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CORRELATION BETWEEN THE DENTAL ARCH MORPHOLOGY AND THE ARTICULAR EMINENCE HEIGHT AND INCLINATION ON CBCT SCANS OF AN EGYPTIAN POPULATION: A CROSS-SECTIONAL STUDY

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ABSTRACT

Aim: The aim of the study was to assess the correlation between the dental arch morphology and the articular eminence inclination and height in a sample of the Egyptian population using cone-beam computed tomography (CBCT) scans.

Methodology: CBCT scans of 87 adult Egyptian patients were analyzed in which the inclination and height of the articular eminence were measured. Dental arches were classified into ovoid, tapered or square according to their shapes, and the arch width, depth and perimeter were measured.

Results: The ovoid dental arch form was the most predominant (41.38%) in the maxillary arch, whereas the square form was the most predominant (49.43%) in the mandibular arch. The articular eminence height presented the highest correlations with dental arch measurements, and the tapered arch forms showed the most significant correlations. There was no association between the dental arch morphology and the articular eminence measurements.

Conclusion: There is no association between the dental arch shape and the articular eminence height and inclination, however, correlations between the articular eminence measurements and the dental arch measurements are found, these correlations should be considered during orthodontic treatment, in which the dental arch width, depth and perimeter should be maintained to avoid any possible alterations in the articular eminence, which in turn could affect TMJ function.

KEY WORDS: Articular eminence, Dental arch, Cone-beam computed tomography, CBCT, TMJ.

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INTRODUCTION

The Temporomandibular joint (TMJ) is one of the most complex and sophisticated joints in the human body. It is a paired joint that connects the mandible to the skull, and plays an essential role in the human mandibular movements which allows for the physiological functions, such as; eating, speaking, as well as facial expressions. It has two articulation surfaces which are; the condyle of the mandible which lies in the glenoid fossa of the temporal bone, and the articular eminence (AE) of the temporal bone **(Vîrlan et al., 2021)**.

The articular eminence (AE) is a part of the temporal bone that is located in front of the mandibular fossa, on which the condyle slides during the movements of the mandible. The articular eminence inclination varies between individuals, and it states the degree of the disc rotation over the condyle and the path of the condylar movements. TMJ movements are also guided by the muscles, ligaments, as well as the dental occlusion **(Vîrlan et al., 2021, Çağlayan et al., 2014)**.

The articular eminence can withstand the masticatory forces caused by the mandibular movements during tooth function. However, its morphology may be remodeled to minimize the joint loads in case of increased functional stresses. It has been suggested that the morphologic variations of the articular eminence (AE) is an etiologic factor in the development of biomechanical alterations of the TMJ; as the trajectory of mandibular movement is determined by the articular eminence morphologic features; including its height and inclination **(Verner et al., 2017, Vîrlan et al., 2021)**.

Dental occlusion is caused by the neuromuscular control of the masticatory apparatus including; teeth in the dental arches, TMJs and their related muscles and ligaments (**Muhamad et al., 2014**). Moreover, dental arch shape and dimensions; including the dental arch length and width, have significant implications on the prosthetic and orthodontic diagnosis, treatment planning, and treatment outcomes in all age groups **(Omar H. et al., 2018)**.

It is well established that there is variation in the shape and size of the human dental arch, and various arch classifications have been claimed, however, the three main arch forms; which are commonly utilized and described in the dental clinical practice are; ovoid, tapered and square arch forms. Several clinical observations and research papers claimed that when the original arch form of the patient is modified, there is strong tendency of relapse after removal of the appliances. Therefore, arch shape determination is crucial in orthodontics for esthetics as well as prolonged occlusal stability through the preservation of the individual arch form **(Singh, 2021, Othman et al., 2012)**.

Many studies have been conducted to evaluate the articular eminence either by direct measurements on dry skulls or by radiographic measurements using different radiographic imaging techniques such as transcranial radiography, computed tomography (CT), and magnetic resonance imaging (MRI). However, these methods have certain limitations, for example, image superimposition in two-dimensional (2D) radiography, difficulty of correct evaluation of mineralized tissues in MRI, high radiation dose to the patient in CT, and high costs in both CT and MRI **(Verner et al., 2017)**.

Cone beam computed tomography (CBCT) has quickly become the preferred imaging modality in dentistry, as it provides three-dimensional (3D) volumetric images of the jaw bone with reasonable radiation dose and cost, in addition to its compact size and availability nearby or in the dental office. CBCT offers shorter scanning time, limited field of view, and better spatial resolution compared to conventional CT. Moreover, accurate and reliable measurements can be obtained by reconstruction of CBCT images, as CBCT machines provide isotropic voxels which are equal in all three directions **(Bromberg & Brizuela, 2023, Venkatesh & Elluru, 2017)**.

A thorough review of the available literature showed that there are no studies on the Egyptian population studying the association between the dental arch morphology and the articular eminence inclination and height, and because there are different ethnic characteristics, genetic variations and variable environmental factors between populations, the studies should be directed to each specific population. Therefore, the goal of this study is to assess the association between the dental arch morphology and the articular eminence inclination and height by using CBCT scans of a sample of the Egyptian population.

