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Research Article

Characteristics of Mandibular Parameters in Different Age Groups. A CBCT Assessment

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Abstract

Background: Studies have demonstrated that CBCT is a highly accurate tool in linear measurements of mandibles when they were compared with anatomical measurements. Evidence of the adult human mandible shows that this bone can be used to determine sex with a high degree of expected accuracy.

Aim and Objective: The aim of this study is to evaluate deferent linear measurement in human mandibles and compare them with age and gender on CBCT.

Material and Methods: A retrospective study comprised of 400 hemi-mandibles, ranging in age from 18 to 75 years, 141 males, and 259 females. The sample was divided into 3 Groups. Images of patients with history of trauma, dysplasia, or orthognathic surgery were excluded. Male patients below the age of 21 also were excluded. The mandible was evaluated for the location of four anatomical points: condyle, coronoid, gonion, and menton. Then the linear measurements were calculated mathematically.

Result: The correlation of the linear measurements against age in the male sample showed a positive significant correlation in the mandibular angle. In the female sample, a positive significant correlation was observed in the mandibular angle and the mandibular length. Comparison of the linear measurement of age groups in male samples showed a significant difference for coronoid length, mandibular length, and angle of the mandible, while the female samples did not show any significant difference between the age groups except for the mandibular angle. All the linear measurements showed a statistically significant difference between male and female samples except for the angle of the mandible.

Conclusion: Linear measurement of the coronoid and mandibular lengths and the angle in the males can be used to identify different age groups. These findings may be useful in forensic studies done on mandible samples for age and gender estimation.

Keywords: *CBCT; Mandibular Length; Mandibular Angle; Linear Measurements*

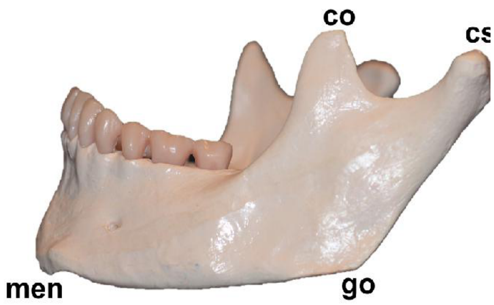
Introduction

Recently in dentistry, a great importance has been attached to cone-beam-computed tomography (CBCT), which has the ability to generate images in deferent planes, which increases diagnostic efficiency [1]. This multiplanar imaging helps us to easily evaluate the morphology, position, shape, size, and variation in several anatomical structures of the oral and maxillofacial region. A normal variation occurs with age, gender, facial type, functional load, and between the right and left sides [2]. Studies have demonstrated that CBCT is a highly accurate tool in linear measurements of mandibles when they were compared with anatomical measurements [1,3]. The mandible was the appropriate bone for this study because it is the most durable facial bone, and it retains its shape better than other facial bones [4]; it is also the strongest and largest face bone. The mandible changes its morphology, depending on its dynamic environment, and forms trabeculae to achieve maximum strength with minimum material according to biodynamic principles [5]. Thus, the development of the mandible is referred with age according to the positions and alignment of the related features [6]. The mandible is an important tool for radiological identification due to its ease of imaging [7]. The mandibular condyles play an important role in the growth and development of the maxillofacial area and may be directly associated with the patient's maxillomandibular characteristics [7,8]. Evidence of the adult human mandible shows that this bone can be used to determine sex with a high degree of expected accuracy [9], which can be explained by its calcium deposition [10,11]. Therefore, the aim of this study is to evaluate deferent linear measurement in human mandibles and compare them with age and gender.

Materials and Methods

This retrospective study was conducted on CBCT examination taken from patients who visited the oral diagnostic department at Riyadh Colleges of Dentistry and Pharmacy Between 2010 - 2015. Images were obtained in Sirona Galileos (Germany) at 85 kV, 5 -7 mA, and 14s. The study comprised of 400 hemi-mandibles of individuals ranging in age from 18 to 75 years, 141 males, and 259 females. The sample was divided into Group A (18 - 35 years), Group B (36 - 50 years), and Group C (51 - 75 years).

