACJ) injuries and coracoclavicular (CC) ligament reconstruction (Mazzocca et al., 2006; Fraser-Moodie et al., 2008; Takase, 2010).

These anatomical dimensions, which are influenced by the length of the clavicle, vary according to side, gender, ethnic and geographical (Fatah et al, 2012; Udoaka and Nwokeduiko, 2013). Accordingly, population and geographical region specific data are important to inform choice of devices and prosthesis in order to minimize complications and failure rates in operative management of distal clavicular fractures (Nagarchi et al., 2014). Fractures of distal clavicle are common in Kenya (Mohammedali et al., 2013). This study, therefore, undertook anatomical measurements of the distal clavicle in a black Kenyan population.

MATERIALS AND METHODS

One hundred and ninety-two dry clavicles were studied from the collection of the Department of Human Anatomy, University of Nairobi. Twelve were excluded due to previous fracture (8) and gross degenerative changes (4). The remaining 180 were classified into right (90) and left (90). Clavicular length (S1) and the distance of medial border of conoid (S2) and centre of trapezoid (S3) tuberosities from the lateral edge of clavicle (Rios et al., 2007) were measured to the nearest millimeter using a ruler (Figure 1). The supero-inferior thickness of lateral edge was measured using a vernier caliper Sealey Professional Tools™, United Kingdom. A single observer collected data at three sittings and the average obtained to reduce intra-observer variability. Data was coded and analyzed using computer software Statistical Package of Social Sciences (SPSS®) Chicago Illinois version 17.0 for windows. Means, standard deviations and ranges of the morphometric data were then calculated. Independent t- test was employed to compare left and right differences. A p-value of ≤ 0.05 was considered significant. Data were presented using tables and scatter plots.

RESULTS

The mean length of clavicle was 148.57±12.63mm (range: 115-178mm). The difference between the left clavicular length (150.38±12.87mm) and the right clavicular length (146.77±12.99mm) was not statistically significant [p=0.055] (Table1).

CT was 39.52±5.93mm from the lateral edge of the clavicle (range, 23-58mm). It was further on the left (40.20±5.59mm) than on the right (38.83±6.21mm). The difference, was however not statistically significant (p=0.120). The TT was 17.96±3.42mm (range 10-28mm) from the lateral edge without statistically significant bilateral asymmetry [p=0.171] (Table 1). Both distances of CT and TT from the lateral edge of clavicle showed a significant positive correlation with the clavicle length [$p \leq 0.05$] (Figure 2). Positive correlation coefficients of 0.464 and 0.448 were recorded respectively.

Figure1: Measurements taken on the clavicle: Inferior view S1-clavicle length, S2- distance from medial end of CT to the lateral edge of clavicle, S3- distance from centre of trapezoid tubercle to the lateral edge of clavicle.