MATERIALS AND METHODS

Based on sample size calculation, a sample of 87 CBCT scans were examined. All 87 CBCT scans were gathered from the CBCT data base of Oral and Maxillofacial Radiology clinic at Faculty of Dentistry, Cairo University, Egypt after the approval of the Ethics Committee, Faculty of Dentistry, Cairo University, Egypt (**No. of approval 24-6-23**). CBCT images were for adult (females and males) Egyptian patients with ages starting from 18 till 45 years, who have already had CBCT examination for their dental diagnosis and treatment planning during the period from June 2023 till June 2024. CBCT scans of patients with complete set of permanent dentitions from the right first molar to the left first molar, with field of view that shows the entire mandibular arch and the TMJ were included. Whereas, scans of patients with pathological lesions in the TMJ or articular eminence, fractures in the articular bone surfaces, as well as scans with artifacts that could interfere with the evaluation of the articular eminence and dental arches were excluded. All studied CBCT scans were captured using **Planmeca Promax 3D Mid CBCT machine** (Planmeca OY, Helsinki, Finland). Scanning protocol for the included scans was 90 kVp, 8 mA, exposure time 13.5 sec., voxel size of 400 µm and maxillo-facial FOV (20 x 10 cm or 20 x 17 cm). **Planmeca Romexis software viewer version 4.6.2.R** (Planmeca OY, Helsinki, Finland) was utilized for all CBCT images analysis.

CBCT images were examined by two Oral and Maxillofacial radiologists (with experiences of 5 and 15 years) independently; blinded from the patients' demographic data and from each other's results. Two weeks after performing all the measurements, the first radiologist re-analyzed 20% of the scans for intra-observer reliability. For inter-reliability assessment, the second observer evaluated 20% of the total sample size. The two observers reached a consensus to resolve any disagreement.

For standardization of the measurements, the Frankfort plane was checked and adjusted on the sagittal image, to ensure that the plane is passing by the most inferior point on the orbital floor and the most superior point on the external auditory meatus. Then, quantitative and qualitative measurements were made for all the CBCT scans included.

On TMJ reformatted images, the maximum mediolateral width of the right and left condyles was selected separately on the axial view to obtain the corrected sagittal and coronal cuts of the condyle, which were used for the analysis.

Articular eminence measurements

For measuring the AE height and inclination, our study followed the same reference points previously suggested and selected by **Verner et al., 2017**. The points and lines were as follows (Table 1, Fig. 1):

The articular eminence height **(AEh)**, was obtained by measurement of the perpendicular distance between the points MF and AE on the sagittal cuts (Fig. 2). The articular eminence inclination was determined by measuring the following angles: **Angle α**; outlined by the intersection of lines 1 and 3 (Fig. 2), and **Angle β**; outlined by the intersection of lines 1 and 4 (Fig. 2). The lateral wall inclination of the glenoid fossa was determined by measuring **Angle δ**; outlined by the intersection of lines 5 and 6 (Fig. 2).

TABLE (1): Points and lines used for articular eminence measurements

Points/Lines	Definitions
MF	The most superior point on the image of the mandibular fossa.
AE	The most inferior point on the image of the articular eminence.
Line 1	The line passing by the point AE, parallel to the Frankfort plane.
Line 2	The line passing by the point MF, parallel to the Frankfort plane.
Line 3	The line tangent to the posterior slope of the articular eminence.
Line 4	The line joining between the points MF and AE.
Line 5	The line passing by the point MF, perpendicular to the Frankfort plane.
Line 6	The line tangent to the lateral wall surface of the mandibular fossa.

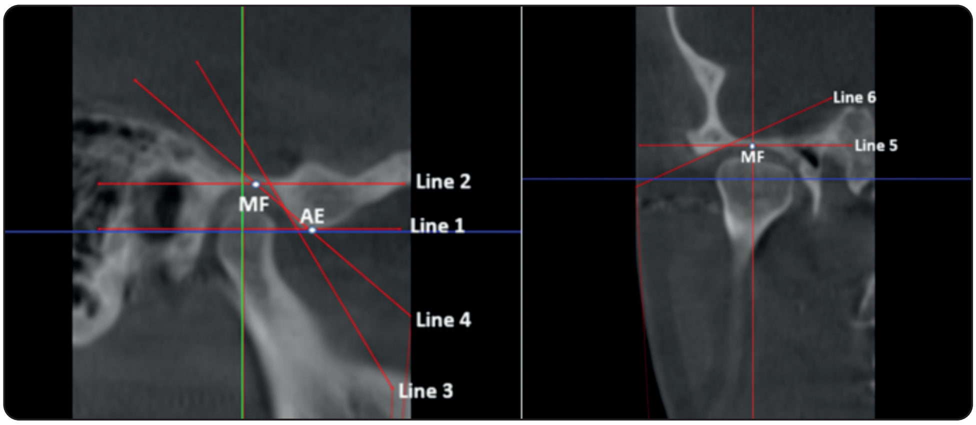

Fig. (1) The points MF and AE, and the lines 1,2,3 and 4 on the corrected sagittal image, and the lines 5 and 6 on the corrected coronal image.