Inclusion criteria of our study include clear visibly of all parameters on CBCT (condyle, coronoid, gonion, and menton). Images of patients with history of trauma, dysplasia, or orthognathic surgery were excluded. Male patients below the age of 21 also were excluded; 400 hemi-mandibles were evaluated for the location of four anatomical points on 3D aspects; axial, coronal and sagittal (Table 1).

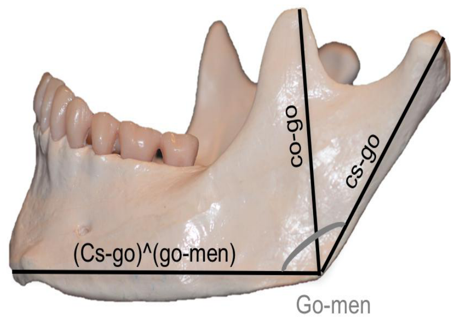


Landmark		Definition
Condylion superior	cs	The most superior point of the mandibular condyle
Coronoid	co	The most superior point of the coronoid processes
Gonion	go	Point midway along curvature of angle of mandible between inferior border of body and posterior border of ramus of mandible viewed sagittally
Menton	men	Most inferior point along the curvature of the chin in the midsagittal plane

Table 1: *Definition and location of the landmarks used in this study.*

Images were exported and viewed using digital images analysis software (CS 3D imaging software 3.1.9_Carestream Health Inc.), which allowed the measurement of the landmarks on three planes (axial, sagittal, and coronal) on 2 mm cuts. The location of these points on three planes represented a 3D coordinates system (x, y, z). The coordinates were recorded for each point; then the linear measurements (Table 2) were calculated mathematically using the formula:

$$\left(d=\sqrt{(X_b-X_a)^2+(y_b-y_a)^2+(z_b-z_a)^2}\right)$$



Measurement		Definition
Condylar Length	cs-go	Distance in mm between condyle and gonion
Coronoid Length	co-go	Distance in mm between coronoid and Gonion
Mandibular Length	go-men	Distance in mm between gonion and menton
Mandibular Angle	(cs-go)^ (go-men)	Angle between condylar line and mandibular line

Table 2: *Linear measurement and the angle evaluated in this study.*

And the angle between the lines were calculated by the following:

- To calculate dot product:

$$a \,.\, b = a_x \cdot b_x \cdot + a_y \cdot b_y + a_z \cdot b_z$$

- To calculate the magnitude of lines:

$$|\, a \,| = \sqrt{a_x{}^2 + a_y{}^2 + a_z{}^2}$$

$$|\, b \,| = \sqrt{b_x{}^2 + a_y{}^2 + a_z{}^2}$$

And the angle between the lines were calculated using:

$$\cos \alpha = -\frac{a \,.\, b}{a \,.\, b}$$

where d was the linear measurement (distance between points), x was determined by the location of the landmark on the axial plane, y on the coronal, and z on the sagittal.

Reliability Assessment

For inter-examiner reliability, the three examiners evaluated 30 scans, and their results were calculated using the Cronbach's alpha for each point. The average of Cronbach's alpha for the points was found to be 0.86.

Statistical Analysis

Calculated measurements were then analyzed and compared against gender and different age groups and subjected to statistical analysis using Student T-test, ANOVA, and post-hoc test, which was prepared using the Statistical Package for Social Sciences [SPSS version 22, Chicago, IL, USA].

Result

In the present study, the correlation of the linear measurements against age in the male sample showed a positive significant correlation between age and the mandibular angle.

	Age	Condylar Length	Coronoid Length	Mandibular Length	Angle
Pearson Correlation	1	-.159	-.083	.052	.216*
Sig. (2-tailed)		.060	.329	.539	.010
N	141	141	141	141	141

Table 3: *Pearson correlation test of the linear measurement against age in male sample.*

In the female sample, a positive significant correlation was observed in the mandibular angle and the mandibular length, while in the coronoid, length was positive but nonsignificant.

