Measurements of the Mandibular Arch Using PAL Technique: MRI Study

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Abstract— **BACKGROUND: Dental arch measurements varied in different ethnic groups and populations, the dimensions continue changing in accordance with growth and development until the adulthood stage, these changes will decrease. The aim of this study is to measure the mandibular arch among Sudanese, using a new technique which is the PAL in MR images.**

METHODOLOGY: 50 Sudanese volunteers (25 males/ 25 females) with no history of cranio- fascial trauma were included in this study. Structural MRI was done to all subjects. The measurements of the mandible were done by means of PAL technique via measuring the inter molar distance and mandibular arch using ImageJ software.

RESULTS: There was a correlation between age of participants and mandibular arch measurements. And, there was no significant difference between male and female regarding the measurements of the mandibular arch.

CONCLUSION: In this study there is a new technique that is the first time used in the measurement of the mandibular arch. We conclude that there was no difference regarding the sex using PAL technique. On the other hand, there is highly significant regarding the length of the inter molar distance in addition there is a positive correlation between age and mandibular arch.

I. Introduction

Dental arch measurements varied in different ethnic groups and populations, the dimensions continue changing in accordance with growth and development until the adulthood stage, these changes will decrease (Carter, G.A. & McNamara Jr, J.A., 1998) (Triviño, T., et al. 2008). The mandible could be a significant determinant of gender due to its pronounced dimorphism, considerable size, and robustness within the skull structure. Various mandibular characteristics, including the gonial angle, ramus dimensions, and other morphological measurements, have been documented in gender determination studies.

The assessment of the mandible, particularly focusing on the ramus area, holds significant value in gender estimation within the realm of forensic medicine (Okkesim, A. & Erhamza, T.S., 2020). The differential development (in terms of size, length, strength, and orientation) of the masticatory muscles is understood to correlate with the dimorphic nature of the mandibular ramus, given the distinct masticatory forces exerted between sexes (Franklin, D., et al. 2008).

In their 2020 study, Okkesim, A. & Erhamza, T.S. conducted research aimed at quantifying the morphometric parameters of 3D mandible models within the Central Anatolian Turkish population, with a focus on determining the significance of these measurements in gender estimation. Their findings indicated that cone beam computed tomography (CBCT) outperformed traditional methods in obtaining measurements closely aligned with actual anatomical measurements, while also producing undistorted, high-quality 3D images with minimal radiation exposure. Although there exists a distinct differentiation in ramus measurements between males and females within each population, there is also variability observed in these measurements across different societies. Another study suggested the potential utility of the CBCT method in measuring anatomical structures that pose challenges for traditional techniques.

Nojima, K. et al., (2001) has studied the relationship between the shapes of the mandibular arch in different ethnic group, the researchers suggested on classifying the patients dentition into 3 arch forms (square, ovoid, and tapered), although the results showed that there was no statistically significant difference found between the Caucasian and Japanese patients within each arch form sample as well as there is no single arch form unique to any of the Angle classifications or ethnic groups.

A study was established in 2019 by (Coombs, M.C., et al) to evaluate the temporomandibular morphometric parameters that are affected by different measurement technique, like MRI, CBCT and physical measurements. The researchers have discovered that physical measurements were generally larger than CBCT and MRI.

The distinction in the imaging modality used, particularly MRI, makes direct comparisons challenging, highlighting its unique importance. This dissimilarity needs to be acknowledged when contrasting MRI data with measurements derived from other imaging techniques.

Markic, G., et al. (2015), in their research, established the length of the mandibular ramus and condylar process using both 2D and 3D measurement methods. Across all 3D imaging modalities, measurements were consistently similar. Despite MRI measurements generally yielding smaller values compared to those obtained from CT and CBCT, it is highly recommended due to its comparability to CT and CBCT, while also offering

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the advantage of avoiding ionizing radiation and exhibiting higher sensitivity in inflammation detection.
The aim of this study is to ascertain the measurements of the mandibular arch in the Sudanese population and compare these findings with those of other available populations.

II. MATERIALS AND METHODS

This is an analytic observational study. The focus of this study is to measure the mandibular arch dimention by applying stereological methods and PAL techniques on MR images with predefined levels of precision. The study was approved by the ethical committee of the Gezira University/ Sudan.

CRITERIA OF SELECTION

A. Inclusion Criteria

50 Sudanese volunteers (25 males/ 25 females) with no history of cranio- fascial trauma.

B. Exclusion Criteria

Exclusion criteria include head trauma, drug abuse and central neurological disorders
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STUDY VARIABLES

A. Measurements of the mandibular arch.
B. Sex & Age of the subjects

MATERIALS

The materials used in this thesis include descriptive questionnaire, MR images, and methods of measurements and analysis.

A. Descriptive Questionnaire

A questionnaire was filled directly through the individual. It includes: Socio-demographic data i.e. code number (to provide data protection), age, gender, and medical history.

C. MR Imaging

Structural MRI was done to all subjects in the MR images section of the department of radiology in the National Ribat University/ Sudan. The scanner USED IN THIS STUDY is Siemens 1.5 Tesla Magnetom Avanto Vision System. T1-weighted images were collected using three-dimensional acquisition by Magnetization Prepared Rapid Acquisition (MP-RA); WHICH produces good grey/white contrast in a very short acquisition time. Slice distance is 1.0mm, the field of view is 250 read, 192mm phase, TR=1657ms, TE=2.95ms, bandwidth 180Hz/pixel, flip angle 15°, ECHO spacing=7.5ms, phase resolution=100%, slice resolution=50%, and acquisition time = 5 minutes & 18 seconds. The images USED WERE in coronal section.
This T1-weighted sequence is part of the standard clinical protocol for qualitative and quantitative analysis of the whole brain in patients with epilepsy.