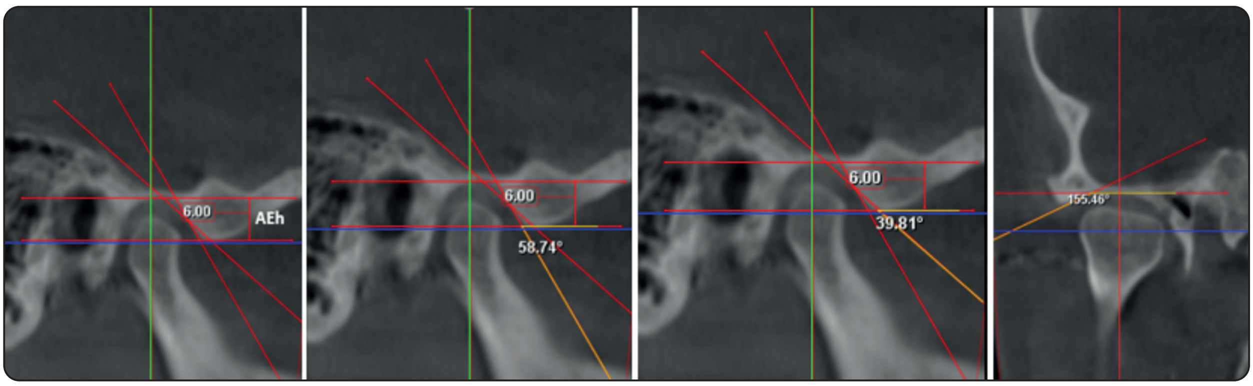

Fig. (2) Measurement of the height of articular eminence (AEh), Angle α, Angle β on the corrected sagittal image, and Angle δ measurement on the corrected coronal image.

Dental arch measurements

Measurements of maxillary and mandibular dental arches (Table 2) were done using the axial cuts.

TABLE (2): Dental arch measurements

Dental Arch Measurements		Definitions
Width	**CI**	Distance between the midpoints of incisal edges of central incisors.
	LI	Distance between the midpoints of incisal edges of lateral incisors.
	C	Distance between the cusp tips of canines.
	1PM	Distance between the buccal cusp tips of first premolars.
	2PM	Distance between the buccal cusp tips of second premolars.
	1M	Distance between the mesiobuccal cusp tips of first molars.
Depth	**AP**	The anteroposterior depth of the dental arch; by measurement of the perpendicular distance between the midpoints of the lines CI and 1M.
Perimeter	**D1**	Distance between the mesial contact point of the left first molar and the distal contact point of the left lateral incisor.
	D2	Distance between the distal contact point of the left lateral incisor and the mesial contact point of the left central incisor.
	D3	Distance between the mesial contact point of the left central incisor and the distal contact point of the right lateral incisor.
	D4	Distance between the distal contact point of the right lateral incisor and the mesial contact point of the right first molar.
	PM	Perimeter of the dental arch; by calculating the sum of the distances D1+D2+D3+D4.

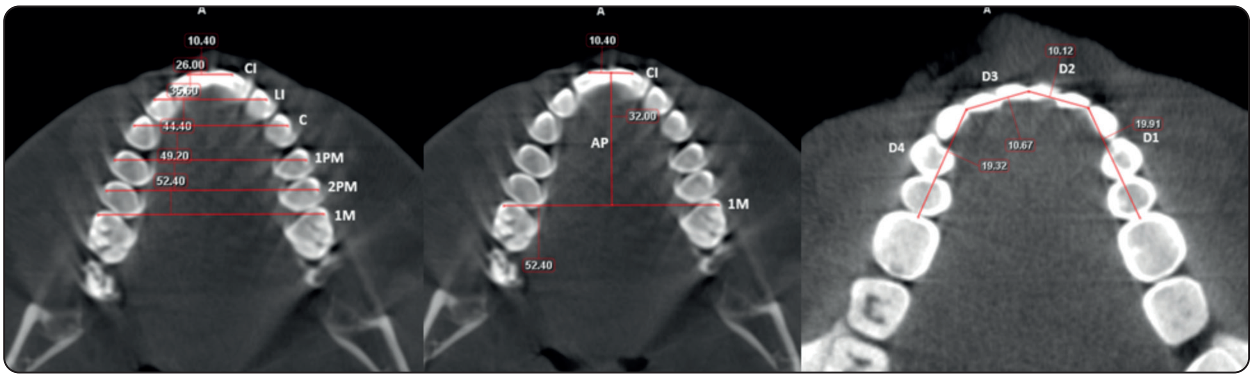

Fig. (3) Width and depth measurement of the maxillary dental arch, and perimeter measurement of the mandibular dental arch on the axial image.