	Age	Condylar Length	Coronoid Length	Mandibular Length	Angle
Pearson Correlation	1	-0.015	0.025	**0.173	**-0.251
Sig. (2-tailed)		0.815	0.685	0.005	0.000
N	259	259	259	259	259

Table 4: *Pearson correlation test of the linear measurement against age in female sample.*

Comparison of the linear measurement of age groups in male samples showed a significant difference for coronoid length, mandibular length, and angle of the mandible (Table 5), while the female samples did not show any significant difference between the age groups except for the mandibular angle (Table 6).

		df	Mean Square	F	Sig.
Condylar Length	Between Groups	2	277.808	2.764	0.067
	Within Groups	138	100.525		
	Total	140			
Coronoid Length	Between Groups	2	312.120	3.655	0.028*
	Within Groups	138	85.385		
	Total	140			
Mandibular Length	Between Groups	2	354.754	3.879	0.023*
	Within Groups	138	91.464		
	Total	140			
Angle	Between Groups	2	683.782	4.702	0.011*
	Within Groups	138	145.422		
	Total	140			

Table 5: *Comparison of linear measurements between age groups in males.*

**Significant when tested by ANOVA.*

		df	Mean Square	F	Sig.
Condylar Length	Between Groups	2	41.378	0.478	0.621
	Within Groups	256	86.632		
	Total	258			
Coronoid Length	Between Groups	2	1.380	0.015	0.985
	Within Groups	256	91.893		
	Total	258			
Mandibular Length	Between Groups	2	163.427	2.301	0.102
	Within Groups	256	71.014		
	Total	258			
Angle	Between Groups	2	818.671	6.713	0.001*
	Within Groups	256	121.960		
	Total	258			

Table 6: *Comparison of linear measurements between age groups in females.*

**Significant when tested by ANOVA.*

Then, the data were compared among genders; all linear measurements showed a statistically significant difference between male and female samples except for the angle of the mandible, which showed no significant difference between them.

	t	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
Condylar Length	2.733	0.007	2.747	0.771	4.722
	2.663	0.008	2.747	0.716	4.778
Coronoid Length	3.702	0.000	3.681	1.726	5.636
	3.717	0.000	3.681	1.732	5.630
Mandibular Length	6.634	0.000	6.210	4.370	8.050
	6.364	0.000	6.210	4.288	8.132
Mandibular angle	-0.554	0.580	-0.677	-3.080	1.726
	-0.539	0.590	-0.677	-3.150	1.796

Table 7: *Gender comparison of the measurements (t-test for equality of means).*

Comparison between right and left mandibular linear measurements showed no statistical differences between them.

	Mean	Std. Deviation	T	Sig. (2- tailed)
R \ L Condylar length	-.915	8.425	-1.532	.127
R \ L Coronoid length	.266	9.065	.415	.678
R \ L Mandibular length	-.234	5.573	-.592	.554
R \ L Mandibular Angle	1.013	8.611	1.660	.098

Table 8: *Paired samples test.*

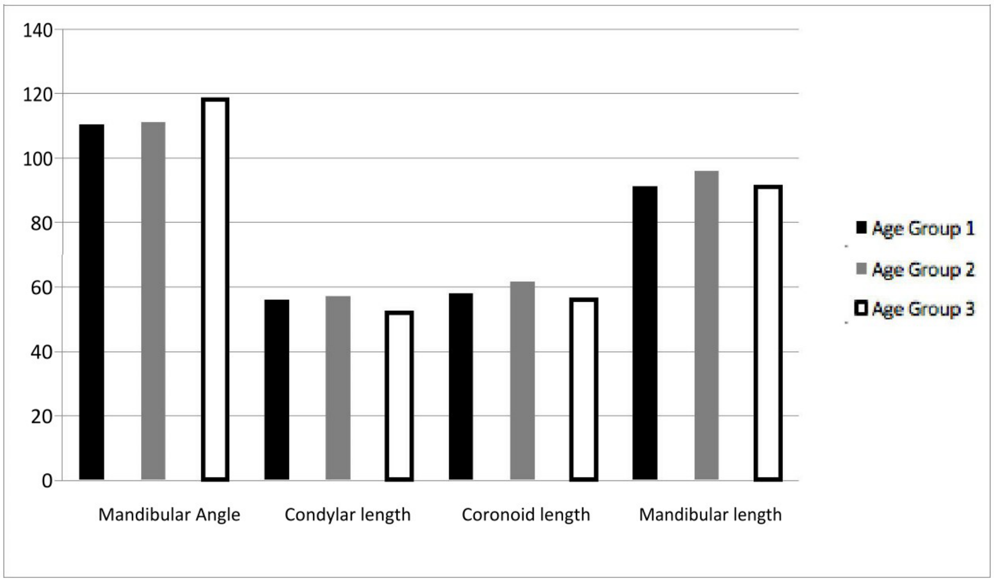


Chart 1: *The mandibular leaner measurements in both genders comparing between Age Groups.*