All subjects were scanned in the supine position. The MR images scanner is like a tunnel about 1.5 meters long surrounded by a large circular magnet. The subject lies on a couch which then slides into the scanner. A receiving device, like an Ariel, is placed behind the head. This detects the tiny radio signals directed from the body. When each picture is being taken the subject needs to lie still for a few minutes otherwise the scan picture may be blurred. The scan itself is painless. The whole procedures take five minutes, without contrast media.

Methods of Measurements

A. The Dicom images of the subjects were transferred to the ImageJ software, a product of the National Institutes of Health (NIH), for analysis. ImageJ is freely available software distributed in the public domain, accessible for download from the Internet at the following site: http://rsb.info.nih.gov/ij/. Notably, it is compatible with various computer systems. This software enables the storage of measurements obtained from images separately and offers a reliable method for obtaining valid measurements of specific structures through a delineation approach.
B. The mandibular arch was measured using the projection area per length squared (PAL). The projection surface area of the mandibular arch is first estimated. Then THE length of a reference distance in the image is measured (Fig. 1).
C. The Formula of PAL technique is demonstrated as followings:

A= projection surface area.
l 2 = length of a reference distance.
PAL= A/l 2

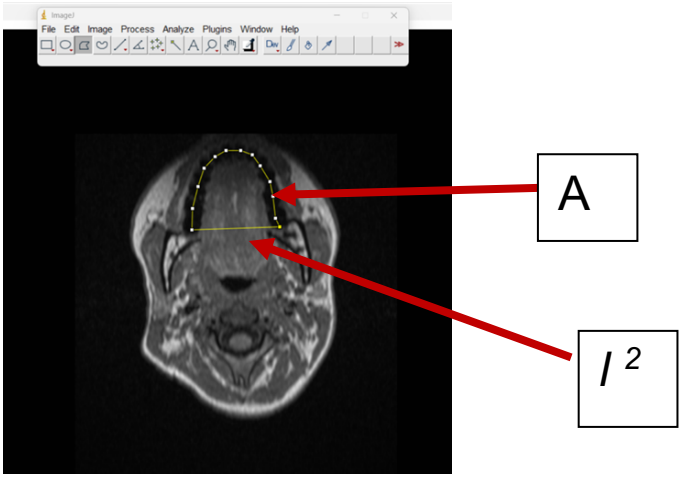

Fig. 1. Measurements of the mandibular arch using the projection area per length squared (PAL)

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III. RESULTS

TABLE I
UNITS FOR MAGNETIC PROPERTIES

PAL			
SEX	Mean	N	Std. Deviation
Female	94.3466	25	15.28
Male	92.2720	25	15.74
Total	93.3093	50	15.39

TABLE II
THE CORRELATION OF THE SAMPLE SIZE REGARDING AGE AND SEX.

Correlations				
			PAL	AGE
Spearman's rho	PAL	Correlation Coefficient	1.000	.001
		Sig. (2-tailed)	.	.995
		N	50	50
	AGE	Correlation Coefficient	.001	1.000
		Sig. (2-tailed)	.995	.
		N	50	50

TABLE II

	SEX	N	Mean	Std. Deviation	p-value
LENGTH	Female	25	43.59	3.60	.019
	Male	25	46.37	4.48	.019
SURFACE AREA	Female	25	1786.27	332.10	.054
	Male	25	1960.08	286.34	.054
PAL	Female	25	94.35	15.28	.638
	Male	25	92.27	15.74	.638

THE MEAN AND STANDARD DEVIATION OF THE LENGTH, SURFACE AREA OF THE MANDIBLE AND THE PAL(P-VALUE<0.05).

DISCUSSION

The main purpose of this study was to determine the measurement of the mandibular arch by using PAL technique (projection area per length squared) based on the MR images and compare the results with other available results. Projection area per length squared (PAL) is a term commonly used in the field of fluid dynamics, especially in the study of porous media or in heat transfer analysis. It represents the ratio of the cross-sectional area of a solid (or porous) object to the square of its length.

PAL is significant in various engineering applications, such as determining the effectiveness of heat exchangers, calculating pressure drop in flow through porous media, or analyzing fluid flow in pipes and channels of varying geometries. It provides a measure of how effectively an object interacts with the fluid or heat transfer process relative to its size. There was no previous study using PAL technique measuring the mandible. The findings of the current investigation show that, the values of PAL do not differ statistically significantly between males and females' patients. Otherwise, some studies found that there are significant differences in the mandible length and the ramus height between males and females (Franklin D. et al. 2008). In their study, Alaa S. et al. (2017) assessed the height of the mandible body with respect to sex within the Iraqi population. The results revealed a notable disparity between males and females, particularly in the midline and mental foramen area. While for the PAL technique as showed in this study there was no significant differences between genders.

The dimensions and configuration of mandibular arches hold significant importance in orthodontic diagnosis and the planning of treatment, impacting both the available space and the stability of dentition (Lee, R.T., 1999). In a study conducted by Dietrichkeit Pereira et al. on the Brazilian population, five mandibular measurements were utilized: coronoid height, gonial angle, bigonial distance, ramus height, and maximum length. The measurements cannot be depended for age estimation. Otherwise in this study the results showed a correlation between the age in adulthood.

CONCLUSION

We used a new technique which as the first time to be used in the measurement of the mandible and in conclusion there was no significant difference between male and female using PAL technique. On the other hand, there is highly significant regarding the length of the inter molar distance, in addition to, there is a positive correlation between age and mandibular arch. Using PAL technique is useful in the field of measurements and large sample size is required.

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