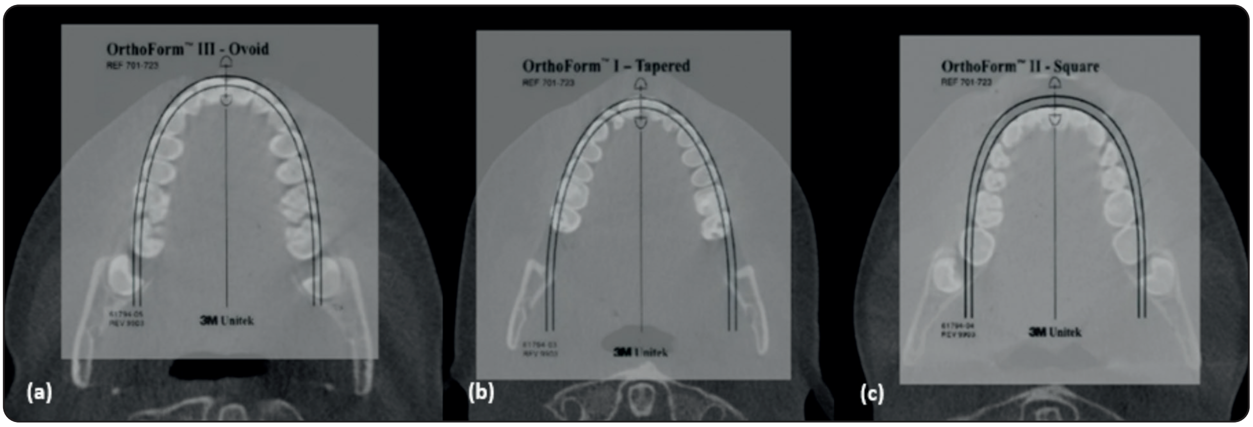

Fig. (4) Classification of (a) the maxillary dental arch as ovoid, (b) the maxillary dental arch as tapered, and (c) the mandibular dental arch as square, by superimposition of the premanufactured arch form templates (OrthoForm, 3M, Unitek) onto the axial CBCT images of the dental arch using Picsart Photo Editor.

Dental arch shape

The shape of the dental arches was classified by the observers as ovoid, tapered, or square by superimposition of premanufactured arch form templates (OrthoForm, 3M, Unitek) onto the axial CBCT images of the dental arches using Picsart Photo Editor (© 2022 PicsArt, Inc.) (Fig. 4).

Statistical analysis

Categorical data were presented as frequencies and percentages. Numerical data were presented as mean with 95% confidence intervals, standard deviation, maximum, and minimum values. They were tested for normality by viewing distribution using Shapiro-Wilk's test. Associations with arch type were analyzed using a one-way ANOVA test. Correlation analysis was made using Spearman's rank-order correlation coefficient. Dimension reduction of measured variables was done using the Principal Component Analysis (PCA). Kaiser–Meyer–Olkin (KMO) and Bartlett's tests were used to determine sampling adequacy and factorizability for (PCA). The residuals were not normally distributed for models predicting articular eminence measurements, so they were predicted using robust regression. Intra-rater and inter-rater reliability were assessed using the intra-class correlation coefficient (ICC). The significance level was set at $p<0.05$ for all tests.

RESULTS

Descriptive Analysis

The study was conducted on 87 cases (30 males and 57 females), with a mean age of (22.75±5.83) years. Of the scanned upper arches, 32 were tapered, 19 were square, and 36 were ovoid. Of the scanned lower arches, 21 were tapered, 43 were square, and 23 were ovoid.

Assessment of the association between different variables

Associations between articular eminence measurements and arch form in both arches

Associations between articular eminence measurements and arch form are presented in Tables (3) and (4), and Figures (5) and (6).

For both sides and both arches, there was no significant association between different articular eminence measurements and dental arch shape.

TABLE (3) Associations between articular eminence measurements and maxillary arch form.

Side	Measurement	Mean±SD			p-value
		Tapered	Square	Ovoid	
Right	**AEh (mm)**	5.79±1.60^{A}	5.99±1.63^{A}	6.26±1.20^{A}	**0.412ns**
	Angle α (º)	53.27±11.96^{A}	51.58±11.24^{A}	55.60±10.69^{A}	**0.427ns**
	Angle β (º)	37.07±7.92^{A}	37.25±8.14^{A}	39.61±7.71^{A}	**0.358ns**
	Angle δ (º)	145.76±8.09^{A}	147.17±7.03^{A}	146.35±9.14^{A}	**0.843ns**
Left	**AEh (mm)**	5.91±1.68^{A}	5.90±1.55^{A}	6.13±1.25^{A}	**0.796ns**
	Angle α (º)	53.06±12.77^{A}	54.93±11.89^{A}	55.77±12.12^{A}	**0.658ns**
	Angle β (º)	32.73±8.38^{A}	34.77±8.47^{A}	34.49±6.70^{A}	**0.559ns**
	Angle δ (º)	146.03±9.29^{A}	148.26±7.11^{A}	146.83±9.34^{A}	**0.688ns**

TABLE (4) Associations between articular eminence measurements and mandibular arch form.

