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Estimation of Age and gender Among Yemeni Population using 3D craniometry: A Computed Tomography based study

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Abstract:
Aim*: This study aimed to estimate age and gender for Yemeni population through the cranium measurements using three dimensional Computed Tomography ((3D CT).*
Materials and Methods: *This cross sectional study was done in the Radiology department of University of Science and Technology Hospital, Sana'a City-Yemen .362 patients were included (190 were males and 172 were females) with different ages. All were examined using CT scan for the cranium. Axial scan was obtained, then 3D reconstruction volume rendering technique (VRT) performed to take cranial measurements for foramen magnum length and width, Bizygomatic breadth and Basion-prosthion length using RadiAnt DICOM Viewer version 5. The measurements were compared according to age and gender.*
Results*: The mean and standard deviation of all cranial measurements were higher in males than female, and the cranial measurements increased with age from infancy to later adulthood with statistical significant difference between both genders and between different age groups (p<0.05).*
Conclusion: *The human cranium considered as a reliable parameter in age and gender determination for forensic and anthropology using 3D Computed Tomography.*
Key Word*: Age and gender; Cranium; Three Dimensional Computed Tomography; Estimation.*

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I. Introduction

Anthropometry is the science of measuring the physical characteristics and dimensions of the human body[(1)]. Anthropometry changed dramatically from traditional methods to advance computer technology in 3D form[(2)]. Age and Gender estimations by human cranium measurements are valuable issues in the advanced technology era[(3)].The estimation of age is very important for many aspects of human life such management of property, marriage, employment, and criminal cases[(4)]. The morphology of craniofacial is varies due to increasing age from infancy to the late adulthood, and differing among both genders [(5)]. Moreover, the skull also shows differences in shape among different races[(6)].So the structures of skull considered a reliable index for age determination and forensic field[(7)]. Anthropologist use skull characteristic for age, gender and ethnic determination[(8)]. Many literatures shows the accuracy of gender determination is 88-90%.[(9)]. The accuracy of gender determination through the skull and pelvis is 98%[(7)] . 3D computed tomography volume rendering technique (VRT) using craniometric measurements is accurate and applicable in forensic and anthropology for human identification[(10, 11)]. Because of the conflict in Yemen, there are many decomposing bodies that have not been identified. This study may contribute in identification of the unidentified bodies specially in case of mass graves. In addition to the variation of Craniofacial morphology among population and human genotype**[(12)]**, the establishment of local reference values of cranial measurements for Yemeni population is important for accuracy in case of human identification, surgical correction and plastic surgery.

II. Materials and Methods

This descriptive analytical cross sectional study was conducted in Radiology department at University of Science and Technology Hospital, Sana'a City-Yemen. The study population consisted of a sample of Yemeni population drawns from all patients admitted to radiological department for skull CT scan or any examination include skull such as craniofacial, head and neck and maxillofacial CT from November 2017 to January 2020. A total of 362 subjects (190 Males and 172 females), the age of the sample was classified into six groups including: infancy 0-2 years, early childhood 3-8 years, adolescence 9-18 years, early adulthood 19- 45 years, middle adulthood 46-65 years and later adulthood >65 years.

Inclusion criteria:

1. Yemeni people.
2. Patients who agreed to participate in this study.
3. Patient with normal skull morphology.

Exclusion criteria:

1. Non-Yemeni people.
2. Patients with congenital anomalies.
3. Traumatic patients.
4. Patients with disease affecting normal skull morphology.

Study Procedures

After verbal explanation the verbal consent was obtained from the selected sample, the data of the patients were collected using a data collection sheet which was divided into two parts: socio-demographic characteristics such as age and gender, and the measurement parameters including length and width of foramen magnum, Bizygomatic breadth and Basion-prosthion length.

A computed tomography scan was performed for the skull, and then the images reconstructed to produce 3D volume rendering techniques (VRT) images. Then the reconstructed images were copied to the DVD to take measurements of the length and width of foramen magnum, Bizygomatic breadth and Basion-prosthion length, using RadiAnt DICOM Viewer version 5. The inferior view of VRT used to measure foramen magnum length and width. Where the Foramen magnum length is the direct distance from basion to opisthion [(13)]. The Foramen magnum breadth (FOB) is the distance between the lateral margins of the foramen magnum at the point of the greatest lateral curvature[(13)] Figure(1) . Then the frontal view of skull VRT used to measure Bizygomatic breadth which is the maximum transvers breadth between right and left zygia or zygomatic arches[(13)] Figure(2). The lateral view of skull VRT was used to measure Basion-prosthion length which is the direct distance between basion and prosthion**[(13)]** Figure(3)**.** Three observers performed cranial measurements (length and width of foramen magnum, Bizygomatic breadth and Basion-prosthion length) using same methods and techniques. The measurements were taken depending on the method mentioned by Iscan et al[(13)].