Discussion

In ancient times, it was assumed that an adult's bones are stable and do not change in size, shape, or dimensions. In the last few years, multiple studies have demonstrated that, with aging in adults, statistically significant changes happen in the shape and size of certain craniofacial bony structures for both genders, even after puberty [2]. Studies have proven that adult growth does occur-but not as rapidly as in childhood. Some of these studies used anatomical measurements of the cadaveric bone [1,3] or by using digital radiograph, such as panorama, cephalogram, or recently CBCT.

The results of our study showed that, with aging, the mandibular linear measurements are statically significantly changed. The mandibular length was increasing in all age groups. Where the mandibular angle, coronoid length, and condylar length were found to increase in age group 2; and decrease in age group 3. Which came in agreement with Pessa., *et al.* who found statistically significant difference in the shape of the mandible for both genders occurring with age and a computerized analysis by Ferrario., *et al.* who showed that the vertical dimension in males increased even after 30 years of age [12,13]. Formby., *et al.* indicated that, in males, the most changes in hard tissue measurements had been accomplished by age 25 year; where in females, both hard and soft tissue measurements had more changes after age 25 years [14].

Mendelson and Wong's findings showed that the entire face becomes longer vertically, deeper in the anterior posterior plane, and wider in the transverse dimension [15]. In previous studies, mandibular length and height both decreased significantly for each gender, disagreeing with our results. Whereas the mandibular angle increased significantly for both genders with increasing age, similar to this study [16,17]. No significant difference was observed in mandibular angle in a study on young Lebanese population [18].

In the present study, the condylar length and coronoid length of the age group A were higher than those of the age group B in male samples. And the lengths of age group C were decreased comparing to age group B. This change was similar in the condylar lengths only in the female sample.

According to Fitzgerald., *et al.* differences between the genders might be expected [19]. Pecora., *et al.* and Virgilio., *et al*. reveal that mandibular growth was greater in men, and the dimensions were larger [13,20]. Fudalej., *et al.* found that the difference in the amount of growth occurs between the sexes during the second decade of life [21].

The result of our study showed that gender plays a major role in the changes of the mandible dimension, which can be explained by the relative development of the musculoskeletal system, particularly the masticatory muscles, which are attached to the mandible. Moreover, there are different growth rates and developmental stages of male and female mandibles. Because females reach puberty earlier than males, development of their mandible and skull appear to either stop or slow down earlier than that in maturing males. Studies show that sex predication can be 100% accurate when the pelvic bone is present for examination. Following that, the skull is the most dimorphic and easily sexed portion of the skeleton [22]. Coronoid height was seen to have 74.1% accuracy [23]. Bicondylar breadth, gonial angle, and minimum ramus breadth were among other parameters that have been used to determine sex [24].

In agreement with previous symmetrical studies, our data showed no significant changes in the measurements between right and left sides of the mandibles in relation to both age and gender [25].

Conclusion/Recommendations

Within the limitation of this study, the changes in the mandibular liner measurements are not correlated to the changes of age, except for the angle in males and the angle and mandibular length in female samples.

Linear measurement of the coronoid and mandibular lengths and angle of the mandible in the males maybe be useful in identifying the age. Mandibular angle and mandibular length are valuable aids for differentiating age in females.

Growth changes occur in the arches and result in adaptive changes over time, both vertically and horizontally. We advise clinicians to observe and report these changes and educate their patients about their possible complications.

CBCT is a valuable and an accurate tool for locating and viewing bony structures of the mandible and have the least chance of damaging the samples. The ease of application and use of CBCT make it a useful tool in anthropological and forensic studies. The 3D coordinates technique is simple and easily applies to any CBCT images. These findings may be useful in forensic studies done on mandible samples for age and gender estimation.

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