Side	Measurement	Mean±SD			p-value
		Tapered	Square	Ovoid	
Right	**AEh (mm)**	5.78±0.95^{A}	6.17±1.71^{A}	6.00±1.32^{A}	**0.605ns**
	Angle α (º)	57.32±11.27^{A}	51.11±11.68^{A}	55.88±9.52^{A}	**0.070ns**
	Angle β (º)	39.26±5.84^{A}	37.32±9.15^{A}	38.71±7.04^{A}	**0.608ns**
	Angle δ (º)	148.79±7.99^{A}	145.10±8.52^{A}	146.32±7.85^{A}	**0.246ns**
Left	**AEh (mm)**	5.63±1.47^{A}	6.27±1.60^{A}	5.82±1.17^{A}	**0.208ns**
	Angle α (º)	52.24±11.20^{A}	54.16±12.91^{A}	57.55±11.74^{A}	**0.342ns**
	Angle β (º)	33.77±7.17^{A}	33.66±8.69^{A}	34.49±6.39^{A}	**0.915ns**
	Angle δ (º)	148.07±10.69^{A}	146.00±8.61^{A}	147.32±7.48^{A}	**0.652ns**

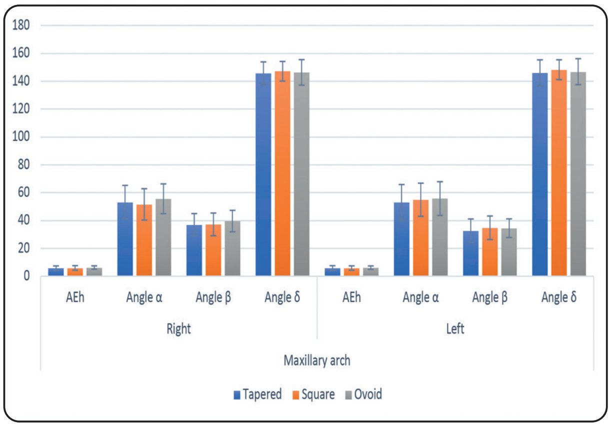

Fig. (5) Bar chart that shows mean and standard deviation (error bars) values for articular eminence measurements in different upper arch forms.

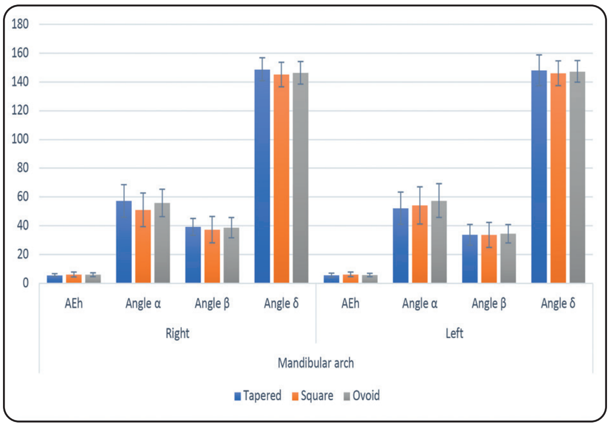

Fig. (6) Bar chart that shows mean and standard deviation (error bars) values for articular eminence measurements in different lower arch forms.

Correlations between dental arch measurements and articular eminence measurements in the different arch forms

Correlations between dental arch measurements and articular eminence measurements are presented in tables (5), (6) and (7).

Tapered arch

For the maxillary arch, both right and left sides showed that all statistically significant correlations were positive, in which there was a strong correlation between (α-1PM), a moderate correlation between AE height and (C, 1PM, 1M, PM), while the right side showed strong correlation between (α-1M), and moderate correlation between (AEh-2PM), (α-2PM) and (β-1M), however, the left side showed strong correlation between (α-2PM), and moderate correlation between (AEh-AP), angle (α) and (LI, C, 1M, PM), angle (β) and (1PM, AP, PM), angle (δ) and (LI, 1PM, AP). Moreover, in the mandible, both right and left sides showed positive correlation between (AEh-1PM), while the left side showed negative moderate correlation between (AEh-PM) and (α-PM).

Square arch

For the square arch form, in both arches, the right side did not show statistically significant correlations, while in maxilla, the left side showed positive strong correlation between (AEh-C), (AEh-1PM), (α-LI), (β-CI) and (β-LI), and there was a moderate correlation between (AEh-CI), (AEh-LI), (AEh-2PM), (α-CI) and (β-2PM). In the mandible, the left side showed positive moderate correlation between (β-LI).

Ovoid arch

In the maxillary arch, the right side showed a moderate positive correlation between (AEh-AP) and (AEh-PM), and a moderate negative correlation between (β-1PM), while the left side showed moderate positive correlation between (AEh-1M). For the mandibular arch, the statistically significant correlations were positive for both right and left sides, in which they showed strong correlation between (AEh-CI), and moderate correlation between (AEh-AP), while the left side showed strong correlation between (AEh-LI) and (AEh-C), and a moderate correlation between (AEh-1PM), (α-CI), (β-CI) and (δ-CI).

TABLE (5) Correlations between dental arch measurements and AE measurements (tapered arch).