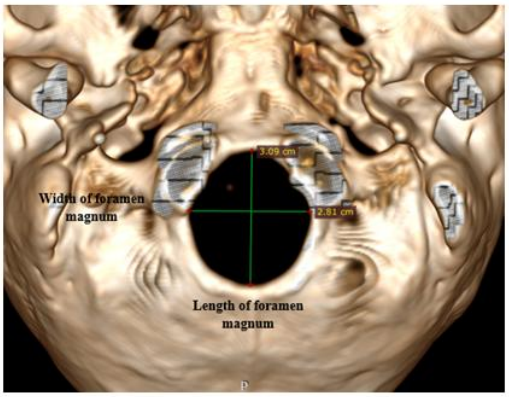

Figure 1: Inferior view VRT show foramen magnum measurements.

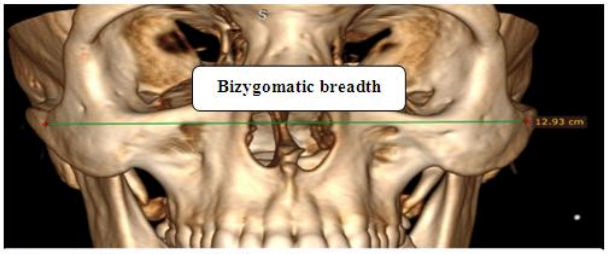

Figure (2): Frontal view VRT show Bizygomatic measurement

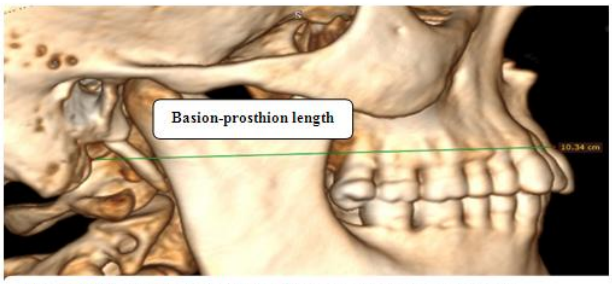

Figure (3): Lateral view VRT show Basion-prosthion measurement

Statistical analysis

The data were analyzed using SPSS program version 24.00.0. The data were presented in the form of tables, where the t-test, ANOVA test, and Chi-square were carried out test of statistical significance at α-level of 0.05.

III. Results

Table (1) Compared cranial measurements between both genders and showed the mean measurements and standard deviations of Foramen magnum length, Foramen magnum width, Bizygomatic breadth and Basion-prosthion length were (33.1±2.76 mm), (28.5±2.49 mm), (113.7±10.62 mm) and (98.2±8.28mm) for males, whereas (31.2±2.73mm), (26.6±2.35mm), (108.2±10.88mm) and (94.7±10.46mm) for females respectively. There were a statistical significant differences between males and females in cranial measurements, where the males showed larger measurements compared with females, also the related t-test values presented significant differences with significant values at p= 0.000 for all cranial measurements.

Table 1: Cranial measurements classified according to gender.

Cranial measurements (mm)	Gender						T-Test	Significant test
	Male			Female				
	Mean±SD	Maximum	Minimum	Mean±SD	Maximum	Minimum		
Foramen magnum Length	33.1±2.76	40	20	31.2±2.73	39	22	6.567	0.000
Foramen magnum Width	28.5±2.49	36	22	26.6±2.35	33	18	7.179	0.000
Bizygomatic breadth	113.7±10.62	134	83	108.2±10.88	132	66	4.838	0.000
Basion-prosthion length	98.2±8.28	130	72	94.7±10.46	130	37	3.531	0.000

Table 2 compared cranial measurements regarding to age groups and showed that, the mean size and standard deviation of Foramen Magnum Length, Foramen magnum Width, Bizygomatic breadth and Basion-prosthion length increased with ages form infancy to adulthood with statistical significant difference p= 0.000 between age groups in all cranial measurements.