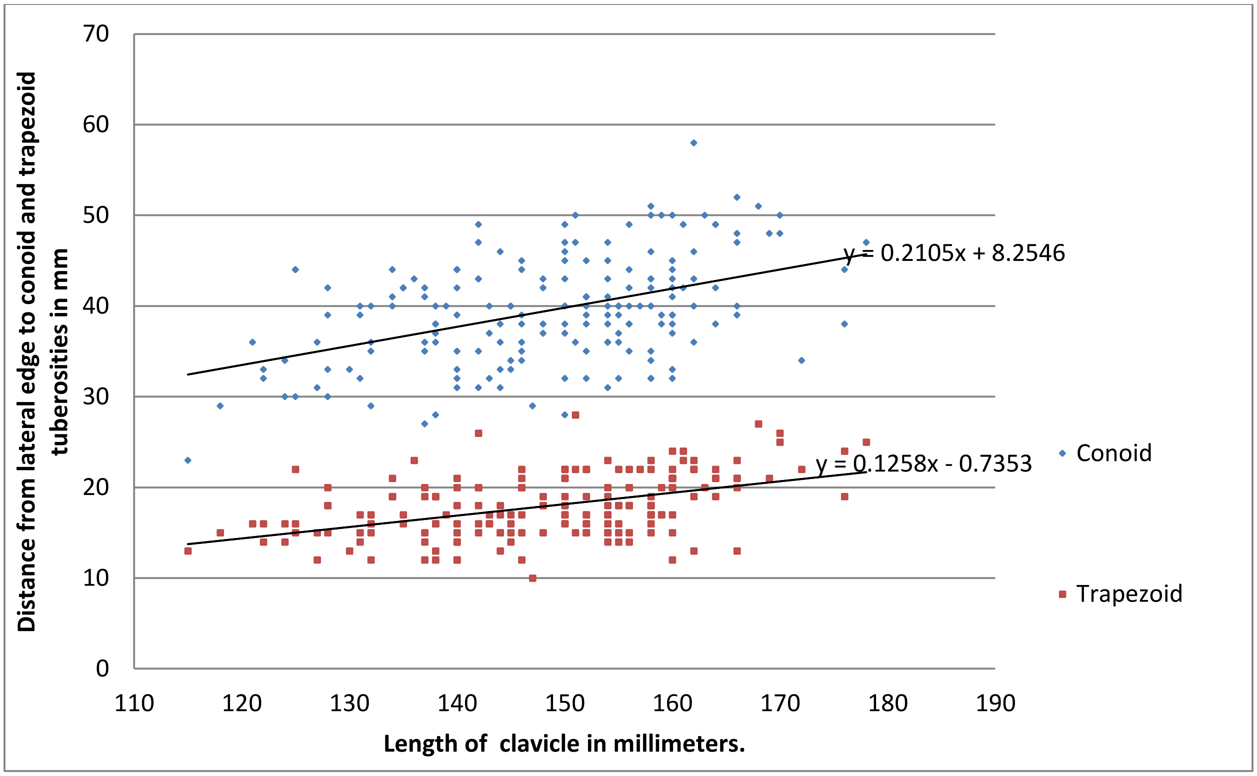

Figure 2: Correlation between clavicle length and distance of conoid and trapezoid tuberosities from the lateral edge of clavicle.

Table 1: Distance of conoid and trapezoid tuberosities from the lateral edge and conoid and trapezoid ratios.

	Left Clavicle	Right clavicle	Average	P-value
Clavicle length (CL) (mm)	150.38±12.87	146.77±12.19	148.57±12.63	0.055
Conoid distance (CD) (mm)	40.21±5.59	38.83±6.21	39.52±5.93	0.120
Conoid ratio CD/CL	***0.27***	***0.26***	***0.27***	
Trapezoid distance (TD) (mm)	18.31±3.29	17.61±3.54	17.96±3.42	0.171
Trapezoid ratio TD/TL	***0.12***	***0.12***	***0.12***	

Table 2: Length of clavicle in different populations.

Author	**Population**	**Length of clavicle (mm)**		
		Mean	**Left**	**Right**
Present study	Kenyan	148.6	150.4	146.8
Kaur et al., 2002	Indian	147.0	143.7	141.9
Andermahr et al., 2007	German	156.0	152.0	149.0
Duprey et al., 2008	Caucacian	142.9	142.2	143.5
Kim et al., 2003	Korean	146.2	146.2	144.3
Walters et al., 2010	South African	150.1	148.2	151.6
Bernat et al., 2013	Belgian	159.0	159.8	158.0
Nagarchi et al., 2014	Saudi Arabian	142.9	143.8	142.1

Table 3: Distances of conoid and trapezoid tuberosities from the lateral edge of clavicle as ratios of entire clavicle length in different populations.

Author	Population	Clavicle length (CL)(mm)	Conoid distance (CD) (mm)	Conoid ratio (CD:CL)	Trapezoid distance (TD)(mm)	Trapezoid ratio (TD:CL)
Present study	Kenyan	148.57	39.52	0.27	17.96	0.12
Boehm et al, 2003	German	150	50.5	0.34	29	0.17
Rios et al, 2007	British	149	46.3	0.31	24.9	0.17
Chung et al,2010	Korean	152.5	41.4	0.27	22	0.14
Average ratio				0.30		0.15

DISCUSSION

Anatomical measurements of the distal clavicle and position of landmarks are important during surgical intervention for fractures of this part, acromioclavicular and coracoclavicular injuries and in design of fixation devices and clavicular prostheses (Rios et al., 2007; Wu and Murrel, 2008; Barlik et al., 2009; Nargarchi et al., 2014). This include overall clavicular length, position of CT, TT and thickness of the distal clavicle. These measurements are reported for a sample of the Kenyan population compared with similar ones in other populations.

Length of Clavicle.