Maxillary Arch					
Side		Correlation coefficient			
		AEh	α	β	δ
Right	CI	-0.070ns	-0.242ns	0.102ns	-0.007ns
	LI	0.223ns	0.082ns	0.132ns	0.105ns
	C	0.387*	0.274ns	0.213ns	0.018ns
	1PM	0.491*	0.515*	0.313ns	0.140ns
	2PM	0.363*	0.412*	0.240ns	-0.102ns
	1M	0.447*	0.527*	0.434*	-0.044ns
	AP	0.328ns	0.199ns	0.160ns	0.063ns
	PM	0.366*	0.316ns	0.245ns	0.114ns
Left	CI	-0.062ns	0.219ns	0.129ns	0.206ns
	LI	0.204ns	0.452*	0.325ns	0.358*
	C	0.364*	0.406*	0.293ns	0.233ns
	1PM	0.422*	0.642*	0.435*	0.391*
	2PM	0.336ns	0.516*	0.295ns	0.104ns
	1M	0.375*	0.417*	0.296ns	0.041ns
	AP	0.362*	0.246ns	0.456*	0.362*
	PM	0.355*	0.498*	0.428*	0.345ns

Mandibular Arch					
Side		Correlation coefficient			
		AEh	α	β	δ
Right	CI	-0.261ns	-0.195ns	-0.197ns	0.044ns
	LI	0.088ns	-0.170ns	-0.043ns	0.292ns
	C	0.197ns	0.225ns	0.336ns	0.064ns
	1PM	0.547*	0.282ns	0.113ns	0.163ns
	2PM	0.332ns	0.220ns	0.021ns	0.038ns
	1M	0.163ns	-0.003ns	0.015ns	0.098ns
	AP	-0.426ns	-0.378ns	-0.285ns	-0.154ns
	PM	-0.374ns	-0.361ns	-0.164ns	-0.198ns
Left	CI	-0.321ns	-0.292ns	-0.252ns	-0.065ns
	LI	0.089ns	-0.034ns	-0.012ns	0.297ns
	C	0.048ns	0.121ns	0.102ns	0.002ns
	1PM	0.498*	0.407ns	0.362ns	0.138ns
	2PM	0.306ns	0.315ns	0.071ns	0.058ns
	1M	0.037ns	0.112ns	-0.128ns	0.092ns
	AP	-0.430ns	-0.520*	-0.207ns	-0.214ns
	PM	-0.481*	-0.452*	-0.413ns	-0.191ns

TABLE (6) Correlations between dental arch measurements and AE measurements (square arch).

		Maxillary Arch				Mandibular Arch			
Side		Correlation coefficient				Correlation coefficient			
		AEh	α	β	δ	AEh	α	β	δ
Right	CI	-0.064ns	0.260ns	0.395ns	-0.074ns	0.258ns	0.208ns	0.183ns	0.285ns
	LI	0.188ns	0.236ns	0.142ns	0.221ns	0.116ns	0.112ns	0.101ns	0.062ns
	C	0.278ns	0.045ns	0.015ns	0.242ns	0.142ns	0.203ns	0.021ns	0.131ns
	1PM	0.302ns	0.153ns	0.035ns	0.174ns	0.234ns	0.060ns	-0.057ns	0.126ns
	2PM	0.038ns	0.016ns	0.021ns	0.226ns	-0.070ns	-0.142ns	-0.146ns	-0.076ns
	1M	-0.013ns	-0.073ns	0.075ns	0.206ns	-0.169ns	-0.220ns	-0.170ns	-0.117ns
	AP	-0.076ns	-0.305ns	-0.330ns	-0.148ns	0.126ns	0.171ns	0.088ns	0.085ns
	PM	0.126ns	0.011ns	-0.148ns	0.117ns	-0.012ns	0.038ns	-0.027ns	0.017ns
Left	CI	0.464*	0.473*	0.517*	0.086ns	0.202ns	0.219ns	0.268ns	0.184ns
	LI	0.485*	0.511*	0.520*	0.108ns	0.111ns	0.295ns	0.308*	0.003ns
	C	0.557*	0.242ns	0.211ns	-0.108ns	0.070ns	0.293ns	0.192ns	0.021ns
	1PM	0.533*	0.407ns	0.358ns	0.085ns	0.285ns	0.198ns	0.190ns	-0.103ns
	2PM	0.481*	0.451ns	0.470*	-0.109ns	0.143ns	0.084ns	0.137ns	-0.191ns
	1M	0.444ns	0.297ns	0.401ns	-0.204ns	0.019ns	-0.007ns	0.113ns	-0.178ns
	AP	0.104ns	0.080ns	0.135ns	-0.201ns	0.078ns	0.250ns	0.256ns	0.206ns
	PM	0.394ns	0.307ns	0.280ns	-0.089ns	-0.026ns	0.150ns	0.169ns	0.101ns

TABLE (7) Correlations between dental arch measurements and AE measurements (ovoid arch).