Table 2: Cranial measurements classified according to age.

Mandibular Measurement	Age groups	Mean±SD	Maximum	Minimum	F	Significant test
Foramen magnum Length	0-2	27.7±4.75	35.0	20.0	9.324	0.000
	3-8	31.1±3.57	39.0	22.0		
	9-18	32.4±2.44	39.0	28.0		
	19-45	32.7±2.63	40.0	26.0		
	46-65	31.9±2.48	39.0	27.0		
	65+	33.0±2.03	37.0	30.0		
Foramen magnum Width	0-2	24.1±2.91	27.0	18.0	12.556	0.000
	3-8	26.0±3.04	36.0	18.0		
	9-18	27.7±2.20	33.0	22.0		
	19-45	28.4±2.28	36.0	21.0		
	46-65	27.1±2.44	36.0	22.0		
	65+	28.2±2.16	32.0	24.0		
Bizygomatic breadth	0-2	83.9±5.45	95.0	75.0	125.294	0.000
	3-8	92.6±7.60	109.0	66.0		
	9-18	108.0±8.25	124.0	93.0		
	19-45	116.0±6.48	134.0	97.0		
	46-65	115.6±5.74	128.0	98.0		
	65+	116.0±5.58	124.0	107.0		
Basion-prosthion length	0-2	79.0±8.40	89.0	60.0	48.841	0.000
	3-8	82.7±10.7	98.0	37.0		
	9-18	96.5±8.46	116.0	73.0		
	19-45	99.9±6.71	130.0	72.0		
	46-65	98.3±5.81	112.0	86.0		
	65+	100.4±5.87	108.0	89.0		

VI. Discussion

Comparing cranial measurements between males and females the study showed that, the males had greater measurements than females. Where the foramen magnum length was 33.1±2.76 mm in males and 31.2±2.73 mm in females, foramen magnum(FM) width was 28.5±2.49 mm in males and 26.6±2.35 mm in females, Bizygomatic breadth was 113.7±10.62 mm in males and 108.2±10.88 mm in females and Basion-prosthion length was 98.2±8.28 mm in males and 94.7±10.46 mm in females. T-test was carried out to determine the significant of means' differences. The findings presented significant differences in cranial measurements between males and females with significant test value P= 0.000 in each cranial measurements. Such results resemble that of El-Atta et al (2020), Zdilla et al (2017), and El- Barrany et al (2016) they reported that, the FM length and width was greater in males than females with statistical significant difference between FM measurments in both genders [(14) (15) (16)]. The difference in shapes of the FM from various reports indicates racial variability among the morphology[(17)]. On the other hand, a studies done by Kosif et al (2013) and Adel et.al (2019) who mentioned that, the mean and standard deviations of prosthion-basion length in males was greater than females [(18) (19)]. Moreover, Debnath et al (2019), Jain et al (2016) revealed that, the value of Bizygomatic width of males were higher compared to females and considered as a reliable parameters in gender prediction with high accuracy[(20, 21)]. And the greatest sexual dimorphism was shown by the bizygomatic width as mentioned by Osvaldo et al (2012) [(22)].

Regrading to the age, Foramen magnum length, FM Width, Bizygomatic breadth and Basion-prosthion length increased with ages form infancy to adulthood. As well as the means' differences between age groups was evaluated by One-way ANOVA analysis. A statistically significant difference (p= 0.000) between age groups in all cranial measurements according to the ANOVA findings. These result were in agreement with the results of a study done by Moodley, et al (2012) who found that, the size of foramen magnum increased from children to adolescents[(23)]. Another study by Shaikh et al (2015) concluded that, the foramen magnum dimension increase with age from fetal to adult with statistically significant difference[(24)]. In contrast to the study by More et al (2015) , who used axial sections to obtain measurements rather than 3D, and mentioned no statistical significant difference in FM size between age groups[(25)]. Saito, et al (2002) used three-dimensional construction images for cranium and found that, the squamous and parietomastoid sutures changes with age[(26)]. These results approved relevant works which reported that, the structures of human skull considered a reliable index for age determination and forensic field[(3), (7), (8)].

IV. Conclusion

According to the study outcomes, it was concluded that; the morphometric analysis of human cranium showed significant difference between both genders where the males showed higher measurements than females. The size of human cranium increased with age with statistical significant difference between age groups. These measurements of human cranium using 3D Computed Tomography considered as a reliable parameter in age and gender determination.

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