The mean length of clavicle was 148.57mm. This was higher than 138mm among the Italians (Gumina et al., 2002), lower than 163mm among the Belgians (Bortier et al., 2009) but comparable with Indians, Austrians and Americans [Table 2] (Kaur et al., 2002, Von Goedecke et al., 2005 and Rios et al., 2007). Bilateral differences were not statistically significant. This is at variance with most contemporary literature reports that the left clavicle is longer than the right (Mays et al. 1999; Auerbach and Raxter, 2008; Fatah et al., 2012; Bernat et al., 2013; Mathieu et al., 2014) and also with the isolated reports (Duprey et al., 2008; Walters et al., 2010) which show that the right one is longer than the left [Table 2]. This variance suggests that the bilateral differences in clavicular length show population differences. These have been attributed to genetics, hormones, body size and activity levels acting through muscle stress markers (Schlecht, 2012; Fatah et al., 2012). Accordingly, population specific bilateral asymmetry should be taken into account during surgery and design of clavicular appliances.

Distance of conoid and trapezoid tuberosities from lateral edge of clavicle.

The distance of CT and TT from the lateral edge of clavicle is important in the repair of ACJ injuries where 5mm bone tunnels are created 40-45mm from the lateral edge of clavicle for conoid ligament and a trapezoid tunnel 15mm lateral to this conoid tunnel (Mazzoca et al., 2004). The position is also important for accurate reconstruction of the coracoclavicular ligaments in ACJ dislocation (Takase, 2010). The accuracy of these procedures may be affected by variant position of these tuberosities in different populations. In this study, the distance from the lateral edge of the clavicle to TT and CT was 17.96±3.42mm and 39.52±5.93mm respectively. Both are lower than those reported for other populations (Boem et al., 2003; Rios et al., 2007; Chung et al., 2010). Having calculated the distances of these tubercles from the lateral edge as a ratio of the entire bone length as 0.27 (to the nearest 2 decimal places) for CT and 0.12 for TT, such ratios were calculated from data in other studies (Table 3).

The positive correlation of the distance of conoid and trapezoid tubercle and tuberosity and clavicular length are concordant with the correlation of length with other measures such as midpoint cortical diameter and radius of medial curvature (Bachoura et al., 2013). This implies that using position of such landmarks may predict the dimensions of the clavicle. However, the high potential for population variations must be taken into account in such predictions, especially if they are to be of clinical value.

Supero-inferior thickness of lateral edge of clavicle.

The supero-inferior thickness of the lateral edge of clavicle was 10.09±2.36mm in the present study. This is lower than 11.4±1.6mm among the British (Rios et al., 2007) but higher than 9.43mm among Koreans (Kim et al., 2013). This thickness is important in predicting how much graft will be contained within the clavicle tunnel and helps in the design of an interference screw of more appropriate length for reconstruction of coracoclavicular ligament in ACJ injuries (Rios et al., 2007). It is also important in design of potential distal prosthesis and in determining safe length of clavicle that may be resected without compromising coracoclavicular and acromioclavicular joint stability (Wu and Murrel, 2008).

For example, a clavicular hook plate®, Synthes Holding AG, Solothurn, Switzerland, has a hook designed to fit under the posterior part of acromion in fixation of lateral third clavicular fractures and ACJ dislocations. The depth of this hook ranges from 15 to 18mm. This may suggest that an interference screw that is longer than the lateral edge thickness may impinge on the subclavian vessels and brachial plexus located deep to the clavicle (Standring, 2004). Furthermore, in fixation of hook plates, thinner ends of the clavicle predispose more to rotator cuff impingement (Mc Connel et al., 2007; Taneja et al., 2007). A hook plate of shorter depth tends to lift the acromion process of scapula and hence the correct anatomic alignment of clavicle and acromion is not achieved (Khan et al., 2009). The population variations suggested by the cited studies indicate the need to domesticate the design of devices employed in management of distal clavicular fractures.

Conclusion: The distance of CT and TT positively correlates with clavicular length. The CT lies at a junction of lateral one third and medial two thirds while the TT is midway between CT and lateral end. These anatomical measurements should be taken in consideration by designers of clavicular implants, surgeons involved in fixation of and repair of acromoclavicular joints fractures. Based on an average of the ratios calculated from different studies, we suggest a ratio of 0.3 and 0.15 to be used to estimate the location of CT and TT in clinical utility.

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