		AEh	α	β	δ	AEh	α	β	δ
Right	CI	0.237ns	-0.124ns	0.117ns	0.166ns	0.516*	0.192ns	0.339ns	0.273ns
	LI	0.087ns	-0.152ns	-0.156ns	0.226ns	0.357ns	-0.215ns	-0.095ns	0.131ns
	C	0.125ns	-0.147ns	-0.240ns	0.191ns	0.315ns	-0.249ns	0.032ns	-0.279ns
	1PM	0.009ns	-0.292ns	-0.404*	-0.122ns	0.227ns	-0.202ns	0.039ns	-0.151ns
	2PM	0.081ns	-0.284ns	-0.305ns	-0.109ns	0.060ns	-0.249ns	-0.168ns	-0.165ns
	1M	0.190ns	-0.217ns	-0.138ns	-0.220ns	0.131ns	-0.143ns	-0.159ns	-0.296ns
	AP	0.368*	0.001ns	0.070ns	0.055ns	0.478*	-0.196ns	0.055ns	0.016ns
	PM	0.450*	0.029ns	0.066ns	0.085ns	0.288ns	-0.214ns	-0.136ns	0.092ns
Left	CI	0.064ns	0.075ns	0.056ns	0.295ns	0.546*	0.458*	0.481*	0.467*
	LI	0.008ns	-0.162ns	-0.102ns	0.153ns	0.520*	0.137ns	0.244ns	0.246ns
	C	0.138ns	0.006ns	-0.116ns	0.131ns	0.511*	0.152ns	0.353ns	0.036ns
	1PM	0.095ns	-0.089ns	-0.174ns	-0.164ns	0.459*	0.230ns	0.262ns	0.197ns
	2PM	0.144ns	-0.144ns	-0.038ns	-0.038ns	0.205ns	0.003ns	0.021ns	0.098ns
	1M	0.336*	-0.043ns	0.061ns	0.072ns	0.258ns	-0.106ns	0.014ns	-0.065ns
	AP	0.088ns	0.017ns	0.052ns	0.057ns	0.486*	0.123ns	0.267ns	0.160ns
	PM	0.312ns	0.151ns	0.160ns	0.249ns	0.280ns	0.081ns	0.078ns	0.151ns

Regression analysis

Regression analysis is presented in Table (8).

Upper arch:

The predictors accounted for 8% of the variability in the articular eminence measurements (R^2), and an increase in dental arch measurements was significantly associated in the articular eminence measurements (p<0.001). Other predictors were not statistically significant.

Lower arch:

The predictors accounted for 2% of the variability in the articular eminence measurements (R^2), and all predictors were not statistically significant.

Table (8): Regression analysis predicting articular eminence measurements.

Arch	Variable	Coefficient	95% CI		p-value	R^2
			Lower	Upper		
Maxillary	Sex (female)	-0.01	-0.33	0.32	**0.974ns**	0.08
	Age	0.01	-0.02	0.03	**0.570ns**	
	Arch form (square)	0.08	-0.32	0.49	**0.685ns**	
	Arch form (ovoid)	0.05	-0.29	0.4	**0.756ns**	
	Dental arch measurements	0.52	0.23	0.81	**<0.001***	
Mandibular	Sex (female)	-0.16	-0.5	0.18	**0.354ns**	0.02
	Age	0.01	-0.02	0.04	**0.452ns**	
	Arch form (square)	-0.06	-0.46	0.34	**0.775ns**	
	Arch form (ovoid)	0.06	-0.38	0.5	**0.790ns**	
	Dental arch measurements	0.22	-0.1	0.54	**0.170ns**	

Inter-rater reliability

There was an excellent agreement between measurements made by both observers that was statistically significant (ICC=1, p<0.001).

Intra-rater reliability

There was an excellent agreement between both observations made by the same rater that was statistically significant (ICC=1, p<0.001).

DISCUSSION

It is crucial to understand the relation between the TMJ and the characteristics of the dental arch, as the components of TMJ has the ability to remodel and adapt to the new functional requirements in response to occlusal changes and dental arch morphological changes, leading to altered masticatory functions **(Verner et al., 2017)**.

Alterations in the dental arch can be caused by the dental procedures, such as; the orthodontic or prosthetic treatment. Such alterations can lead to malocclusion, which is considered as one of the etiologic factors of the temporomandibular joint disorders **(Matsuda et al., 2022)**. Therefore, studying the association between the morphology of the dental arch and the articular eminence may arise the importance of preserving the perimeter, depth and width of the dental arch during dental procedures; in order to avoid distortion of the TMJ integrity.

The current study utilized CBCT radiographic images which provide 3D volumetric evaluation of the dental arches and articular eminence with minimal distortion and elimination of the superimposition in the area of interest **(Hou et al., 2022)**. It also allows for short scanning time and lower radiation dose compared to conventional CT. Moreover, it is possible to obtain accurate and standardized linear and angular measurements of the dental arch and articular eminence by reconstruction of CBCT images in the different planes (axial, coronal and sagittal).

In the previous studies which assessed the articular eminence measurements, various methods were utilized for measurement of the inclination of the posterior slope of the articular eminence, and it has been reported that the view of the articular eminence in the central slice represents the steepest area of the eminence (**İlgüy et al., 2014**). Therefore, the central sagittal cut of the condylar process was utilized in the present study for measurements of the AE inclination.

In the current study, the anteroposterior inclination of the AE was measured by 2 methods, which are angles α and β. Despite both angles represent the same inclination, they provide a more accurate and complete evaluation of the articular eminence when considered together. Angle α method relies on the posterior slope of the AE, and is directly related to the direction of movement of the condyle–disk complex, whereas angle β method relies on localizing the crest of the AE in relation to the highest point of the glenoid fossa, and is related to the AE height (AEh). In addition, the lateral wall inclination of the glenoid fossa was evaluated in relation to its most superior point (angle δ), knowing that the condyle–disk complex performs lateral and anteroposterior translational and rotational movements, which is in accordance with the previous work of **Verner et al., 2017**, and **Tawfieq et al., 2024**. On the contrary, some studies evaluated the AE inclination using the anteroposterior direction only, such as **Sümbüllü et al., 2012**, **Kranjčić et al., 2012**, **Çağlayan et al., 2014**, and **İlgüy et al., 2014**.

In our study, the qualitative classification of the dental arch form into tapered, ovoid, or square, was done digitally by superimposing the premanufactured arch form templates (OrthoForm, 3M, Unitek) onto the axial CBCT images of the dental arch using Picsart Photo Editor (© 2022 PicsArt, Inc.), which is an accurate and convenient method of classification. On the other hand, other studies classified the arch form by manually superimposing the premanufactured templates (OrthoForm, 3M, Unitek) onto a printed image of the dental arch, as in **Ali & Yassir, 2022**, and **Othman et al., 2012** studies. Other studies superimposed the premanufactured templates onto the dental casts to detect the arch form as **Sharaf et al., 2022**, and **Ferro et al., 2017**.

Based on the results of this study regarding the dental arch form, it was concluded that the ovoid arch form was more prevalent (41.38%) in the maxillary arch, followed by tapered (36.78%), and square (21.84%) arch forms, whereas in the mandibular arch, the square arch shape was the most prevalent (49.43%), followed by ovoid (26.44%), and tapered (24.14%) arches.

Similar to our findings, **Tawfieq et al., 2024**, **Sharaf et al., 2022**, **Saeed & Mageet, 2018**, **Verner et al., 2017**, and **Othman et al., 2012** concluded that the ovoid arch form was the most predominant in the maxillary arch in samples of Iraqi, Egyptian, Sudanese, Brazilian and Malaysian populations. Moreover, **Lee et al., 2013** stated that the square arch shape was the most predominant in the mandibular arch in Vietnamese population, and **Kook et al., 2004** reported that the square mandibular arch shape was more common among the Korean population.

On the contrary, the results of the current study contradict with **Othman et al., 2012,** who concluded that the most frequent mandibular arch shape was the tapered form in Malaysian population, and **Tawfieq et al., 2024**, **Sharaf et al., 2022** and **Verner et al., 2017,** who stated that the ovoid dental arch shape was the most frequent in the lower arch among Iraqi, Egyptian and Brazilian populations. The variation in the prevalence of the dental arch shape between different studies might be attributed to different populations with genetic variations and different arch size and shape.

According to the results of our study, there was no significant association between the dental arch shape and the articular eminence measurements on both arches, which is in accordance with the study by **Tawfieq et al., 2024** on Iraqi population. On the other hand, **Verner et al., 2017** found an association between the morphology of the dental arch and the articular eminence in a sample of the Brazilian population. To the best of our knowledge and based on thorough literature searching, these two studies were the only studies found assessing the association between the dental arch and articular eminence, and the different conclusions can be related to the different ethnic characteristics of the populations being studied, and the variability between the samples under investigation in which the larger the sample size, the higher the variability, and the higher the inconsistency among the subjects. Therefore, further large-scale studies are required for assessment of this outcome.

In this study in hand, correlations were found between the articular eminence measurements and dental arch measurements, which corresponds to the fact that the TMJ morphology is directly affected by the dental arch development, and the AE ultimate shape is completely derived from the functional forces exerted by the teeth and masticatory muscles (**Bender et al., 2018**). The tapered arch forms showed more correlations, followed by the ovoid arch form, and the square form showed the least correlations. Moreover, the articular eminence height was the variable that presented the highest correlations with the dental arch measurements, which ascertains the strong correlation between the articular eminence height and the normal overbite (**Matsumoto & Bolognese, 1995**). These results came in accordance with **Verner et al., 2017**, contrarily, **Tawfieq et al., 2024** reported that there were no statistically significant correlations between the arch and eminence measurements, except for the significant positive correlation between (AEh-CI), and the negative correlation between (AEh-AP) in the tapered maxillary arch, and a positive correlation between (AEh-1M) in the square maxillary arch, and a negative significant correlation between (AEh-AP) in the ovoid mandibular arch, which indicates the different characteristics of the dental arch between different populations.

The current study has some limitations as it assessed the most central sagittal section of the articular eminence only, while the medial and lateral aspects were not considered. Another constraint is that it did not evaluate patients with history of orthodontic treatment. Therefore, further research should be performed to assess such variables.

CONCLUSION

In our study, it was found that there is no association between the dental arch shape and the articular eminence measurements in the Egyptian population, however, correlations between the articular eminence measurements and the dental arch measurements are found, these correlations should be considered. Therefore, the dental arch width, depth and perimeter should be preserved during orthodontic treatment and dental procedures, to avoid alterations in the articular eminence height and inclination which affects the TMJ integrity. Moreover, regarding the prevalence of the different shapes of dental arch in Egyptian population, the ovoid arch shape was more predominant in the maxillary arch, while the square arch shape was the most prevalent in the mandibular arch.

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